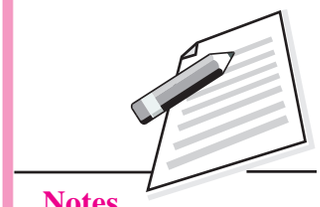


11

MINERALS

11.1 INTRODUCTION

Minerals are indispensable part of a complete diet of farm animals. In this unit, dietary essential minerals functions, factors affecting the requirements and sources will be discussed. Minerals are essential for the normal growth and maintance of the body. If the daily requirement is more than 100mg/day they are called major elements and if the daily requirements is less than 100mg/day they are called minor elements. The roles of minerals and vitamins in the maintenance of homeostatic balance and mediation of metabolic reactions in the skeleton, tissues, body fluids, digestive juices, etc.

OBJECTIVES

After reading this lesson, you will be able to:

- classify minerals
- describe the functions, Daily requirements of minerals

11.2 CALCIUM

Total calcium in the human body is 1 to 1.5kg, out of which 99% is seen in bone and 1% in extracellular fluid. The main source of calcium is milk. But in India cereals is major source of calcium. The daily requirement of calcium for child is 1200mg/day and for adult it is 500mg/day. During pregnancy /lactation the calcium requirement is 1500mg/day.

The absorption of calcium takes place in 1^{st} and 2^{nd} part of deuodenum. Calcium absorption requires carrier protein, helped by Ca^{2+} - dependent ATpase.

Factors responsible for increase in calcium absorption include Vitamin D, Parathyroid hormone, acidity and amino acids. Factors such as phytic acid,oxalates,

Notes

malabsorption syndromes and Phosphates decreases calcium absorption. The normal calcium level in blood is 9-11mg/dl.

11.2.1 Function of Calcium

The major functions of calcium are

(a) Excitation and contraction of muscle fibres needs calcium. The active transport system utilizing calcium binding protein is called Calsequestrin. Calcium decreases neuromuscular irritability.

(b) Calcium is necessary for transmission of nerve impulse from presynaptic to postsynaptic region.

(c) Calcium is used as second messenger in system involving protein and inositol triphosphate.

(d) Secretion of insulin, parathyroid hormone, calcium etc, from the cells requires calcium.

(e) Calcium decrease the passage of serum through capillaries thus, calcium is clinically used to reduce allergic exudates.

(f) Calcium is also required for coagulation factors such as prothrombin.

(g) Calcium prolongs systole.

(h) Bone and teeth contains bulk quantity of calcium.

11.2.2 Factors regulating blood calcium level

The factors regulating the blood calcium level includes

(i) Vitamin D

(a) Vitamin D and absorption of calcium:

Active form of calcium is calcitriol. Calcitriol enters intestinal wall and binds to cytoplasmic receptor and then binds with DNA causes depression and consequent transcription of gene code for calbindin. Due to increased availability of calbindin, absorption of calcium increases leading to increased blood calcium level.

(b) Vitamin D and Bone:

Vitamin D activates osteoblast, bone forming cells & also stimulates secretion of alkaline phosphatase. Due to this enzyme, calcium and phosphorus increase.

(c) Vitamin D and Kidney:

Calcitriol increase reabsorption of calcium and phosphorus by renal tubules.

(ii) Parathyroid hormone (PTH)

Normal PTH level in serum is 10-60ng/l.

(a) PTH and bones:

In bone, PTH causes demineralization. It also causes recreation of collagenase from osteoclast leads to loss of matrix and bone resorption. As a result, mucopolysacharides and hydroxyproline are excreted in urine.

(b) PTH and Kidney:

In kidney, PTH causes increased reabsorption of calcium but decreases reabsorption of phosphorus from kidney tubules.

(iii) Calcitonin

Calcitonin decreases serum calcium level. It inhibits resorption of bone. It decreases the activity of osteoclasts and increases osteoblasts.

11.2.3 Hyper Calcemia

When plasma Ca^{2+} level is more than 11mg/dl is called Hypercalcemia. It is due to parathyroid adenoma or ectopic PTH secreting tumor. In this condition, calcium excreted in urine decreases excretion of chloride causing hyperchloremic acidosis. The main symptoms of hyperchloremic acidosis are:

(a) Anorexia, nausea,vomiting

(b) polyuria, polydypsia

(c) Confusion, depression, psychosis

(d) renal stones

(e) osteoporosis

11.2.4 Hypocalcemia

Plasma calcium level less than 8mg/dl is called hypocalcemia. Tetany due to accidental surgical removal of parathyroid glands or by autoimmune disease. In tetany, neuromuscular irritability is increased. Increased Q-7 internal in ECG is seen. Main manifestation is carpopedal spasm. Laryngismus and stridor are also observed. Laryngeal spasm may lead is death. The causes of laryngeal spasm includes

