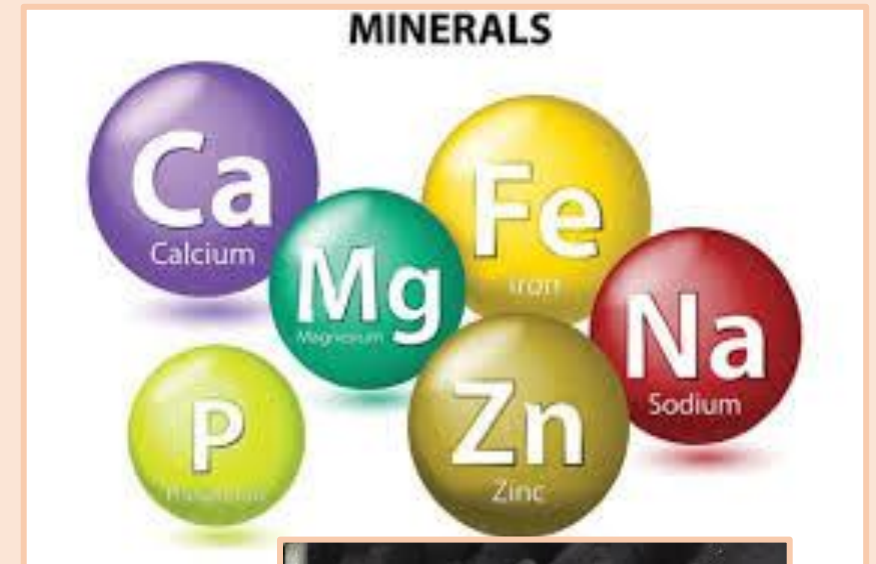


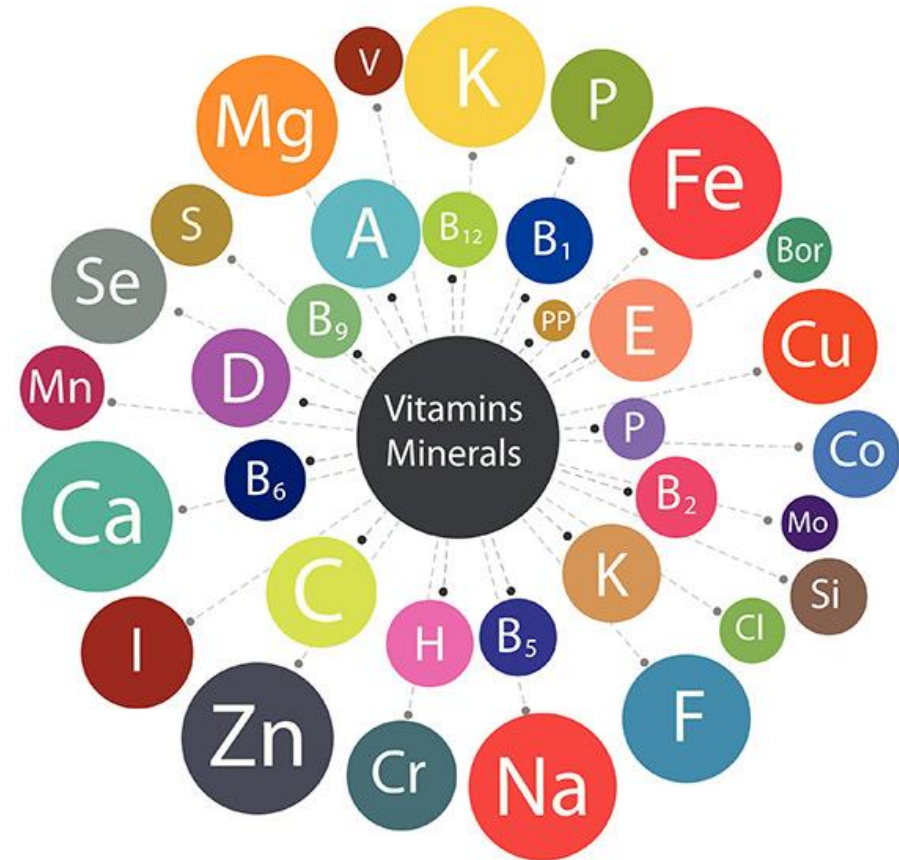
MINERAL AND VITAMIN REQUIREMENT GUIDELINE (Level 3)

Topic	Training & information Content
3.1	Estimating feeding value of fodder & feed on dairy farms
3.2	Sampling feeds & forages/analysis interpretation
3.3	Estimating Dry Matter intake for various breeds/age categories of dairy cattle in the tropics
3.4	Reviewing feed intake, rumen fill, Body Condition Scoring (BCS)
3.5	Life weight estimation of cows
3.6	Rumen fermentation
3.7	Mineral & vitamin requirement, guidelines
3.8	Manure scoring and evaluation
3.9	Guidelines for ration calculations for various breeds, heifers, lactation stage (Rumen8)
3.10	Use of Rumen8 software for ration calculation
3.11	Optimization of ration with Rumen8
3.12	Feeding management guidelines
3.13	Feeding management of dry cows/close-up
3.14	Feeding systems
3.15	Metabolic disorders
3.16	Scoring locomotion and hoof condition
3.17	Mycotoxin in dairy cattle nutrition
3.18	Heat stress in dairy cattle nutrition
3.19	Monitoring feeding management, using KPIs (based on Rumen8)



1. You will learn about (learning objectives):

- Types of minerals and vitamins.
- Functions of minerals and vitamins in a dairy cow.
- Mineral and vitamin requirements by dairy cattle.



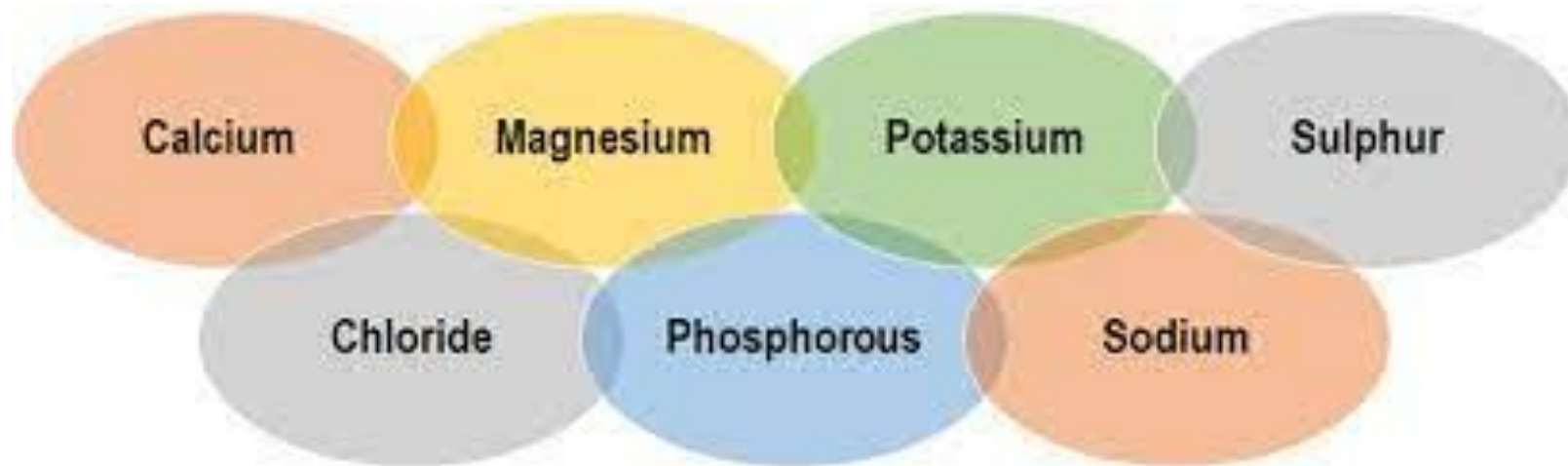
2. Introduction

- **Minerals:** are inorganic elements needed in the cow's body to support some functions.
- **Vitamins:** are organic compounds needed in small quantities to maintain life and body functions.
- Animals get minerals and vitamins through feeding.
- Minerals are found in forages and feeds although its contents vary between species and is influenced by environmental factors.
- Mineral are divided into two categories;
 - i. Macro minerals,
 - ii. Micro minerals.



