
UNIT 2 MINERAL AND VITAMIN SUPPLEMENTS

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2.0 OBJECTIVES

After studying this unit, you should be able to:

- explain the need of mineral and vitamin supplements;
- identify different sources of minerals and vitamins; and
- describe different deficiency diseases of minerals and vitamins in poultry.

2.1 INTRODUCTION

Minerals and vitamins, though required in very small amount in poultry ration, are essential nutrients as these help in many physiological and reproductive functions. Like protein and energy rich feedstuffs, you can also find several feedstuffs which are rich in minerals and vitamins. Their concentrations, no doubt, vary from feed to feed in several agro-climatic conditions. Therefore, basic knowledge on mineral and vitamins supplements and their deficiency signs in poultry will be useful while rearing the flock for commercial production of eggs and meat.

2.2 MINERAL SUPPLEMENTS

You have already learnt about the functions of minerals in poultry rations in the previous unit. In this unit, you will learn about various sources of minerals, whether macro (major) or micro (minor/trace) elements. Minerals when fed less or more than the required amounts in poultry diets lead to nutrient imbalance and cause various manifestations (diseases). Delayed sexual maturity, disturbed reproduction,

drop in egg production, embryonic death, poor feed conversion, stunted (reduced) growth etc. have been noticed due to deficiency of one or more minerals.

2.2.1 Mineral Sources

Almost all the feed ingredients that are added in poultry diets provide all essential minerals, but the mineral concentrations in various ingredients are variable due to several factors such as adulterants, agro-climatic conditions, toxic attributes and processing conditions. It has been noticed that just by adding animal or vegetable feedstuffs to poultry diets, the requirements of various minerals may not be fulfilled and may require extra supplementation with inorganic mineral sources. Therefore, a large number of mineral supplements are available in the market. The minerals are supplemented either through a readymade mineral mixture or through specific mineral salt.

i) Major mineral sources

Chalk powder, limestone, marble chips and oyster shell (Fig. 2.1 to 2.4) are good sources of calcium (Ca) and contain about 33 to 38% Ca content and can be fed along with feeds for chicks and layers. Growing chicks require 1% Ca in their diet for body growth and skeleton build up. Whereas, the layers require about 3% Ca in their diet to lay eggs with thick shell. In case, if you do not offer adequate Ca to growing chicks and laying birds, you may get weak chicks and drop in egg production and sometimes, even shell-less eggs. Rickets and Osteomalacia are produced in chicks and layers, respectively due to deficiency of Calcium (Ca) and Phosphorus (P). While using in layer diet, the particle size of the Ca supplement should be granular in form, whereas, the chicks prefer fine powder. Marble chip is a good source of granular calcium supplement. The bio-availability of Ca is more in oyster shell than the chalk powder or limestone. The steamed bone meal (Fig. 2.5) contains 24-26% Ca and 12-13% P.

The di-calcium phosphate (DCP) is prepared either from chemical treatment of bone or rock phosphate (Fig. 2.6) and the Ca concentration is from 25 to 28% and P from 15 to 18%. The fluorine level should not exceed 0.2%. The P present as phytin in vegetable feedstuffs is unavailable to chicken because of absence of phytase enzyme in the gut and only 30 % of P is considered available, whereas the P present in animal feeds is available 100 per cent.

Common salt or table salt (sodium chloride) is a good source of sodium and chlorine. Every care should be taken to add salt at 0.3% and 0.5 % level in chick and layer ration, respectively. Salt deficiency leads to a bad habit called cannibalism or feather pecking. Excess salt in poultry diet increases water intake and causes loose or watery diarrhoea.



Fig. 2.1: Chalk Powder



Fig. 2.2: Limestone



Fig. 2.3: Marble chips



Fig. 2.4 Oyster shell



Fig. 2.5 Bone meal



Fig. 2.6 Dicalcium phosphate

ii) Micro/Trace element sources

Feed grade of potassium iodide can be used as a source for potassium and iodine. Ferrous sulphate is a good choice for providing iron to birds. Manganese carbonate or manganese chloride or manganese sulphate is a source for giving manganese to birds. Alfalfa meal, rice bran and wheat bran are rich sources of manganese. Deficiency of manganese causes slipped tendon or perosis or hock enlargement and lameness. Fish meal and meat scraps are relatively good source of zinc. Zinc carbonate, zinc oxide and zinc sulphate are good inorganic sources of zinc. If you are feeding soybean meal or sesame meal in poultry ration, then, addition for extra zinc through inorganic source is very much needed. While preparing mineral mixture at your farm, you may select suitable individual inorganic salt from Table 2.1 showing different alternatives to inorganic salts.

