Unit 1

Fundamentals of Animal Nutrition, Classification of fodder and Anti-Nutritional Factors

1. Introduction of Animal Nutrition
2. Nutritional Terms and Their Definitions
3. Nutritional Aspect of Carbohydrates, Proteins, and Fats
4. Classification of Feed and fodder
5. Anti-Nutritional Factors in Feeds

1. Introduction of Animal Nutrition

1. **Father of Nutrition** - Antoine Laurent de **Lavoisier**
2. Designed **animal calorimeter** for detecting body heat- **Laplace**
3. **Starch equivalent** system of energy given by **Kellner.**
4. Constructed **respiration calorimeter &** also developed **Net energy system for** evaluating Feed **Armsby**
5. Developed the **fibre estimation** method **Van Soest**
6. **Vitamin K** discovered by **Henrik Dam**
7. **Vitamin A** discovered by **McCollum and Davis**
8. Developed the use of weight to the **0.75 power Max kleiber**

1.2 Importance of Nutrients in Animal Production and Health

Nutrients are essential for growth, reproduction, maintenance, and overall well-being of animals. nutrients are two type-

Macronutrients

- **Carbohydrates**: Primary energy source. Found in grains, cereals, and forages.
- **Proteins**: For growth, repair, and maintenance of body tissues. Sources are soybean meal, fish meal, and legumes.
- **Fats**: Concentrated energy source; essential for cell membrane integrity. Common sources are oilseeds and animal fats.
- **Water:** Vital for digestion, nutrient transport, waste excretion, and temperature regulation.

Micronutrients

- **Vitamins**: Essential for various biochemical functions.
  - **Vitamin A**: Important for vision, reproduction, and immune function.
  - **Vitamin D**: Necessary for calcium absorption and bone health.
  - **Vitamin E**: Antioxidant that protects cell membranes.
  - **Vitamin K**: For blood clotting.
- **Minerals**: Required for structural and regulatory functions.
  - **Macrominerals**: Calcium, phosphorus, potassium, sodium, and magnesium.
  - **Microminerals**: Iron, iodine, copper, selenium, zinc and Manganese (Mn).

Co-factors

A **cofactor** is a **non-protein** chemical compound or ion that is required for an enzyme to function properly. It helps catalyze biochemical reactions by aiding in enzyme activity.

1.Inorganic Cofactors (Metal ions)

1. These are **minerals** that help enzymes.
2. **Examples**: **Mg^{2+}, Zn^{2+}, Fe^{2+}, Cu^{2+}**

2.Organic Cofactors (Made of carbon, often vitamins)

Two subtypes:

a) **Coenzymes** → **Loosely attached** to the enzyme, can leave after the reaction.

Examples: **NAD^+ (from Niacin), FAD (from Riboflavin), Coenzyme A**

b) **Prosthetic Groups** → **Permanently attached** to the enzyme, never leaves.

1. **Examples**: **Heme (in hemoglobin), FAD (in flavoproteins), Biotin**

Quick Trick to Remember

📌 **Cofactors = Enzyme Helpers**

➞ **Metal ions (Inorganic Cofactors)** = Permanent **(e.g., Mg^{2+}, Zn^{2+})**

➞ **Vitamins (Organic Cofactors)** = Can be **temporary (coenzymes)** or **permanent (prosthetic groups)**

✅ **All coenzymes and prosthetic groups are organic cofactors.**

✅ **All prosthetic groups are cofactors, but not all cofactors are prosthetic groups!**

1. Fat Requires the Most Cofactors

- **Metabolic Pathway**: β-Oxidation → Citric Acid Cycle → Electron Transport Chain
- **Key Cofactors**: NAD^+, FAD, Coenzyme A, Carnitine
- **Reason**: Fat metabolism is complex and involves multiple steps.

2. Protein Metabolism – Moderate Cofactor Use

- **Metabolic Pathway**: Deamination → Citric Acid Cycle
- **Key Cofactor**: Pyridoxal Phosphate (Vitamin B6)
- **Reason**: Proteins must be broken into amino acids before energy production.