3. Macro minerals

- These are minerals that are needed by cows in bigger/larger quantities as compared to microminerals.
- Macro minerals are expressed and measured as a percentage of dry matter intake (DMI).
- They are fed at the rate of grams per animal per day and calculated based on the density in the feed ingredients together with the mineral content in the mineral mix used.
- Examples of these minerals are;
 - Calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K), Sulphur (S), sodium (Na) and chlorine (Cl).

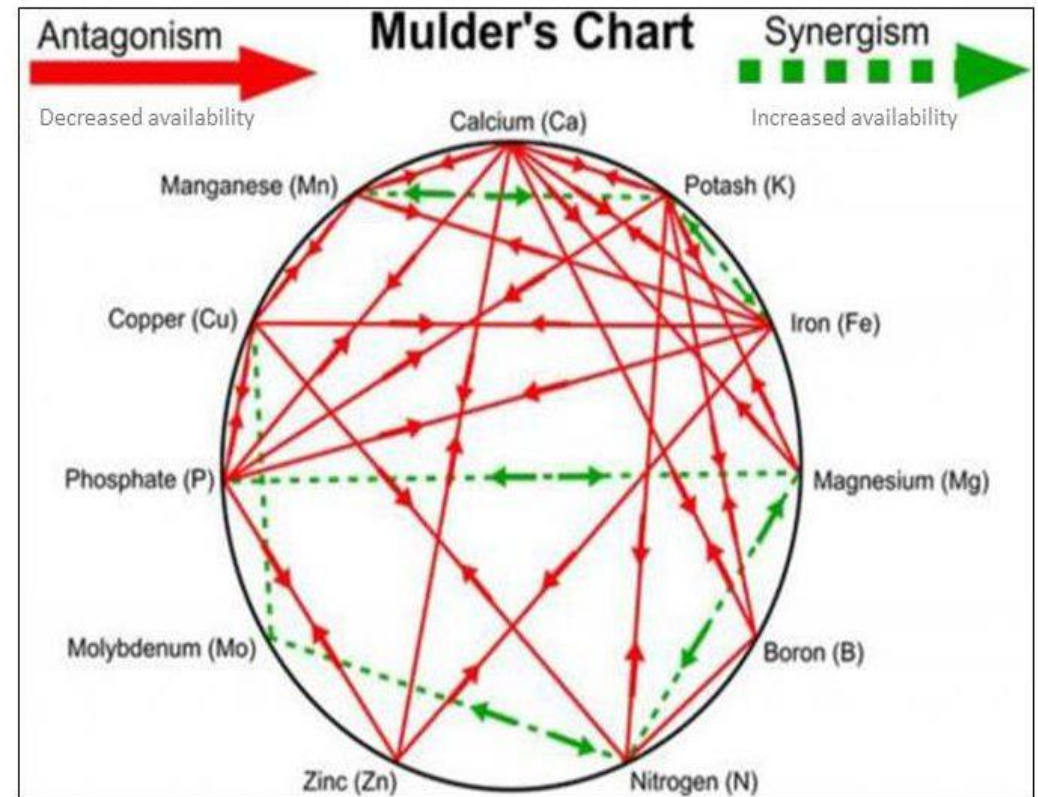


5. Mineral bioavailability

- This refers to total amount of minerals that can be utilized for normal body function at dietary and tissue level.
- Minerals should be available in ionic form (cations and anions) to make them suitable for transport and uptake. This facilitates absorption within the gastrointestinal tract by enterocytes.
- Bioavailability of one mineral influences concentration of other minerals in the diet, creating antagonisms or synergisms.

Synergism

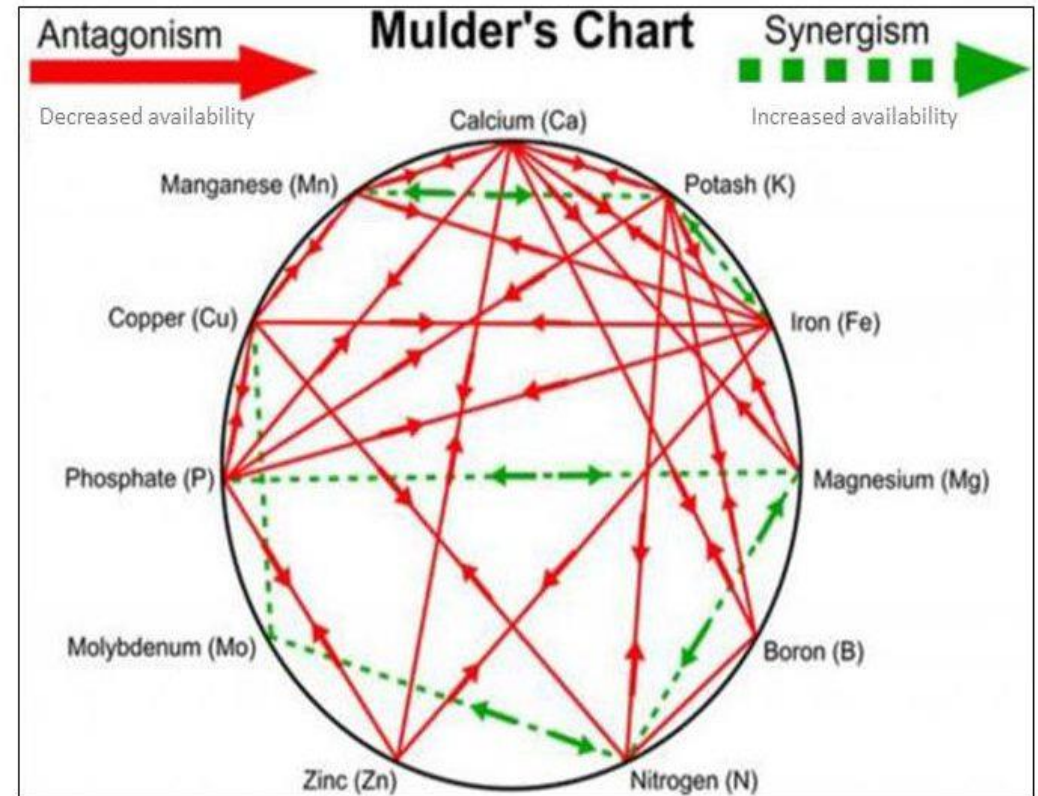
- Refers to cooperation of two/more agents causing greater effect when combined/used together.



5.1 Mineral bioavailability cont'd...

Antagonism

- Mineral concentrations have to be balanced to avoid two or more minerals from being opponents of each other.
- Some minerals can be bonded to other minerals leading to insoluble complexes that make them unavailable.
- This can also be caused by competition for absorption in a site, reducing availability.
- These cause an antagonistic effect mostly in the rumen.
- **Example:** High levels of molybdenum interferes with copper absorption.



6. Factors to consider when formulating mineral mixture

- It is important for farmers to identify mineral sources.
- Identify also, the possible deficiencies in a farm through mineral analysis. This can be done through forage and feed mineral analysis.
- Analysis reports of the above guide farmers to take corrective steps when supplementing cattle with minerals.



7. Mineral analysis

- Analysis helps correct feeds and forage that are insufficient or excessive amounts of certain minerals.
- Mineral content of forages is influenced by availability of nutrients in the soil (soil fertility).
- Mineral challenges are area specific depending on the type of soil.
- Because of the type of soil some farms may need specific supplementation of certain minerals while other farms may have sufficient minerals in the forage-based rations.