Table 2.1: Element composition of inorganic salts for mineral mixture

Inorganic salt	Element
Calcium Carbonate	Calcium (40%)
Copper Carbonate	Copper (53%)
Copper Chloride	Copper (47%)
Copper/Cupric Sulphate Pentahydrate	Copper (25%)
Copper/Cupric Oxide	Copper (75%)
Dicalcium Phosphate Dihydrate	Calcium (23%), Phosphorus (18%)
Ferrous Carbonate	Ferrous (38%)
Ferric Chloride	Ferrous (35%)
Ferrous Sulphate Heptahydrate	Ferrous (20%)
Manganese Carbonate	Manganese (43%)
Manganese Chloride	Manganese (44%)
Manganese Sulphate Hydrate	Manganese (33%)
Manganese Sulphate Heptahydrate	Manganese (20%)
Potassium Iodate	Iodine (59%) Potassium (18%)
Potassium Iodide	Iodine (76%) Potassium (24%)
Sodium Chloride	Chlorine (60%) Sodium (40%)
Sodium Selenate	Selenium (41%) Sodium (27%)
Sodium Selenite	Selenium (45%) Sodium (24%)
Zinc Carbonate	Zinc (52%)
Zinc Chloride	Zinc (48%)
Zinc Oxide	Zinc (73%)
Zinc Sulphate Heptahydrate	Zinc (23%)

2.2.2 Commercial Mineral Mixture

The minerals which are generally deficient in poultry diet include calcium, chlorine, copper, iodine, iron, manganese, phosphorus, sodium and zinc. These minerals must be fed to birds of all ages as per their requirements. Many commercial mineral mixtures are available in the market wherein, all necessary minerals are mixed in the standard proportions. Generally, you can get two types of mineral mixture in the market. One is with salt and the other is without salt. The mineral mixture without salt is preferred to poultry as the use of fish meal as a protein supplement contains some amount of salt and by its inclusion in the diet, birds may get salt to some extent. Therefore, the level of salt should be viewed in this context, and an excess level of salt should be avoided. The salt is added separately @ 0.3 to 0.5 % depending on the age of the birds, climate and type of fish meal used in poultry ration. The Bureau of Indian Standards (BIS) marked mineral mixture for poultry (Table 2.2) is always advisable to use for optimum productivity of eggs and meat.

Table 2.2: Mineral Mixture as per BIS Specifications

Parameters	Requirement
Moisture, per cent by weight, Maximum-3	Maximum (5%)
Calcium (as Cal), per cent by weight, Minimum-30	Minimum (28%)
Phosphorous (as P), per cent by weight, Minimum-9	Minimum (8%)
Manganese, per cent by weight, Minimum-0.30	Minimum (0.27%)
Flourine, Maximum-0.03	Maximum (0.05%)
Spores of <i>Bacillus anthracis</i> , <i>Clostridium</i>	Nil
Acid Insoluble Ash	Maximum (3.5%)

If you are feeding readymade mineral mixture, you do not need to add any individual mineral element. Otherwise, you can also prepare mineral mixture at your poultry farm by mixing the individual ingredients as shown in Table 2.3 for broilers and layers reared at the farm.

Table 2.3: Composition of Mineral Mixture for Poultry

Mineral Supplement	Broiler Diet	Layer Diet
Limestone (%)	1-2	5-7
Bone meal/Dicalcium phosphate (%)	1-2	1-2
Copper Sulphate (mg/kg)	20-25	20-25
Ferrous Sulphate (mg/kg)	200-250	200-250
Manganese Sulphate (mg/kg)	100-150	200-250
Potassium Iodide (mg/kg)	1	1
Sodium Chloride (%)	0.3-0.5	0.3-0.5
Zinc Sulphate (mg/kg)	200-250	200-250

Check Your Progress 1

Note: a) Use the space given below for your answers.

b) Check your answers with those given at the end of the unit.