(a) Deficiency of vitamin D

(b) Deficiency of parathyroid

(c) Increased calcitonin

(d) Deficiency of calcium intake

INTEXT QUESTION 11.1

1. The total calcium range in human is .....
2. Calcium absorption requires ..... dependent ATpase.
   (a) Ca (b) Mn (c) Mg (d) fe
3. Factors responsible for increase in calcium absorption include .....
4. When plasma Ca^{2+} level is more than 11mg/dl is called .....
   (a) Hypercalcemia (b) Anemia (c) Fluorosis (d) Selenosis

11.3 PHOSPHORUS

Total body content of phosphorus is 1 kg. Bone posses 80 % of total phosphorus and muscle contains 10 % of total phosphorus. Human body requires 500 mg of phosphorus per day. Milk is the good source of phosphorus and it contains about 100 mg/dl of phosphrous. Apart from milk, cereals, nuts and meat are moderate sources of phosprous.

Serum level of phosphate is 3-4 mg/dl for adults and 5-6 mg/dl in children. Consumption of calcitriol increases phosphate absorption.

11.3.1 Functions of phosphorus

(a) Plays key role in formation of tooth and bone
(b) Production of high energy phosphate compounds such as ATP, CTP, GTP etc.,
(c) Synthesis of nucleotide co-enzymes such as NAD and NADP
(d) Formation of phosphodiester backbone structure for DNA and RNA synthesis

Hypophosphatemia is the condition which leads to decrease in absorption of phosphorus. Further it leads to hypercalcamia, chronic alcoholism and increased excretion of urinary phosphate. In case of hyperphosphatemia, increase in absorption of phosphate was noticed. Hyperphosphatemia leads to cell lysis, hypocalcemia and thyrotoxicosis.

INTEXT QUESTIONS 11.2

1. Bone posses ..... % of total phosphorus.
2. Serum level of phosphate is ..... mg/dl for adults.
   (a) 4-8 (b) 3-4 (c) 8-9 (d) 1-2
3. ..... plays key role in formation of tooth and bone

11.4 MAGNESIUM

Optimal level of Magnesium for human consumption ranges 300-400 mg/day. The main source of Magnesium includes cereals, beans, leafy vegetables and fish. The normal serum level of Magnesium is 1.8 to 2.2. mg/dl.

11.4.1 Functions of Magnesium

(a) Irritability of neuromuscular tissues is lowered by Magnesium

(b) Magnesium deficiency leads to decrease in Insulin dependent uptake of glucose

(c) Magnesium supplementation improves glucose tolerance

Decrease in Magnesium content leads to the condition called as hypomagnesemia. It causes increase in urinary loss. Causes such as liver cirrhosis, protein calorie malnutrition and hypo para thyroidism leads to hypomagnesemia. Increase in the level of Magnesium is called as hypermagnesemia. The main causes of hypermagnesemia includes renal failure, hyper para thyroidism, rickets, oxalate poisoning and multiple myeloma.

INTEXT QUESTIONS 11.3

1. Optimal level of ..... for human consumption ranges 300-400 mg/day.
2. Irritability of neuromuscular tissues is lowered by .....
3. Magnesium supplementation improves ..... tolerance

   (a) lactose (b) glucose (c) toxin (d) microbial

11.5 IRON

Total body content of iron is 3 to 5 gm out of which 75 % is recorded in blood and rest of them are recorded from liver, spleen, bone marrow and muscle. The normal limit for iron consumption is 20 mg/day for adults, 20-30 mg/day for children and 40 mg/day for pregnant women. The main source of iron is jaggery. Other source of iron includes leafy vegetables and meat etc., Milk is considered as a poor source of iron.

11.5.1 Factors influencing absorption of iron

Iron is absorbed by upper part of duodenum and is affected by various factors

(a) Only reduced form of iron (ferrous) is absorbed and ferric form are not absorbed

Notes

(b) Ascorbic acid (Vitamin C) increases the absorption of iron

(c) The interfering substances such as phytic acid and oxalic acid decreases absorption of iron

11.5.2 Regulation of absorption of Iron

Absorption of iron is regulated by three main mechanisms, which includes

(a) Mucosal Regulation

(b) Storer regulation

(c) Erythropoietic regulation

In mucosal regulation absorption of iron requires DM-1 and ferroportin. Both the proteins are down regulated by hepcidin secreted by liver. The above regulation occurs when the body irons reserves are adequate. When the body iron content gets felled, storer regulation takes place. In storer regulation the mucosal is signaled for increase in iron absorption. The erythropoietic regulation occurs in response to anemia. Here the erythroid cells will signal the mucosa to increase the iron absorption.