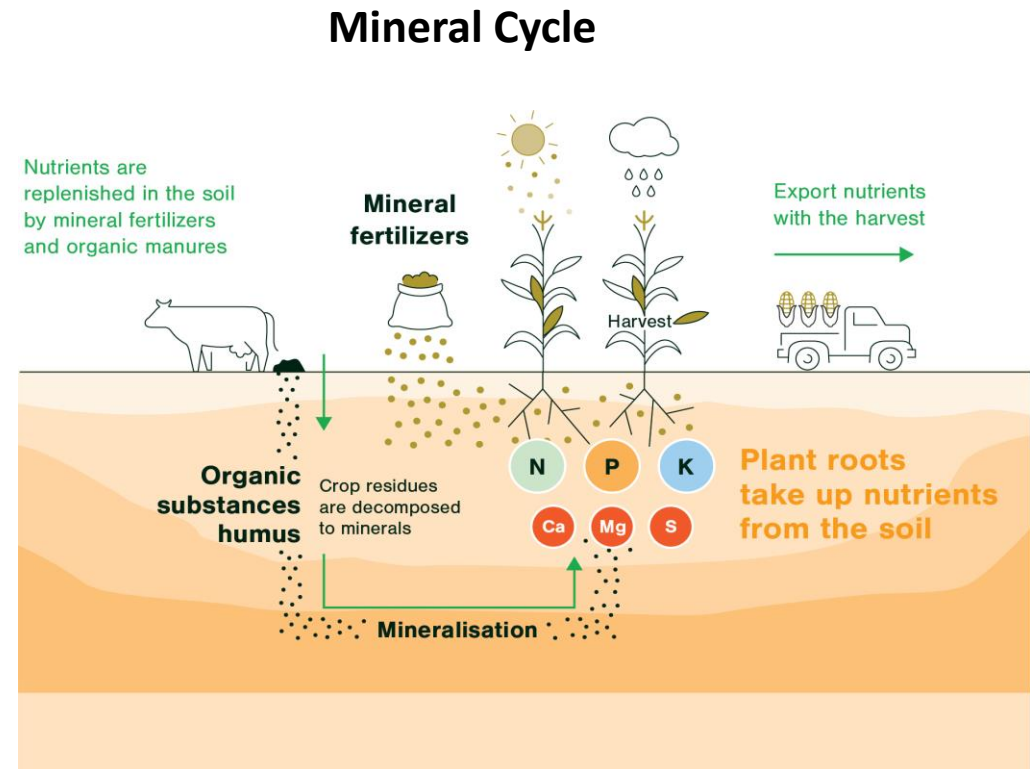
4. Micro minerals

- These are minerals needed in smaller quantities.
- They are added to cows ration as premixes.
- They are fed at the rate of milligrams (mg) per kilogram (kg) per day.
- Micro minerals are expressed and measured as parts per million (ppm). To convert ppm or mg/kg to grams one can divide by 1,000 for easy ration balancing.
- Examples of these trace minerals are;
 - Cobalt (Co), copper (Cu), iron (Fe), iodine (I), manganese (Mn), molybdenum (Mo), selenium (Se), zinc (Zn), nickel (Ni) and chromium (Cr).



8. Factors affecting forage mineral availability

- Minerals can be taken in by cows through feeds and forages or mineral supplementation.
- Forages vary in mineral content from one region to another due to differences in physical and chemical properties of the soil.
- Some of factors that influence the mineral content of forages are:
 - Type of soil
 - Soil fertility and fertilization
 - Climate
 - Plant species
 - Stage of maturity

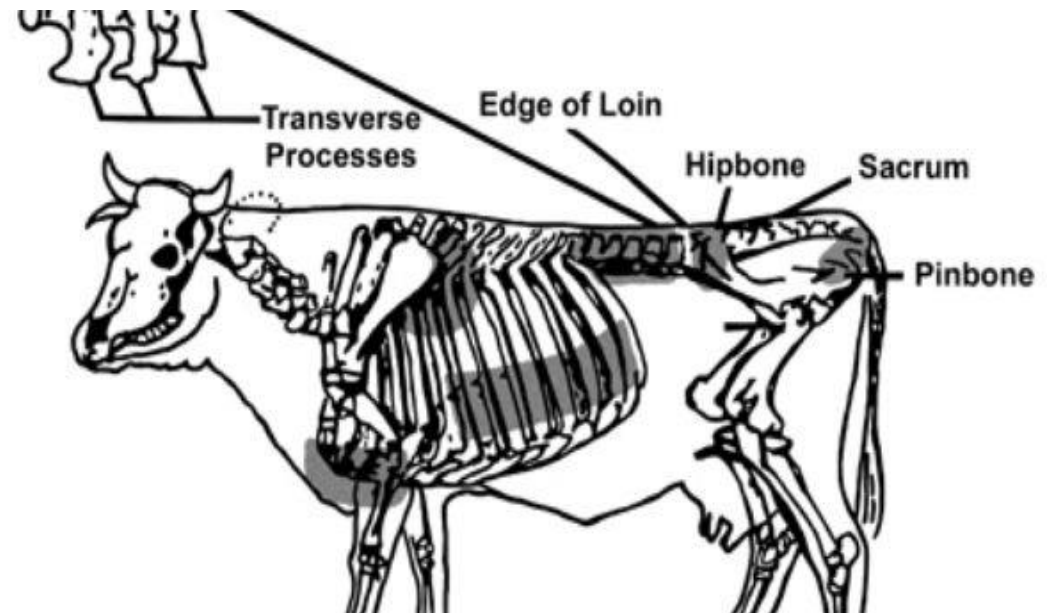


9. Macro minerals: Calcium (Ca)

- Majority of calcium in the cow's body is found in animals bones and teeth.
- During dietary deficiencies, bones can supply calcium in the short-term.
- Forages also contain calcium (legumes contain more Ca than grasses).

Functions of Calcium

- Important for bone & teeth formation, development and maintenance.
- Needed for milk production (component of milk).
- Important for blood clotting.
- Supports muscle contraction.
- Aids in nerve impulse transmission.



9.1 Calcium (Ca) Cont'd...

Signs of Calcium deficiency

It causes:

- Rickets in young stock due to poor bone growth.
- Retarded growth and development.
- Weak and brittle bones (Osteomalacia).
- Milk fever in dairy cows after calving (clinical deficiency).

Impact of high Calcium levels

- High calcium levels reduces absorption of zinc and phosphorus.



Supplemental sources of Ca

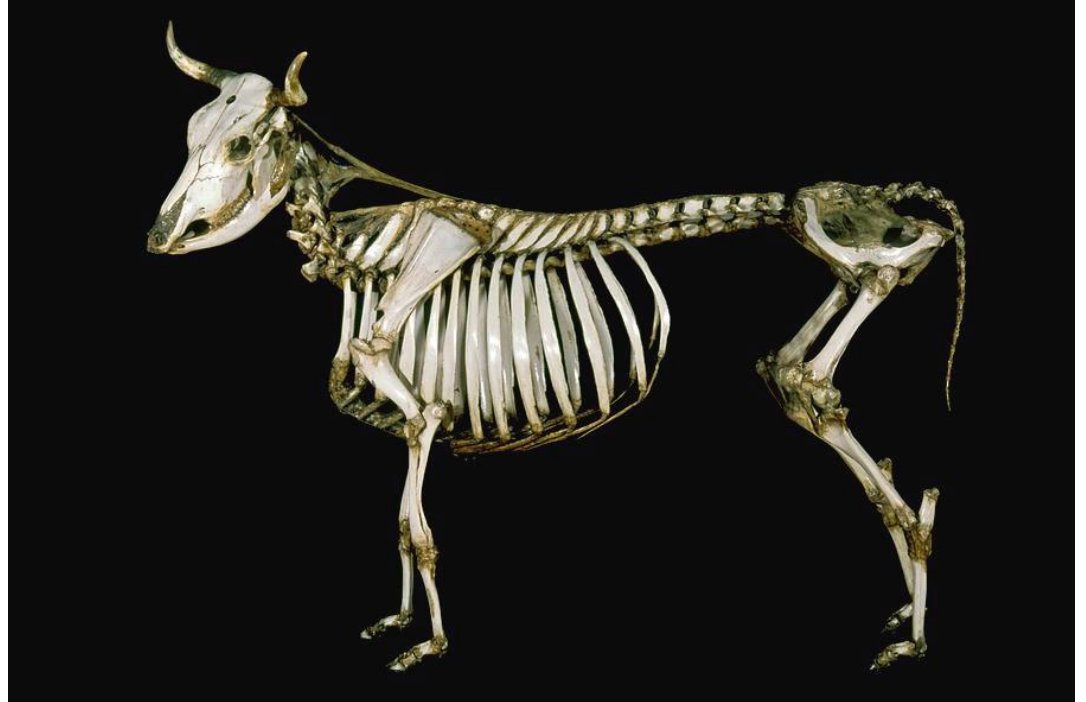
- Limestone(Calcium carbonate) dicalcium phosphate, calcium sulphate, bone meal and oyster shells.