1) Write True or False

- i) Bone meal provides calcium and phosphorus
- ii) Chalk powder is rich in calcium
- iii) DCP is a source for trace mineral
- iv) Limestone is rich in phosphorus
- v) Marble chip is granular in nature

2) Give the composition of mineral mixture in broiler diet.

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Activity 1

Visit a market or feed mixing plant and note down the different types of mineral sources and commercial mineral mixtures available. Note down the composition of different minerals present in the raw materials or pre-mixes.

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2.3 MINERAL DEFICIENCIES

Minerals are involved in wide variety of bodily functions. Deficiency symptoms arising out of major and trace minerals are shown in Table 2.4:

Table 2.4: Deficiency Symptoms Arising out of Mineral Elements in Chicks and Layers

Minerals	Deficiency Symptoms	
	Chicks	Layers
Macro (Major) Minerals		
Calcium	<ul style="list-style-type: none"> • Rickets in chicks (deformed skeletons, lameness, loss of appetite, stunted growth) 	<ul style="list-style-type: none"> • Osteomalasia in layers (cage layer fatigue, leg weakness, low egg weight, lowered hatchability, poor egg shell quality, reduced egg production, yolk mottling, blood spots)
Magnesium	<ul style="list-style-type: none"> • Less feed intake • Depressed growth • Breathing by opened mouth • Nervous signs (hyperirritability, tetany, muscular in-coordination); panting; poor feathering; sudden convulsive death. 	<ul style="list-style-type: none"> • Decreased egg production • Lowered egg weight • Poor shell quality
Phosphorus	<ul style="list-style-type: none"> • Rickets in chicks (deformed skeletons, lameness, loss of appetite, stunted growth, cannibalism) 	<ul style="list-style-type: none"> • Poor egg shell quality, poor hatchability, reduced egg production in layers
Potassium	<ul style="list-style-type: none"> • Depressed growth • General weakness • Paralysis • Reduced appetite 	<ul style="list-style-type: none"> • Decreased egg production • Poor shell quality
Sodium and Chloride	<ul style="list-style-type: none"> • Decrease in plasma fluid volume • Growth retardation • Loss of appetite • Poor feed utilization 	<ul style="list-style-type: none"> • Cannibalism • Decreased egg production • Moulting
Micro (Trace) Minerals		
Copper	<ul style="list-style-type: none"> • Abnormal feather • Anaemia • Bone disorder • Depigmentation of feathers • Lameness 	<ul style="list-style-type: none"> • Decreased egg production • Embryonic mortality • Poor hatchability • Shell-less eggs
Iodine	<ul style="list-style-type: none"> • Depressed growth • Enlarge thyroid (goiter) • Poor feathering 	<ul style="list-style-type: none"> • Decreased hatchability • Decreased sperm count in cocks
Iron	<ul style="list-style-type: none"> • Anaemia • Depressed body weight • Loss of appetite • Poor feathering 	<ul style="list-style-type: none"> • Embryonic mortality • Poor hatchability
Manganese	<ul style="list-style-type: none"> • Star gazing posture • Chondrodystrophy/ Perosis/Slipped Tendon - Lameness and swollen hock (Fig. 2.7) 	<ul style="list-style-type: none"> • Decreased egg production • Poor hatchability • Thin shelled/shell-less eggs • Embryonic defects (Chondrodystrophy characterized by oedema, protruded abdomen, parrot beak, round head)

Selenium	<ul style="list-style-type: none"> • Exudative diathesis (subcutaneous accumulation of green blue fluid on abdomen and breast) • Degeneration and white striations in skeletal muscles. This may become worse in case of deficiencies of cystine/methionine and vitamin E 	<ul style="list-style-type: none"> • Decreased egg production • Embryonic defects
Zinc	<ul style="list-style-type: none"> • Depressed growth • Loss of appetite • Poor feathering • Scales on limb • Shortening/thinning of long bones • Swollen hocks 	<ul style="list-style-type: none"> • Decreased egg production • Delayed sexual maturity • Embryonic abnormalities characterized by curved spine, fusion of lumbar vertebrae, missing toes, missing legs, weak hatched chick • Poor hatchability



Fig. 2.7: Slipped Tendon

Check Your Progress 2

Note: a) Use the space given below for your answers.
 b) Check your answers with those given at the end of the unit.