3. Carbohydrate Metabolism – Fewer Cofactors

- **Metabolic Pathway**: Glycolysis → Citric Acid Cycle
- **Key Cofactors**: NAD^+, FAD
- **Reason**: Carbohydrates enter energy cycles more directly than fats or proteins.

4. Vitamins – Not an Energy Source

- **Function**: Act as cofactors but are not metabolized for energy.

Note: Each **Acetyl-CoA** oxidation in the **TCA cycle** generates **12 ATP** through **NADH, $FADH_2$, and GTP**.

ROLE AND REQUIREMENT OF WATER, METABOLIC WATER

Vital for digestion, nutrient transport, waste excretion, and temperature regulation.

Metabolic water is produced internally during the metabolism of nutrients, particularly carbohydrates, proteins, and fats.

Energy Metabolism (Ordered by Water Production per Gram)

For every gram metabolized:

1. **Protein** → **0.4 g** of water
2. **Carbohydrate** → **0.6 g** of water
3. **Fat** → **1.1 g** of water

Element	Approx. Percentage of Body Weight	Why?
Oxygen (O)	**~65%**	Found in **water (H_2O), blood, and biomolecules**
Carbon (C)	**~18%**	Backbone of **organic molecules (proteins, DNA, fats, carbohydrates)**
Hydrogen (H)	**~10%**	Present in **water, biomolecules, and organic compounds**
Nitrogen (N)	**~3%**	Found in **proteins, amino acids, and nucleic acids**

1. Building nutrient of animal body is **(UKPSC, 2024)**

a) Protein
b) Fat
c) Minerals
d) Carbohydrate

2. Assertion (A): Plants and animals benefit each other as members of food chains and ecosystems.
Reason (R): When animals die and decompose, they enrich the soil with nitrates that stimulate plant growth. **JKPSC - 2020**

A) A & Rare true and R is the correct explanation of A
B) A & R are true and R is the not correct explanation of A
C) A is true but R is false
D) A is false but R is true

JKPSC - 2019

3. Fat is included in the diets of livestock during heat stress because
1) The heat of digestion of fat is less
2) The heat of nutrient metabolism is less
3) The calorific value of the fat is higher
4) Source of fat soluble vitamins

Which of the above statements is/are correct?
A) 3 and 4
B) 1, 2 and 4
C) 3, l, and 4
D) 1, 2 and 3

(JKPSC2019)