10. Phosphorus (P)

- Majority of phosphorus can be found in bones and teeth.
- Concentrates are higher in phosphorus than forages.
- Forage phosphorous levels are lower in mature forages and during dry spells.
- Animals fed on high forage rations should therefore be supplemented with P.

Functions of Phosphorus

- Phosphorus is required for skeleton development and maintenance.
- Used to make energy.
- Aids in muscle tissue building.
- Important for cell growth and differentiation.
- Needed for fiber digestion by microbes in the rumen.
- Components of milk.



10.1 Phosphorus (P) Cont'd...

Signs of Phosphorus deficiency

It causes:

- Decreased appetite (DMI) and growth.
- Reduced milk production.
- Cows eating soil, rocks, wooden post or bones (pica).
- Rickets due to weak and fragile bones (clinical deficiency).

Impact of high Phosphorus levels

- Excess phosphorus is secreted mostly through feces into the environment.
- Phosphorus has environmental impact and secretion should be managed to reduce runoff of excreted phosphorus to surface water.
- High phosphorus levels in cows body results to urinary calculi.

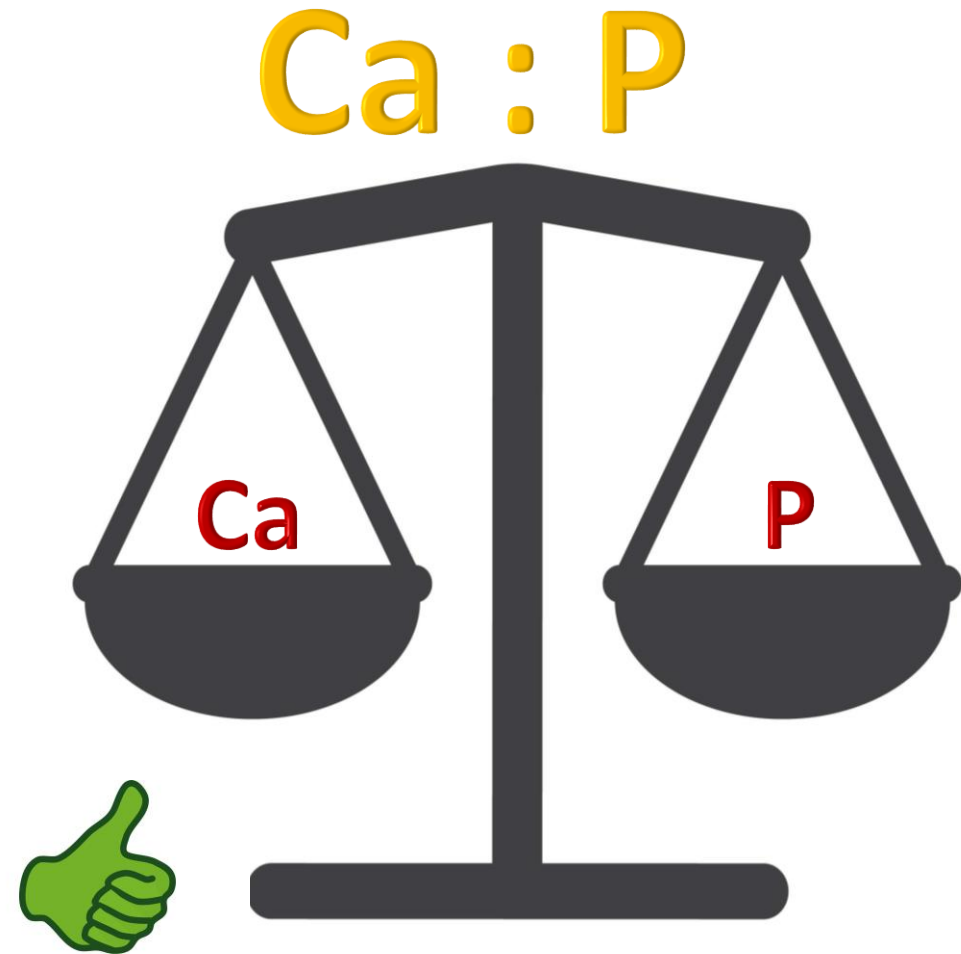


Supplemental sources of P

- Dicalcium phosphate and monocalcium phosphate.

11. Calcium (Ca) and Phosphorus (P) proportion

- Calcium and phosphorus are one of the major minerals and should be balanced for best utilization by cow.
- Interactions between calcium and phosphorus affects required level of each other in rations.
- High levels of phosphorus and low levels of vitamin D may lead to deficiency of calcium.
- One and a half part calcium to one part phosphorus (1.5:1) is recommended.
- An imbalance of the calcium and phosphorus ration can impact fertility.

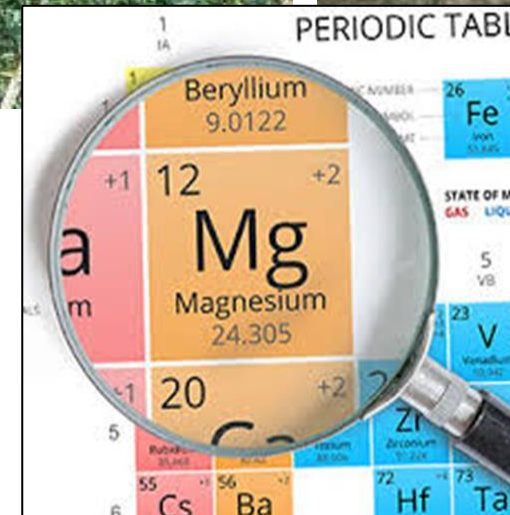


12. Magnesium (Mg)

- Three quarter of magnesium is found in bones of cows.
- Mg is found in feeds, with plant protein sources having higher Mg content.
- Mg levels in diet should not exceed 0.4%.

Functions of Magnesium

- Important in nerve functions.
- Is a component of several enzymes involved in metabolism.
- Needed for muscle contraction.
- Aids in controlling blood levels.



PERIODIC TABLE																																																																																																																							
1 IA	2 IIA	3 IIIA	4 IVA	5 VA	6 VIA	7 VIIA	8 VIIIA	9 VIIIA	10 VIIIB	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA	19 IA	20 IIA	21 IIIB	22 IIIB	23 IIIB	24 IIIB	25 IIIB	26 IIIB	27 IIIB	28 IIIB	29 IIIB	30 IIIB	31 IIIA	32 IIIA	33 IIIA	34 IIIA	35 IIIA	36 IIIA	37 IA	38 IIA	39 IIIB	40 IIIB	41 IIIB	42 IIIB	43 IIIB	44 IIIB	45 IIIB	46 IIIB	47 IIIB	48 IIIB	49 IIIB	50 IIIB	51 IIIA	52 IIIA	53 IIIA	54 IIIA	55 IIIA	56 IIIA	57 IIIA	58 IIIA	59 IIIA	60 IIIA	61 IIIA	62 IIIA	63 IIIA	64 IIIA	65 IIIA	66 IIIA	67 IIIA	68 IIIA	69 IIIA	70 IIIA	71 IIIA	72 IIIA	73 IIIA	74 IIIA	75 IIIA	76 IIIA	77 IIIA	78 IIIA	79 IIIA	80 IIIA	81 IIIA	82 IIIA	83 IIIA	84 IIIA	85 IIIA	86 IIIA	87 IIIA	88 IIIA	89 IIIA	90 IIIA	91 IIIA	92 IIIA	93 IIIA	94 IIIA	95 IIIA	96 IIIA	97 IIIA	98 IIIA	99 IIIA	100 IIIA	101 IIIA	102 IIIA	103 IIIA	104 IIIA	105 IIIA	106 IIIA	107 IIIA	108 IIIA	109 IIIA	110 IIIA	111 IIIA	112 IIIA	113 IIIA	114 IIIA	115 IIIA	116 IIIA	117 IIIA	118 IIIA	119 IIIA	120 IIIA

12.1 Magnesium (Mg) Cont'd...

Signs of Magnesium deficiency

It causes:

- **Muscle** convulsions.
- Frothing at the mouth.
- Muscle tremors (grass tetany) - See module metabolic disorders.
- Increased blood flow.