- 1) Write True or False
 - i) Calcium deficiency leads to shell-less eggs.
 - ii) Manganese deficiency causes swollen hocks.
 - iii) Phosphorus deficiency causes skin lesions.
 - iv) Sodium deficiency causes cannibalism.
 - v) Iodine deficiency cause anaemia
- 2) Name the deficient mineral
 - i) Anaemia
 - ii) Goitre
 - iii) Perosis
 - iv) Rickets
 - v) Scales on limbs

2.4 VITAMIN SUPPLEMENTS

Vitamins are organic compounds, though present in feed in minute quantities, necessary for various physiological functions in birds. If these are deficient in diet,

several disorders characterized by generalized or specific lesions (signs) may appear. In practical feeding, out of many fat or water soluble vitamins, only supplements containing Vitamin A, B₂ (Riboflavin), D₃ (Cholecalciferol) and K are mixed in the diet. The feedstuffs used for preparation of poultry rations also contain vitamins at variable concentrations.

2.4.1 Vitamin Sources

i) Vitamin A

Vitamin A exists as such in animals and animal products and as carotene in plants which is converted to Vitamin A in digestive tract epithelium. There are three forms of Vitamin A *viz.*, retinal, retinol and retinoic acid. It is important for growth, normal functioning of mucous membrane, egg production and vision. Green vegetable leaves like berseem, cabbage, cauliflower and lucerne are very palatable and supply Vitamin A to poultry. The maize, maize gluten meal and synthetic vitamins are good source of carotene, which is the precursor of Vitamin A. The practical dose of Vitamin A is 5000-8000 international units (IU) per kg diet.

ii) Vitamin D

Vitamin D exists in two forms *viz.* Vitamin D₂ (ergocalciferol) produced from ergosterol of plants and Vitamin D₃ (cholecalciferol) derived from 7-dehydrocholesterol found in animals and birds. It is also known as anti-rachitic vitamin. It is important for proper development of bones, egg shell and utilization of calcium and phosphorus. Green and fresh plants have no Vitamin D. Fish liver oil and synthetic vitamins are good sources of Vitamin D. Its dose is 400-600 international chick unit (ICU) per kg diet.

iii) Vitamin E

Chemically known as tocopherol, it acts as a natural anti-oxidant and controls reproduction. Alpha tocopherol is the most active form. This is also called as anti-sterility factor. Distillers' dried grains, green grass, lucerne meal, vegetable oils, wheat germ, synthetic vitamin etc. are fairly good source of Vitamin E. Its use is 10 and 5 mg per kg diet for chicks and layers, respectively.

iv) Vitamin K

It is also known as anti-hemorrhagic or coagulation factor. Naturally occurring compound is phyloquinone (K₁) present in all green leafy materials and menaquinone (K₂) synthesized in the intestine by the bacteria. A synthetic compound known as menadione (K₃) is 3.3 times more active than naturally occurring ones. Deficiency leads to hemorrhagic syndrome in young chicks. Green leafy materials, fish meal, liver meal, soybean meal, wheat bran and synthetic vitamin are good sources of vitamin K. It can be given up to 0.5 to 1 mg per kg diet.

v) Vitamin B complex

Contains a group of vitamins known as B₁ (Thiamin), B₂ (Riboflavin), B₆ (Pyridoxine), biotin, choline, folacin (folic acid), niacin, pantothenic acid (pantothenate) and B₁₂ (Cyanocobalamin). These are necessary for growth, reproduction, fertility and hatchability. Groundnut cake, liver meal, milk products, molasses, rice polish, sunflower meal, wheat germ, yeast and synthetic B vitamins are good source of Vitamin B complex. The practical poultry ration contains Vitamin B₂ @ 3-5 mg/kg feed. If you are required to add individual Vitamin B complex, you may feed B₁ @ 2 mg/kg for broilers and 6 mg/kg for layers; B₂ @ 3 mg/kg for broilers and 5 mg/kg for layers; B₆ @ 3 mg/kg for both broilers and layers and biotin, folacin, niacin and pantothenate @ 10 mg/kg for broilers and 15 mg/kg for layers.

vi) **Vitamin C**

Chemically known as ascorbic acid. Soluble in water and synthesized in the body of birds. Its rate of secretion decreases during heat stress and therefore it may be required for supplementation in summer. Fresh fruits especially citrus (like lemon) and leafy vegetables are good sources of Vitamin C. Under heat stress, you can give Vitamin C @ 100 mg/kg diet.