4. Who developed the starch equivalent value of feed
(A) Atwater
(B) Morrison
(C) Armsby
(D) Kellner

5. The chief energy source of cattle ration is: **(JKPSC2012)**
(A) Protein
(B) Carbohydrate
(C) Minerals
(D) Vitamins

6. Which of the following is a fat soluble vitamin **(PPSC 2021)**

(A) Vitamin B1
(B) Vitamin B2
(C) Vitamin C
(D) Vitamin E

7. Starch equivalent based energy system was given by **(RPSC 2013)**

(1) Morrison
(2) Armsby
(3) Kellner
(4) Dubois

8. A water soluble vitamin which is deficient in the egg: (OPSC, 2021-22)

(A) Ascorbic
(B) Thiamin
(C) Cobalamin
(D) Riboflavin

9. Which one of the following has the most cofactors per 100g reduced during its metabolism? (OPSC, 2021-22)

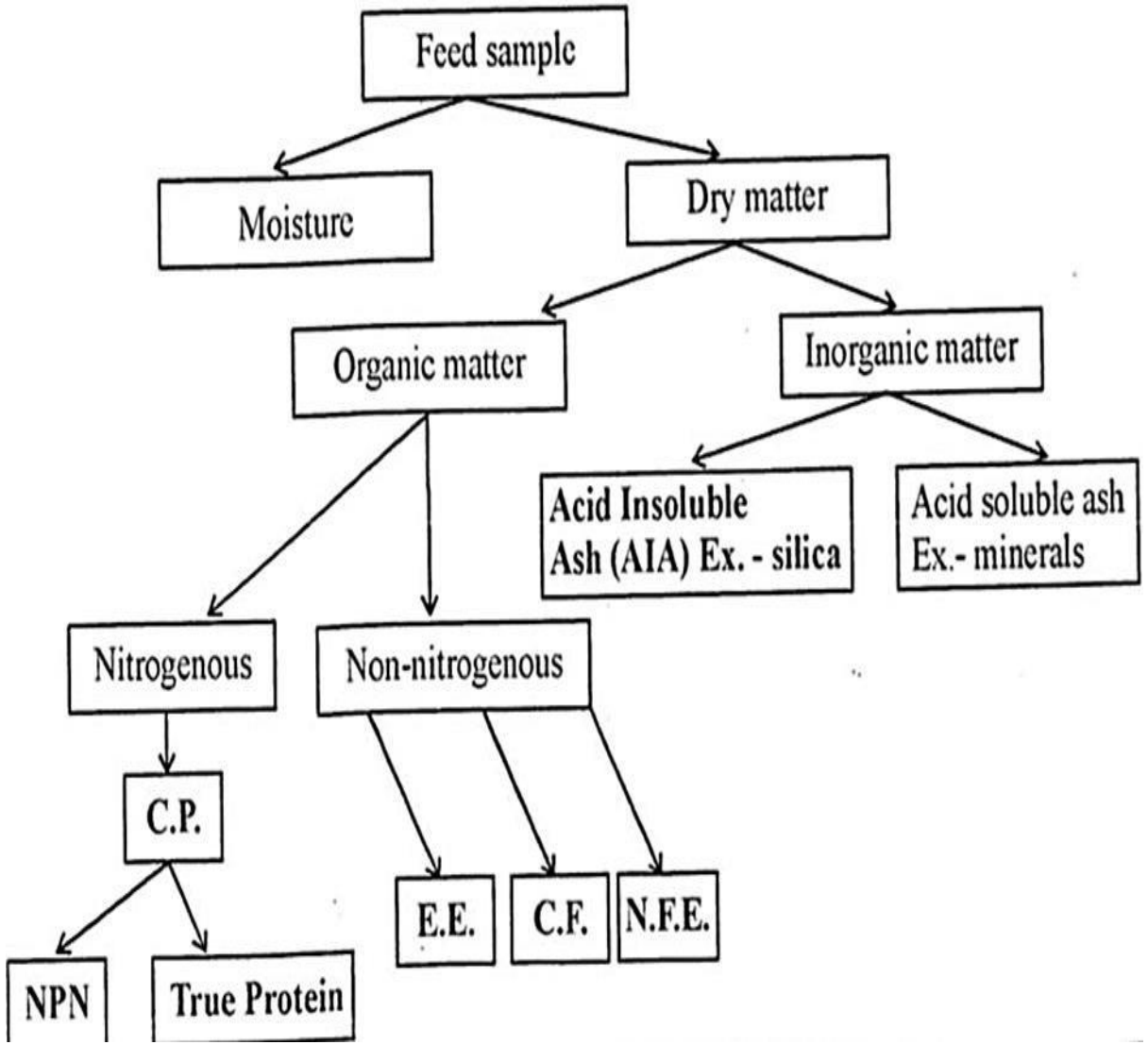
(A) Carbohydrate
(B) Protein
(C) Fat
(D) Vitamins