Supplemental sources of Mg

- Magnesium oxide and magnesium sulphate.

13. Potassium (K)

- Potassium is the third most abundant mineral in a cow's body.
- Forages are a good source of potassium especially well growing green pastures.
- Potassium should not exceed 3% in the diet.

Functions of Potassium

- Important in nerve transmission.
- Aids in the balance of acid and base.
- Important in controlling osmotic pressure.
- For milk production.
- For muscle contraction.
- Aids transport function of oxygen and carbon dioxide.
- Body water balance.



13.1 Potassium (K) Cont'd...

Signs of Potassium deficiency

It causes:

- Reduced feed and water intake.
- Low milk production.
- Reduced weight gain.
- Rough haircoat.
- Muscle weakness.

Impact of high Potassium levels

- Leads to decline in magnesium utilization.
- Can lead to low calcium level in blood as a result increase risk of milk fever.



Source:

https://www.google.com/search?q=potassium+deficiency+in+cattle&rlz=1C5CHFA_enKE951KE951&sxsrf=APq-WBunNhtxda4Z00MueQwl2mYVtVR9PA:1648058511163&source=lnms&tbn=isch&sa=X&ved=2ahUK Ewi1x4Gx6Nz2AhWDhv0HHZk8AqkQ_AUoAXoECAEQAw

Supplemental sources of K

- Potassium bicarbonate, potassium chloride, potassium sulphate and potassium carbonate.

14. Sodium (Na) and Chlorine (Cl)

- Salt concentration should be balanced to avoid excessive or under consumption of salt in animal diets.
- Cattle consume 0.005-0.010 % of their body weight as salt daily.

Functions of Sodium and Chlorine

- Important for bone and teeth formation.
- Important for blood clotting.
- Maintains osmotic pressure.
- Regulates water balance (Na & Cl).
- Supports muscle contraction.
- Aids operation of some enzyme systems (Na).
- Used to produce hydrochloric acid in abomasum (Cl).
- Aids respiratory gas exchange (Cl).



Source:
<https://www.google.com/url?sa=i&url=https%3A%2F%2Fzychemical.en.made-in-china.com%2Fproduct%2FgKwmLflrsQpS%2FChina-Mineral-Salt-Block-for-Cattle-and-Sheep-Lick.html&psig=AOvVaw2UPyFqxyW8pWIndVMFDa2I&ust=1648145342297000&source=images&cd=vfe&ved=0CAsQjRxqFwoTCNcf1ITq3PYCFQAAAAAdAAABAD>

14.1 Sodium (Na) and Chlorine (Cl) Cont'd...

- Sodium deficiency is common and not chlorine. Sodium deficiency may lead to;
 - Decreased appetite.
 - Abnormal eating habits.
 - Low dry matter intake (DMI).
 - Cows licking soil and wood (pica).



Supplemental sources of Na

- Sodium chloride (common salt), sodium bicarbonate (optimize chlorine levels), sodium sulphate and sodium containing phosphates.

Supplemental sources of Cl

- Sodium chloride (common salt), potassium chloride.

15. Sulphur (S)

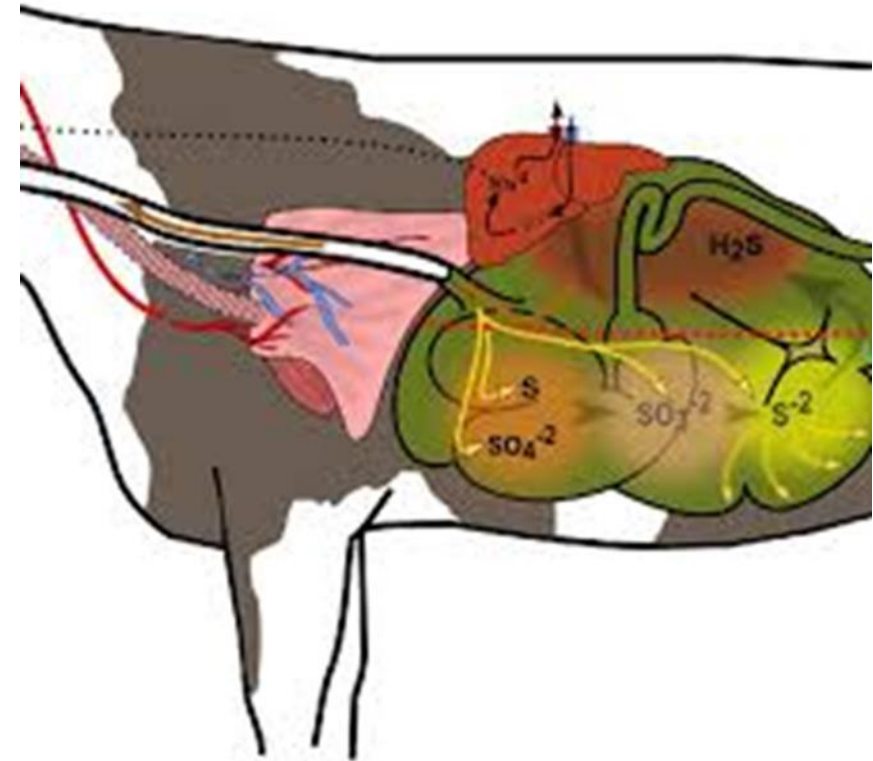
- Sulphur is a building block for various amino acids and vitamin B (thiamin & biotin) and assists in acid-base balance.
- Sulphur in feedstuff is largely found as a component of protein.
- Low Sulphur levels can reduce copper levels.
- For optimal microbial synthesis nitrogen, Sulphur ratio should be 10 parts nitrogen and 1 part Sulphur.
- Sulphur in diets should not exceed 0.4%.

Signs of high Sulphur levels/Sulphur toxicity

- Diarrhea in cows.
- Restlessness and difficulty in breathing.
- Muscle twitching.

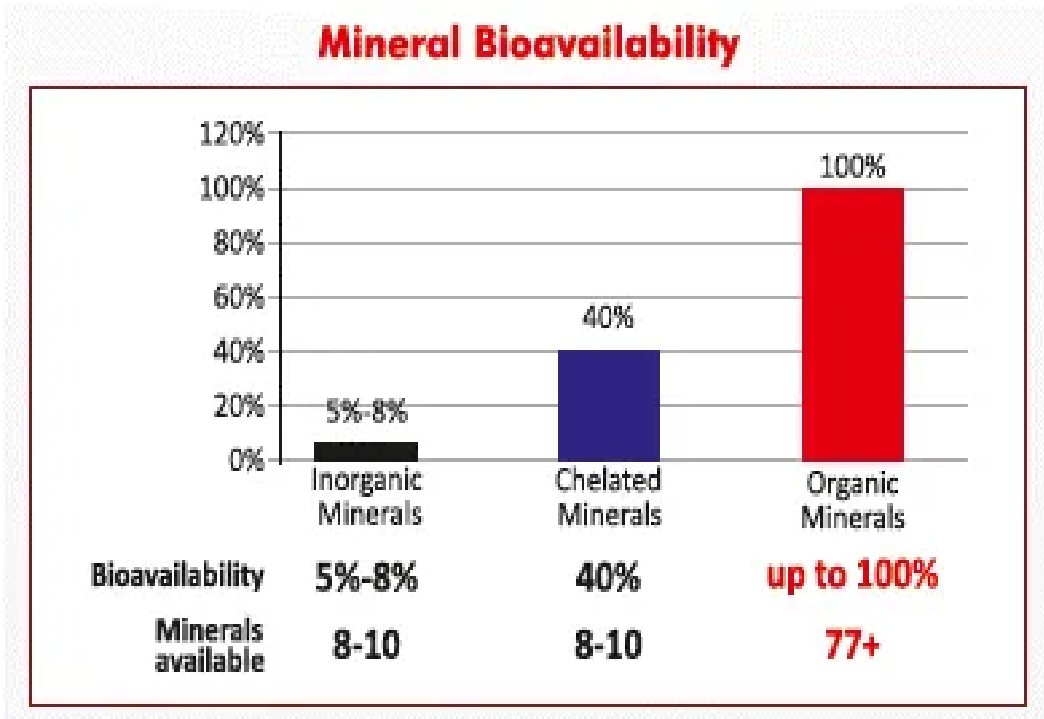
Supplemental sources of S

- Sodium sulphate, calcium sulphate, ammonium sulphate and other elements containing sulphur.