11.5.3 Iron transport in blood

The transport form of iron in blood is transferin. Transferin are glycoprotein secreted by liver. In blood, the ceruloplasmin is the ferroxidase which oxidizes ferrous to ferric state.

$$\text{Apo-Transferin} + 2Fe^{2+} \longrightarrow \text{Transferin combined with } 2Fe^{3+}$$

Storage form of iron is ferritin. Almost no iron is excreted through urine. Feces contains iron as well as iron trapped in the intestine cells.

11.5.4 Anemia

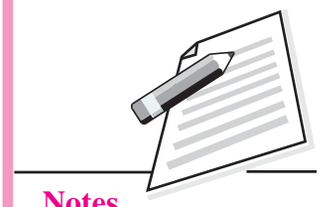
Anemia is the most common nutritional deficiency disease. The microscopic appearance of anemia is characterized by microcytic hypochromic anemia. Iron toxicity or excess of iron is called as hemosiderosis. Iron toxicity occurs due to repeated blood transfusion. The abnormal gene responsible for hemosiderosis is located on the short arm of chromosome No.6. The main causes of iron deficiency or anemia are

(a) Nutritional deficiency of iron

(b) Lack of iron absorption

(c) Hook worm infection

(d) Repeated pregnancy



(e) Chronic blood loss

(f) Nephrosis

(g) Lead poisoning

INTEXT QUESTION 11.4

1. Match the following

Adults	20 - 30 mg/day
Children	40 mg/day
Pregnant women	20 mg/day

2. ..... is the most common nutritional deficiency disease
3. The transport form of iron in blood is .....

11.6 COPPER

Total human body contains about 100 mg of copper and are encountered in muscle, liver, bone marrow, brain, kidney, heart and in hairs. Enzymes such as cytochrome oxidase, tyrosinase, lysyl oxidase, allanine synthase, monoamine oxidase, superoxide dismutase and phenol oxidase contains copper. The normal copper limit for human are 1.5 to 3 mg/day. The main sources of copper are cereals, meat, liver, nuts and green leafy vegetables. From the total dietary copper only 10% are absorbed. Copper are mainly excreated through bile. The normal serum level of copper is 25 to 50 mg/dl.

11.6.1 Functions of copper

(a) Copper is necessary for iron absorption and incorporation of iron into hemoglobin.

(b) It is very essential for tyrosinase activity

(c) It is the co-factor for vitamin C requiring hydroxylation

(d) Copper increases the level of high density lipo protein and protects the heart

11.6.2 Abnormal metabolism of copper

The abnormal metabolism of copper leads to Wilson's disease and Menke's kidney hair syndrome.

(a) Wilson's disease

In case of Wilson's disease ceruloplasmin level in blood is drastically reduced. The incidence of Wilson's disease is noticed for 1 in 50,000 populations. The

Notes

defect in a gene encoding copper binding ATPase of liver cells leads to Wilson's disease. Wilson's disease leads to

(i) Accumulation of copper in liver leads to hepatocellular degeneration and cirrhosis

(ii) Deposition of copper in brain basal ganglia leads to leticular degeneration

(iii) Copper deposits as green pigmented ring around cornea and the condition is called as Kayser-Kleischer ring

Over accumulation of copper can be treated by consumption of diet containg low copper and injection of D-penicillamine, which excretes copper through urine.

(b) Menke's kidney hair syndrome

It is X-linked defect. In this condition copper is absorbed by GI tract, but cannot be transported to blood. The defect in transport of copper to blood is due to absence of an intracellular copper binding ATPase, which is due to mutation in gene encoding them.

INTEXT QUESTIONS 11.5

1. Total human body conatins about ..... mg of copper

   (a) 100 (b) 200 (c) 300 (d) 400

2. Menke's kidney hair syndrome is ..... linked defect.

3. Deposition of copper in ..... leads to leticular degeneration

11.7 ZINC

The daily requirement of Zinc for human consumption ranges 10mg /day. The major sources of Zinc includes grains, beans, nuts cheese, meat and shellfish. The normal serum level of Zinc in human is 100mg/day. In the human total body the content of Zinc is 2gm, out of which 60 % is encountered in skeletal muscle and 30% in bones highest concentration is seen in hippocampus area of brain and prostatic secretion.