10. Which of the following elements contains the maximum percentage of animal body weight? opsc 2021-22

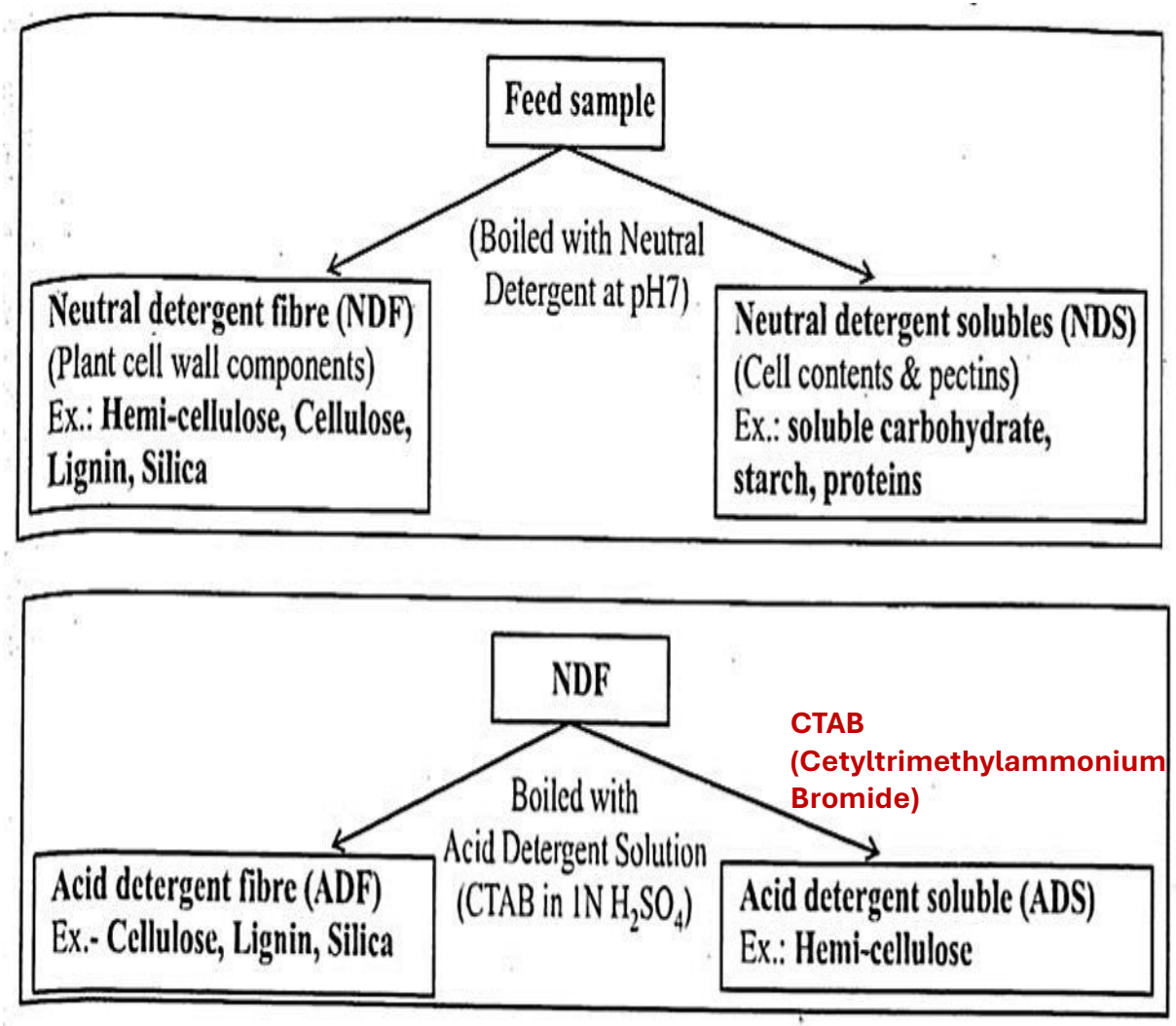
(A) Nitrogen
(B) Hydrogen
(C) Iron
(D) copper

2. Nutritional Terms and Their Definitions

1. **Dry Matter (DM):** The portion of feed remaining after removing water content.
2. **Crude Protein (CP):** Measure of protein content in feed, calculated from nitrogen content.
3. **Crude Fiber (CF):** Indigestible cellulose, lignin, and hemicellulose.
4. **Ether Extract (EE):** Portion of feed soluble in ether, representing fat content.
5. **Nitrogen-Free Extract (NFE):** Readily digestible carbohydrates such as sugars and starches.
6. **Ash:** Inorganic residue after burning feed, representing total mineral content.
7. **Acid Detergent Fiber (ADF):** Measures cellulose and lignin, indicating the less digestible portion of the feed. Higher ADF =Lower digestibility.
8. **Neutral Detergent Fiber (NDF):** Measures hemicellulose, cellulose, and lignin, indicating the total fiber content. Higher NDF =Lower feed intake potential, but necessary for rumen health.
9. **NDF-ADF =Hemicellulose**