2.4.2 Commercial Vitamin Premix

Vitamins are supplemented either through premixes or through individual vitamins. Two types of vitamin premixes are available in the market. One premix supplies Vitamin A, B₂ (Riboflavin) and D₃ and in some products vitamin E and K are also present. A large number of pharmaceutical companies manufacture vitamin premix with different combinations. Generally, the vitamin premix containing A, B₂, D₃ and K is very suitable for different types of birds. The practical dose of such premixes ranges from 10 to 30 g per 100 kg feed. The other type of vitamin premix contains Vitamin B complex and C. A combination of Vitamin B complex and C can also be given to chicks and layers @ 10-20 g per 100 kg of feed.

Check Your Progress 3

- Note:** a) Use the space given below for your answers.
b) Check your answers with those given at the end of the unit.

- 1) Write True or False
- i) Carotene is precursor of Vitamin A₁
 - ii) Riboflavin is used in poultry ration.
 - iii) Fish liver is a good source of Vitamin D.
 - iv) Vitamin C lowers the summer stress in birds.
 - v) Vitamin E is called as anti-hemorrhagic factor.
- 2) Give the chemical name of the following:
- i) Vitamin B₁
 - ii) Vitamin B₂
 - iii) Vitamin B₆
 - iv) Vitamin B₁₂
 - v) Vitamin C

Activity 2

Visit a market and note down the commercial vitamin premixes available. Note down the composition of different vitamins present in the pre-mixes.

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2.5 VITAMIN DEFICIENCIES

Poultry requires all known vitamins except Vitamin C. The deficiency symptoms are shown in Table 2.5.

Table 2.5: The Deficiency Symptoms Arising Out of Vitamins in Chicks and Layers

Vitamins	Deficiency Symptoms	
	Chicks	Layers
Fat Soluble		
Vitamin A	<ul style="list-style-type: none"> • Ataxia (Loss of the ability to coordinate muscular movement) • Reduced growth • Emaciation (weakness) • Dryness of eye (Xerophthalmia) • General weakness • Ruffled feathers (rough feathers) 	<ul style="list-style-type: none"> • Decreased egg production • Increased embryonic death • Poor hatchability
Vitamin D ₃	<ul style="list-style-type: none"> • Depigmentation of feathers • Depressed growth • Rickets characterized by lame (stiff-legged) gait, reluctance to walk, soft and rubbery beak, claws, leg and other bones. 	<ul style="list-style-type: none"> • Decreased egg production • Poor hatchability • Thin shelled/shell-less eggs • Weak embryos unable to pip the egg shell
Vitamin E	<ul style="list-style-type: none"> • Encephalomalacia (crazy chick disease, ataxia, head retraction, flexed toes, outstretched legs and cycling with legs) • Hemorrhage and oedema within cerebellum (brain) • Enlarged hocks 	<ul style="list-style-type: none"> • Poor hatchability • Increased embryonic death
Vitamin K	<ul style="list-style-type: none"> • Gizzard erosion • Impaired blood clotting • Intramuscular bleeding 	
Water Soluble		
Vitamin B ₁ (Thiamin)	<ul style="list-style-type: none"> • Cardiac abnormalities like enlargement of heart, oedema and slowing of heart beat • Emaciation • General weakness • Loss of appetite • Nervous symptoms like convulsions, opisthotonus or star gazing 	<ul style="list-style-type: none"> • Atrophy of reproductive organs
Vitamin B ₂ (Riboflavin)	<ul style="list-style-type: none"> • Curled-toe paralysis (Fig. 2.8) characterized by enlargement of brachial and sciatic nerves, curved toes inside, walking on hock, reluctant to move • Depressed growth • Dermatitis • Diarrhoea 	<ul style="list-style-type: none"> • Decreased egg production • Dwarf embryos • Poor hatchability