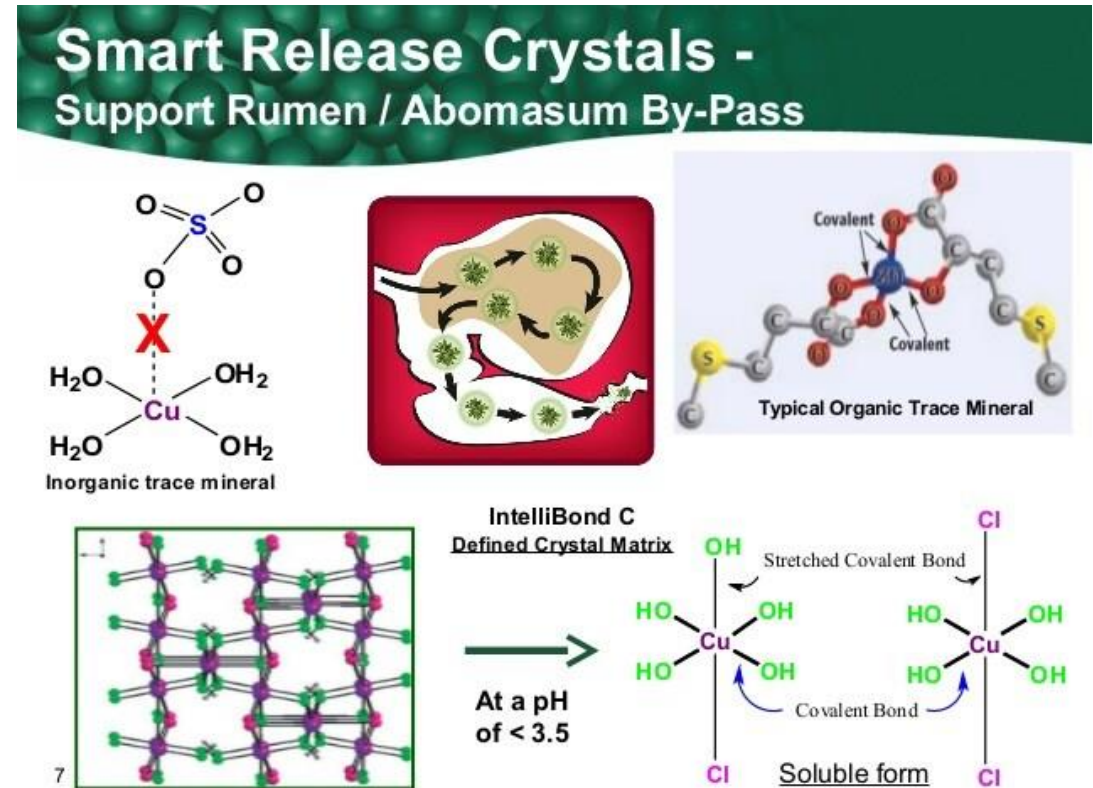
16. Bioavailability of micro minerals

- Micro minerals can either be:
 - Organic trace minerals,
 - Inorganic trace minerals, or
 - Hydroxy trace minerals.
- **Organic minerals** – are minerals bound to organic molecules i.e. amino acids and polysaccharides.
- They have the greatest bioavailability and are more expensive.
- Inorganic minerals have a relative bioavailability and are less expensive compared to organic & hydroxy trace minerals.
- Inorganic trace minerals come in the form of; sulphates, chlorides, oxides and carbonates.



17. Hydroxy micro minerals

- Hydroxy micro minerals have a crystalline structure with tight covalent bond to multiple hydroxyl group.
- The crystalline structure protect the metal ions.
- This bonds allow trace minerals to by-pass rumen digestion, increasing bio-availability.
- These minerals can be included in high stress situations due to their high bioavailability and medium cost.



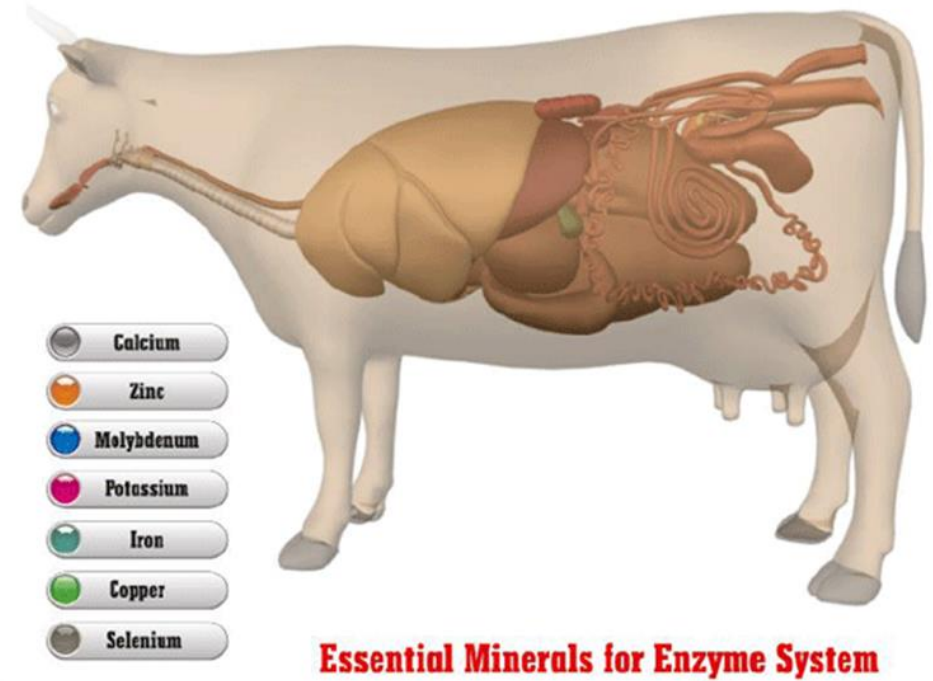
18. Micro minerals: Zinc (Zn) and Iron (Fe)

Zinc (Zn)

- Plant proteins have higher Zn than cereal grains.
- Zn is a component of key enzymes used to activate other enzymes.
- Zinc plays a role in development and functioning of immune system.
- In diets Zn should not exceed 0.5 grams (500 ppm).

Iron (Fe)

- Is a component of hemoglobin and myoglobin (oxygen transfer).
- Fe aids electron transfer chain in the body.
- Fe contributes to copper deficiency.
- Lack of iron causes anemic conditions, pale mucous membrane, reduced feed intake and abnormal raised tissue structure of the tongue.
- Fe in the diet should not exceed 1 grams (1,000 ppm).



19. Cobalt (Co) and Manganese (Mn)

Cobalt (Co)

- Is the building block for Vitamin B12 (cobalamin).
- Rumen microbes use vitamin B12 to produce propionate which is a volatile fatty acid used to give energy to cows.
- Young stock are more sensitive to Co deficiency than mature stock.
- Legumes are higher in Co than grass.
- Cobalt should not exceed 0.01 grams (10 ppm) in the diet.

Manganese (Mn)

- Important for bone growth and formation.
- Maintains fertility in female cattle.
- Aids metabolism functions.
- Mn levels should not exceed 1 gram (1,000 ppm) in the diet.



20. Copper (Cu) and Iodine (I)

Copper (Cu)

- Cu is more available in concentrates than in forages.
- Cu aids in iron absorption and metabolism.
- Aids many enzyme systems i.e. hemoglobin formation.
- Important in immune functions (connective tissue formation).
- Cu should range between 0.04-0.1 grams (40-100 ppm), should not exceed 0.1 grams (100 ppm) in the diet.