Weende Method (Proximate Analysis)



Van Soest Method (Modern Fiber Analysis)

Van Soest Method (Modern Fiber Analysis)

Term	What It Contains	Measure	Use
NDF	Hemicellulose + Cellulose + Lignin + Silica	**Total fiber**	Total fiber estimation
NDS	Soluble carbs, starch, proteins	**Digestible nutrients**.	Non-fiber digestible portion
ADF	Cellulose + Lignin + Silica	**Indigestible fiber**	Energy & digestibility prediction
ADS	Hemicellulose	**More digestible than ADF**	Separates digestible fiber

Key Takeaways

More NDF = More fiber = Less digestible feed = for belly filling and digestion of other paerts of feed.

More ADF = Lower energy value (more lignin = harder to digest).

1. In Van Soest method of Forage analysis, the hemicellulose is determined as **(RPSC 2019)**

(1) NDF-ADF
(2) ADF-Lignin
(3) ADF-Cellulose
(4) None of these

2. Which of the following is absorbed in omasum? **opsc 2018-19**

(A) Water
(B) Volatile fatty acid
(C) Both of the above
(D) None of the above

3. NDF stands for: opsc 2021-22

(A) Neutral Detergent Fibre
(B) Non Digestible Fibre
(C) Nitrogen Digestible Fibre
(D) Non Degradable Fibre

2. What % of the dietary true protein escapes ruminal digestion? opsc 2021-22

(A) 30
(B) 40
(C) 50
(D) 60

3. Which of the following terms represents the portion of feed that remains after removing the water content?

A) Crude Protein (CP)
B) Crude Fibre (CF)
C) Dry Matter (DM)
D) Ether Extract (EE)

6. What does the Ether Extract (EE) in feed analysis measure?

A) Protein content
B) Indigestible cellulose
C) Fat content
D) Ash content

7. If a feed has a high Acid Detergent Fibre (ADF) content, it indicates:

A) Higher digestibility
B) Lower digestibility
C) Higher intake potential
D) Increased protein content

8. The term 'Nitrogen-Free Extract (NFE)' in feed analysis refers to which component?

A) Crude fibre
B) Indigestible carbohydrates
C) Readily digestible carbohydrates
D) Fat content

9. Which of the following methods was developed by Van Soest in 1960 for forage analysis?

A) Proximate composition
B) Detergent method
C) Calorimetry
D) Nitrogen balance study

10. How much water is produced during the metabolism of 1 gram of fat?

A) 0.4 grams
B) 0.6 grams
C) 1.1 grams
D) 1.5 grams

3. Nutritional Aspect of Carbohydrates, Proteins, and Fats

The **calorific value** (energy content) of macronutrients is measured in **kilocalories per gram (kcal/g)** or **kilojoules per gram (kJ/g)**.

Macronutrient	Calorific Value (kcal/g)	Calorific Value (kJ/g)
Carbohydrates	**4 kcal/g**	**17 kJ/g**
Proteins	**4 kcal/g**	**17 kJ/g**
Fats (Lipids)	**9 kcal/g**	**37 kJ/g**

- **Fats provide the most energy** (9 kcal/g) because they have more carbon-hydrogen bonds.
- **Carbohydrates and proteins provide the same energy** (4 kcal/g).
- **Proteins are primarily for structure & function, not just energy.**
- **Carbs are the body's preferred quick energy source.**
- **Fats are the body's long-term energy storage.**