Vitamin B ₆ (Pyridoxine/ Pyridoxol/Pyridoxamine)	<ul style="list-style-type: none"> • Characteristic posture with wings slightly spread and head resting on ground, birds run aimlessly, violent convulsion • Depressed growth • Gizzard erosion • Loss of appetite • Poor feathering 	<ul style="list-style-type: none"> • Decreased egg production • Poor hatchability
Vitamin B ₁₂ (Cyanocobalamin/ Cobalamin)	<ul style="list-style-type: none"> • Anaemia • Depressed growth • Gizzard erosion • Poor feathering • Reduced feed intake 	<ul style="list-style-type: none"> • Reduction in egg weight • Poor hatchability • Embryonic defects
Biotin	<ul style="list-style-type: none"> • Crooked legs • Depressed growth • Dermatitis on feet and around beak and eyes • Disturbed feathers • Perosis (Defective hocks) • Poor feed utilization 	<ul style="list-style-type: none"> • Decreased egg production • Poor hatchability • Parrot beak
Choline	<ul style="list-style-type: none"> • Perosis characterized by pin point hemorrhage and flattening of hock and slipping of Achilles tendon from condyles • Depressed growth 	<ul style="list-style-type: none"> • Decreased egg production • Lower egg size
Folic acid	<ul style="list-style-type: none"> • Feather depigmentation • Poor feathering • Depressed growth 	
Niacin or nicotinic acid	<ul style="list-style-type: none"> • Bowed legs (Fig. 2.9) • Depressed growth • Diarrhoea • Enlarged hocks • Inflammation of tongue and mouth cavity (Black tongue) • Poor feathering • Scaly dermatitis of the feet and skin 	<ul style="list-style-type: none"> • Decreased egg production • Loss of body weight • Poor hatchability
Pantothenic acid	<ul style="list-style-type: none"> • Crusty scab-like lesions at corners of mouth and on feet • Depressed growth • Dermatitis at the corners and near the beak, cracks on skin between feet and toes • Mild dermatitis • Poor feathering • Viscous exudate causes the eyelids to become granular and stick together 	<ul style="list-style-type: none"> • Decreased egg production • Increased embryonic death • Oedematous embryos • Poor hatchability
Vitamin C (Ascorbic acid)	<ul style="list-style-type: none"> • Lowered immunity • Susceptible to excess cold or heat or disease 	<ul style="list-style-type: none"> • Poor fertility • Poor hatchability • Thin egg shell



Fig. 2.8: Curled toe paralysis



Fig. 2.9: Bowed legs

Check Your Progress 4

Note: a) Use the space given below for your answers.
b) Check your answers with those given at the end of the unit.

- 1) Write True or False
 - i) Black tongue is caused due to deficiency of niacin.
 - ii) Eye lesions are related with Vitamin C deficiency.
 - iii) Bowed legs are caused due to deficiency of niacin.
 - iv) Perosis is caused due to choline deficiency.
 - v) Swollen hock is related with perosis.
- 2) Name the vitamin responsible for:
 - i) Curled toe paralysis
 - ii) Rickets
 - iii) Gizzard erosion
 - iv) Parrot beak
 - v) Xerophthalmia

2.6 LET US SUM UP

Minerals and vitamins, though required in very small amount in poultry rations, are essential nutrients as these govern many physiological and reproductive functions. Minerals when fed less or more in poultry diets lead to nutrient imbalance and cause various manifestations such as delayed sexual maturity, disturbed reproduction, drop in egg production, embryonic death, poor feed conversion, stunted growth etc. have been noticed due to deficiency of one or more minerals. Almost all the feed ingredients that are added in poultry diets provide all essential minerals, but the mineral concentrations in various ingredients are variable due to several factors such as adulterants, agro-climatic conditions, toxic attributes, processing conditions. It has been noticed that just by adding animal or vegetable feedstuffs to poultry diets, the requirements of various minerals may not be fulfilled and may require extra supplementation with inorganic mineral sources. Therefore, a large number of mineral supplements are available in the market. The minerals are supplemented either through a readymade mineral mixture or through specific mineral salt. Chalk powder, limestone, marble chips and oyster shell are good sources of calcium (Ca) and can be fed along with feeds for chicks and layers. Many commercial mineral mixtures are available in the market wherein, all necessary minerals are mixed in the standard proportions. Generally, you can get two types of mineral mixture in the market. One is with salt and the other is without salt. Two types of vitamin premixes are available in the market. One premix supplies Vitamin A, B₂ (Riboflavin) and D₃ and in some products Vitamin E and K are also present. The other type of vitamin premix contains Vitamin B complex and C.