Iodine (I)

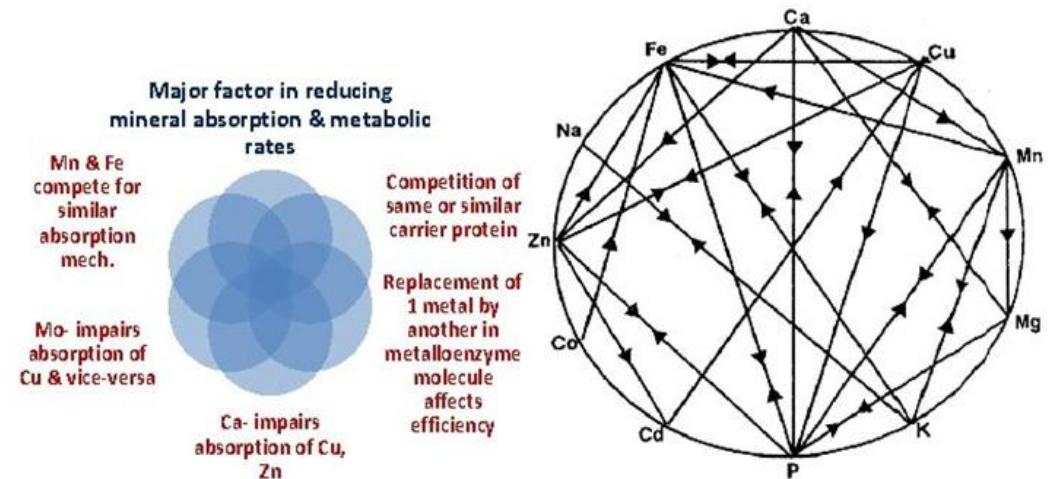
- Important component of the thyroid hormones for energy metabolism regulation in the body.
- Lack of iodine reduces immunity and calves born may be blind. It also causes enlarged thyroid gland (goiter).
- Iodine levels should not exceed 0.5 grams (50 ppm) in the diet.



21. Molybdenum (Mo)

- Mo is a component of some enzymes.
- Excess Mo causes decreased weight of heifer at puberty.
- Excess Mo affects conception rates.
- Copper & sulphur work against Mo in the body.
- Copper can reduce molybdenum toxicity while molybdenum contributes to copper deficiency.
- Maintaining Cu and Mo helps reduce this.
- Maintaining a Cu:Mo ratio of between 2:1 to 4:1 is recommended.
- Mo should not exceed 0.005 grams (5 ppm) in the diet.

Mutual antagonism



22. Selenium (Se)

- Is an antioxidant and component of some enzymes.
- Se is needed for pancreas functions.
- Functions of Vitamin E and selenium are interrelated.
- Lack of selenium affects immune system response of calves.
- It also lead to white muscle disease.
- Se should not exceed 0.002 grams (2 ppm) in the diet.



Selenium

23. Nickel (Ni) and Chromium (Cr)

Nickel (Ni)

- Ni is a component of some enzymes (urease enzyme- responsible for urea breakdown).
- Ni should not exceed 0.05 grams (50 ppm) in the diet.

Chromium (Cr)

- Chromium assists in glucose clearance.
- Chromium supplementation improves immune response of stressed animals.
- Cr should not exceed 1 gram (1,000 ppm) in the diet.



24. Guidelines for feeding macro minerals

Mineral	Lactating cows	Dry cows	Growing calves	Maximum tolerable level
Calcium, %	0.31	0.18	0.58	-
Magnesium, %	0.10	0.12	0.20	0.40
Phosphorus, %	0.21	0.16	0.26	-
Potassium, %	0.60	0.60	0.70	3.0
Sodium, %	0.07	0.07	0.10	-
Sulphur, %	0.15	0.15	0.15	0.40

NRC, 1996. Adapted from NRC. Nutrient Requirements of Beef Cattle, Sixth Edition

25. Factors affecting mineral intake

- Mineral availability and content.
- Palatability and form of the mineral product.
- Mineral feeder location. Place mineral blocks or mineral lick near watering points to increase consumption.
- Deficiency of other nutrients in the diet (protein and energy).
- Forage quality and other feed supplements.
- Concentration of other minerals i.e. phosphorus in high levels can affect ability of using other minerals like Ca, Mg, Fe and Zn.



26. Vitamins

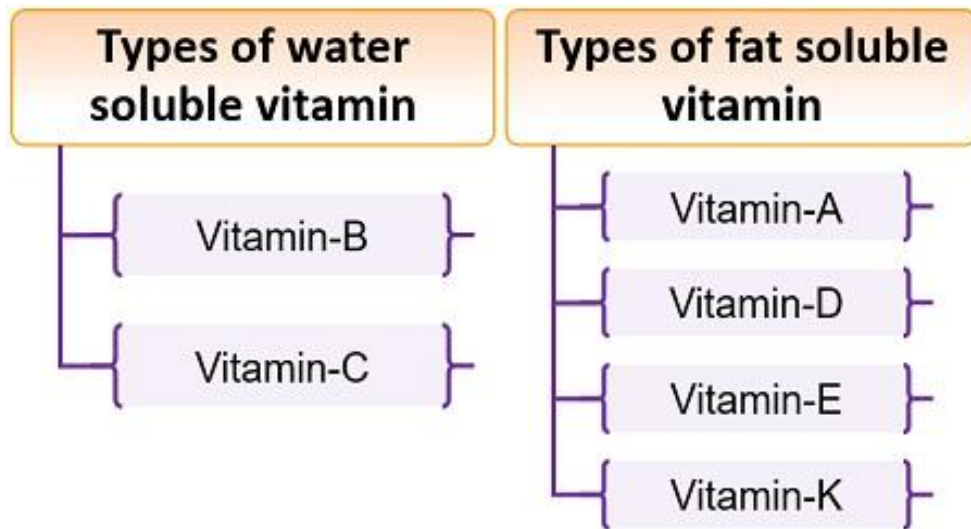
- Vitamins are important for normal functioning of the cow's body.
- Different types of minerals works towards sustaining various operations of the body.
- Colostrum contains vitamins and is a source of vitamins to newborn calves.
- Most vitamins are bound to specific proteins.
- Young calves obtain soluble-vitamins directly added to their diets.



Colostrum is a source of vitamins to newborn calves

27. Types of Vitamins

- There are various classes of vitamins namely;
 - i. Water-soluble vitamins,
 - ii. Fat-soluble vitamins.
- Vitamins are mostly stored in the liver with fat soluble vitamins stored in cow's body fat.



i. Water soluble vitamins

- These vitamins include;
 - Vitamin B complex, vitamin C
- They are provided by rumen microbes. Rumen microbes synthesize water-soluble vitamins to meet her nutritional requirement.
- Most of these vitamins are (co-factors) required for proper enzyme function.
- For mature cows, water-soluble vitamins do not have to be supplemented.
- For young calves these vitamins can be supplements. They are added to rations in milligrams per day.



27.1 Types of Vitamins Cont'd...

ii. Fat soluble vitamins

- High levels of fat can improve absorption of these vitamins.
- They are added to rations in international units (IU) per day.
- These vitamins include;
 - Vitamin A, D, E and K.



Types of fat soluble vitamin

Vitamin-A

Vitamin-D

Vitamin-E

Vitamin-K

28. Vitamin A

- Vitamin A can be obtained from feeds or through injections.
- Vitamin A is stored in the liver.
- It is specially known to maintain tissues (skin, stomach and intestinal cell lining).
- Helps in maintaining normal vision & bone development.
- Supports reproduction functions and growth.
- Supplement at a rate of 100,000-200,000 IU.