More than 300 enzymes in human body are zinc-dependent; some of them are carboxypeptidase, carbonic anhydrase, alkaline phosphatase, lactate dehydrogenase, alcohol dehydragenase. The enzyme RNA polymerase, which is required for transcription, contains zinc and it is essential for protein bio synthesis.

Deficiency in Zinc leads to poor wound healing, lesions of skin impaired spermatogenesis, hyperkeratosis, dermatitis and alopecia. Consumption of more than 1000 mg /day leads to zinc toxicity. Zinc toxicity leads to gastric ulcer, pancreatitis, anemia, nausea and vomiting.

INTEXT QUESTIONS 11.6

1. ..... and ..... are major source of Zinc

2. ..... number of enzymes are zinc dependent

   (a) 100 (b) 300 (c) 500 (d) 50

3. The normal serum level of Zinc in human is ..... mg/day

11.8 FLUORIDE

Fluoride is well known for their protective effect on caries. The safe limit of fluorine is about 1PPM in water. But excess of fluoride causes Flourosis. Flourosis is more dangerous than caries. When Fluoride content is more than 2 PPM, it will cause chronic intestinal upset, gastroenteritis, loss of weight, osteosclerosis, stratification and discoloration of teeth. In India Flourosis is widespread in Punjab, Rajasthan, Delhi and Tamilnadu. Fluoride rich source includes sea fish, cheese, tea and jowar.

Flourosis could be prevented by providing and consumption of fluoride free water, Further supplementation of vitamin c and usage of toothpaste containing regulated level of Fluoride could prevent Fluorosis.

INTEXT QUESTIONS 11.7

1. ..... is well known for caries protection.

   (a) calcium (b) fluoride (c) iron (d) Magnesium

2. Fluoride rich source includes .....

11.9 SELENIUM

The normal limit of Selenium for human consumption is 50-100 mg/day and the normal serum level is 50-100 mg/day. Selenium dependent enzymes include glutathione Peroxidase and 5-de-iodinase. Selenium concentration in testis is the

Notes

highest in adult. It is very necessary for normal development and maturation of sperm.

Selenium toxicity could be termed as selenosis. The toxicity symptoms include hair loss, falling of nails, diarrhea, weight loss and garlicky odor in breath.

INTEXT QUESTIONS 11.8

1. The normal limit of Selenium for human consumption is ..... mg/day
2. Glutathione peroxides is a ..... dependent enzyme

11.10 MANGANESE

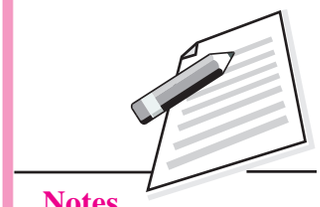
The normal limit of Manganese for human is 5mg/day. The major source of Manganese are nuts. In metabolism, its absorption is inhibited by iron. In blood, it binds with transmanganin and excreted through bile.

INTEXT QUESTIONS 11.9

1. The major source of Manganese is .....
2. Manganese are excreted through .....

WHAT HAVE YOU LEARNT

- In this lesson you have learnt about the importance and types of clinically significant mineral elements.
- Mineral elements are solid crystalline, chemical elements that cannot be decomposed and synthesized by ordinary chemical reactions.
- They are present in both plants and animals to execute specific functions and the amount to be required is largely determined by certain inherent factors.
- Minerals although nutritionally required in smaller amounts are essential for maintenance and production purposes. However the major and trace minerals are needed by the body in large and small amount respectively.
- Generally, deficiencies of most minerals are shown by a reduced appetite and production, slow growth and occasionally death.



TERMINAL QUESTIONS

1. Write a short note on minerals?
2. What are the elements of major and minor minerals?
3. Write a note on calcium and its finctions?
4. What are the functions of phosphorous?
5. Narrate the importance of iron?

ANSWERS TO INTEXT QUESTIONS

11.1

1. 1 to 1.5 kg
2. Ca
3. Vitamin D
4. Hypercalcemia

11.2

1. 80 %
2. 3-4
3. Phosphorus

11.3

1. 300 to 400
2. Magnesium
3. Glucose

11.4

1. Adults 20 mg/day
   Children 20 – 30 mg/day
   Pregnant women 40 mg/day
2. Anemia
3. Transferin

Notes

11.5

1. 100
2. X-linked
3. Brain basal ganglia

11.6

1. Beans and nuts
2. 300
3. 10

11.7

1. Fluoride
2. Fish

11.8

1. 50-100
2. Selenium

11.9

1. Nuts
2. Bile