2.7 GLOSSARY

- Anaemia** : Lack of blood in the body; a low proportion of red cells in the blood.
- Cannibalism** : An animal that feeds on others of its own kind.

Chelated Minerals	: The chelated minerals/mineral chelates are organic minerals that have been chemically engineered by binding (chelating) a single metal ion to single or multiple protein/amino acid molecules.
Deformed	: Distorted in form; misshapen; so badly formed or out of shape as to be ugly.
Dermatitis	: Inflammation of skin.
Dwarf	: An animal or bird smaller than normal size.
Fat Soluble Vitamins	: Complex organic substances required in minute quantities and are soluble in fat. These are vitamin A, D, E and K.
Lameness	: Disabled so that movement, especially walking, is difficult or impossible.
Major (Macro) Minerals	: The inorganic substances required in gram (g) quantities and are having several physiological functions. These include seven elements such as Calcium (Ca), Phosphorus (P), Sodium (Na), Magnesium (Mg), Potassium (K), Sulphur (S) and Chlorine (Cl).
Micro (Minor/Trace) Minerals	: The inorganic element required in milligram (mg) or microgram (μ g) amounts. They are found in animal and plant tissues in very low concentrations. They often serve as components of enzyme cofactors or hormones. Examples of micro or trace minerals are Copper (Cu), Iodine (I), Iron (Fe), Manganese (Mn), Selenium (Se) and Zinc (Zn).
Mottled	: To mark with spots of different shades or colours.
Muscular Dystrophy	: Degeneration of skeletal muscle caused due to deficiency of selenium trace mineral and Vitamin E.
Oedema	: An abnormal accumulation of fluid in the tissues of the body, causing swelling.
Panting	: Breathing heavily; To breathe rapidly in quick succession.
Paralysis	: Loss or impairment of the ability to move a body part, usually as a result of damage to its nerve.
Perosis	: Leg disorder characterized by swollen hock and caused due to deficiency of manganese and choline. It is also called slipped tendon.

Stunted	: Inferior in size or quality or to check the growth or development.
Supplement	: A product that contains high level of one or more nutrients and is fed to correct or prevent deficiencies of these nutrients.
Tetany	: Clinical neurological syndrome characterized by muscular twitching and cramps.
Water Soluble Vitamins	: Complex organic substances required in minute quantities and soluble in water. They are Vitamin C and B complex group.

2.8 SUGGESTED FURTHER READING

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2.10 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

- 1)
 - i) True
 - ii) True
 - iii) False
 - iv) False
 - v) True

- 2) The composition of mineral mixture in broiler diet:

Mineral supplement	Broiler Diet	Layer Diet
Limestone (%)	1-2	5-7
Bone meal/Dicalcium phosphate (%)	1-2	1-2
Copper Sulphate (mg/kg)	20-25	20-25
Ferrous Sulphate (mg/kg)	200-250	200-250
Manganese Sulphate (mg/kg)	100-150	200-250
Potassium Iodide (mg/kg)	1	1
Sodium Chloride (%)	0.3-0.5	0.3-0.5
Zinc Sulphate (mg/kg)	200-250	200-250

Check Your Progress 2

- 1)
 - i) False
 - ii) True
 - iii) False
 - iv) True
 - v) False

- 2)
 - i) Iron
 - ii) Iodine
 - iii) Manganese
 - iv) Calcium, Phosphorus
 - v) Zinc

Check Your Progress 3

- 1)
 - i) True
 - ii) True
 - iii) True
 - iv) True
 - v) False

- 2) i) Thiamin
- ii) Riboflavin
- iii) Pyridoxine
- iv) Cyanocobalamin
- v) Ascorbic Acid

Check Your Progress 4

- 1) i) True
 - ii) False
 - iii) True
 - iv) True
 - v) True
- 2) i) Vitamin B₂ or Riboflavin
 - ii) Vitamin D₃
 - iii) Vitamin B₆ or Pyridoxine
 - iv) Biotin
 - v) Vitamin A