Signs of vitamin A deficiency

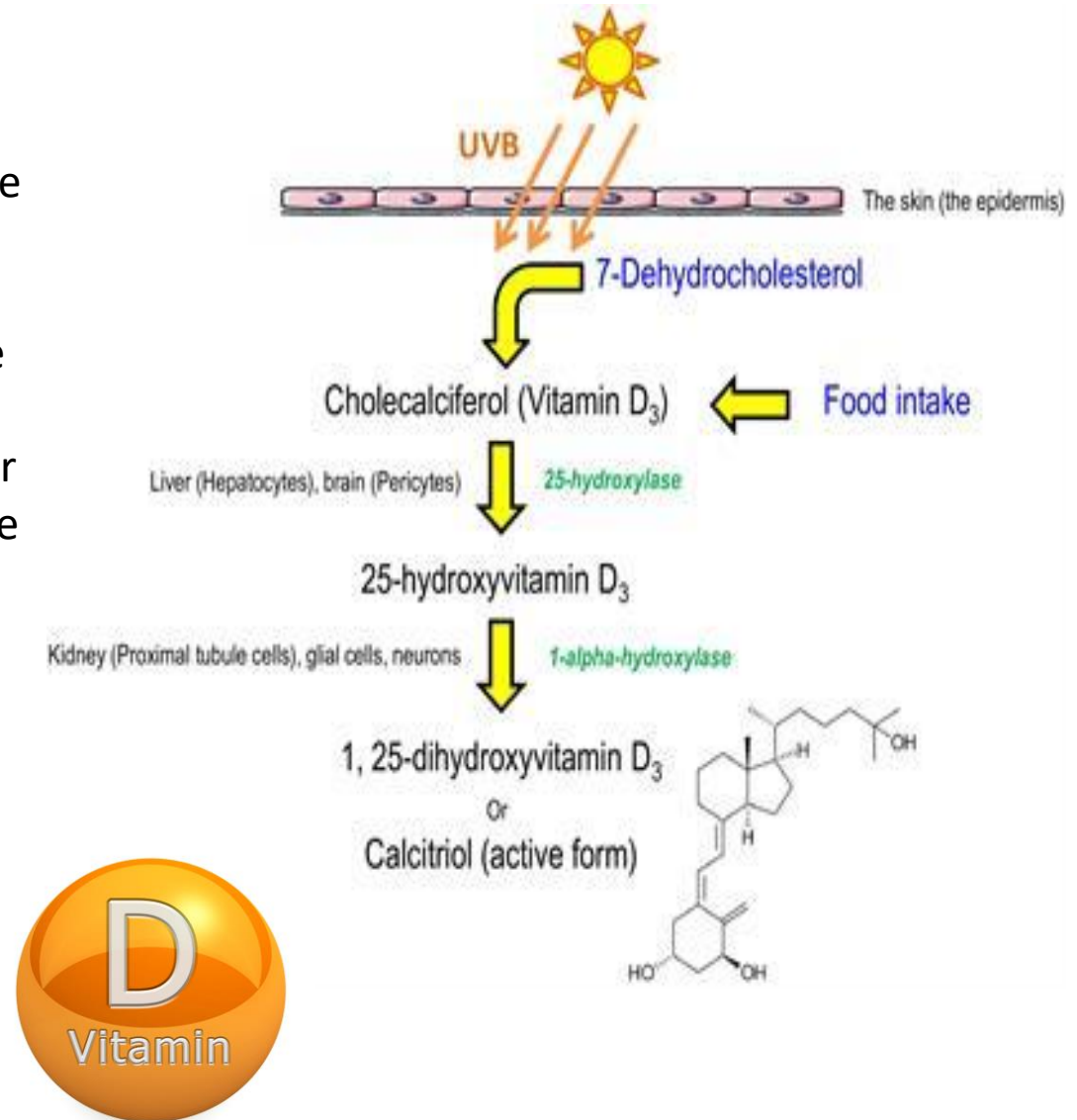
- Excessive tears.
- Night blindness, blindness in calves and general blindness.
- Result in still births or abortion.
- Low conception rates and retained placenta.



Vitamin A deficiency can lead to retained placenta

29. Vitamin D

- Vitamin D is found in plants (D2) and animals take in vitamin D when fed sun-cured forages.
- Vitamin D is made when animals are exposed to sunlight (animals with black hair coat may not be making enough vitamin D).
- It is considered a pro-hormone as it is a precursor for the production of calcium regulating hormone (1.25-dihydroxyvitamin).
- It is required for phosphorus and calcium absorption.
- Vitamin D assists in calcium mobilization from bones and aids normal bone mineralization.
- Supplement at a rate of 7,500-20,000 IU.



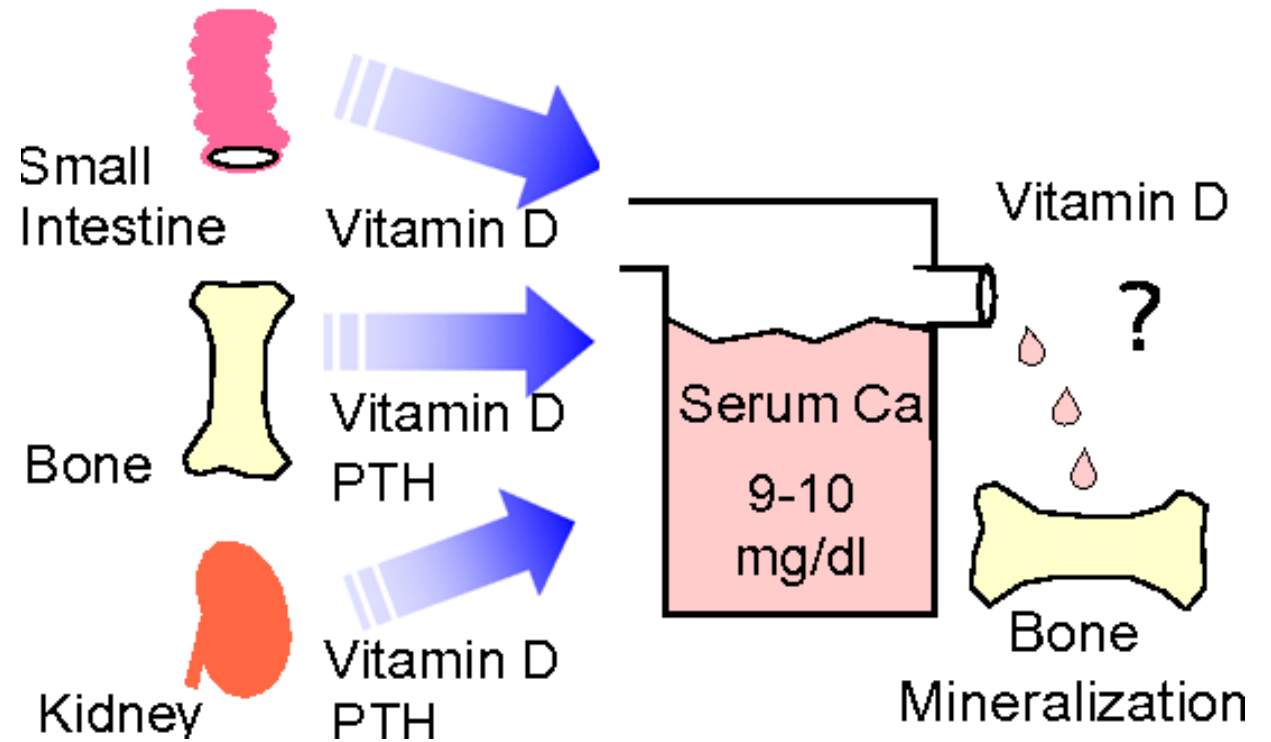
29.1 Vitamin D Cont'd...

Signs of vitamin D deficiency

- Difficulty in breathing.
- Stiff joints.
- Brittle bones.
- Leads to rickets due to poor Ca and P absorption.
- Irritability.

Signs of Vitamin D toxicity

- Decreased appetite.
- Weight loss.
- Bone demineralization.
- Calcification of soft tissues.



30. Vitamin E

- Vitamin E is closely linked with similar deficiency characteristics as selenium.
- Vitamin E acts as an antioxidant in the body.
- Assists in resisting diseases.
- Vitamin E supports membrane formation.
- Supports muscle structure and functioning.
- Supplement at a rate of 50-100 IU.

Signs of vitamin E deficiency

- Respiratory difficulties.
- Muscle weakness in calves.
- Difficulties in swallowing.

Note: Similar characteristics to white muscle disease.



31. Vitamin K

- Vitamin K is important for thrombin (blood clotting) production in the liver.
- Vitamin K are produced by rumen bacteria in sufficient quantities to meet the cow's body requirements. For this reason vitamin K is rarely supplemented.
- However some cows experience low blood clotting either due to disruptions of microbes.
- Moldy feeds should be avoided since it interferes with vitamin K functions.
- Vitamin K can be supplemented through administration to support blood clotting.