✅ **Fat gives more than double the energy of carbs & proteins!**

CLASSIFICATION OF CARBOHYDRATES

1. Monosaccharides (Simple Sugars)

- Monosaccharides are classified based on the number of **carbon atoms** in their structure.
- **A. Trioses (3-Carbon Sugars)**
- Example: **Glyceraldehyde**, **Dihydroxyacetone**
- **B. Tetroses (4-Carbon Sugars)**
- Example: **Erythrose**, **Threose**
- **C. Pentoses (5-Carbon Sugars)**
- Examples:
  - **Ribose** (Component of RNA)
  - **Arabinose** (Common in plant gums)
  - **Xylose** (Found in plant cell walls)
- **D. Hexoses (6-Carbon Sugars)**
- Examples:
  - **Glucose** (Main energy source in the body)
  - **Galactose** (Part of lactose in milk)
  - **Fructose** (Found in fruits and honey)

CLASSIFICATION OF CARBOHYDRATES

2. Disaccharides-

- Lactose (Galactose and Glucose by beta 1-4 linkage)/ Milk sugar
- Sucrose (Glucose and Fructose by alfa 1-4 linkage)/ Table sugar/ Non reducing sugar
- Maltose (Glucose and Glucose by alfa 1-4 linkage)/ Malt sugar
- Cellobiose (Glucose and Glucose by beta 1-4 linkage)

3. Trisaccharide-

- Raffinose (Galactose, Glucose and Fructose)

4. Polysaccharide-

- Glycogen (alfa 1-4 & alfa 1-6 glucose), Starch, Cellulose (beta 1-4 glucose),
- Dextrin, Inulin
- Mix Polysaccharide- Hemicellulose (beta 1-4 xylose), chitin, Pectin, Mucilage
- Complex polysaccharide- Glycolipids, Glycoproteins

Carbohydrate

- Rumen microbes **ferment carbohydrates** into **volatile fatty acids (VFAs)** (Acetate, Propionate, Butyrate), which are the **main energy source** for ruminants.
- Note: Fructose is a **ketohexose** because it contains a **ketone (-CO) group** at the second carbon, while glucose, galactose, and mannose are **aldohexoses** (with an aldehyde group).
- **Dextrose** is another name for **glucose**, specifically **D-Glucose**, which is the naturally occurring form.

CLASSIFICATION OF AMINO ACID

1 Based on Structure

A. Aliphatic Amino Acids (Non-Aromatic)

- **Simple**: Glycine, Alanine
- **Branched-Chain**: Valine, Leucine, Isoleucine
- **Sulfur-Containing**: Methionine, Cysteine

B. Aromatic Amino Acids (Contains Benzene Ring)

- Phenylalanine, Tyrosine, Tryptophan

C. Heterocyclic Amino Acids (Contains Rings with Other Atoms)

- Histidine, Proline, Tryptophan

2 Based on Polarity

A. Non-Polar (Hydrophobic)

- Glycine, Alanine, Valine, Leucine, Isoleucine, Methionine, Phenylalanine, Tryptophan, Proline

B. Polar (Hydrophilic)

- **Uncharged**: Serine, Threonine, Tyrosine, Cysteine, Glutamine, Asparagine
- **Charged**: Aspartate, Glutamate (Negative), Lysine, Arginine, Histidine (Positive)

- **Examples of Non-Polar Amino Acids (Uncharged):**

1.Aliphatic (Hydrocarbon Side Chains)

1. Glycine (Gly)
2. Alanine (Ala)
3. Valine (Val)
4. Leucine (Leu)
5. Isoleucine (Ile)
6. Proline (Pro)

2.Aromatic (Benzene Ring)

1. Phenylalanine (Phe)
2. Tryptophan (Trp)

3.Sulfur-Containing

1. Methionine (Met)

•**Non-polar amino acids are uncharged** at physiological pH.
•They do not have functional groups that ionize (gain or lose protons).
•They are **hydrophobic**, meaning they avoid water and often fold into the interior of proteins.

Definitions:

1.Polar (Hydrophilic):

1. A molecule or molecular group is considered **polar** if it has regions of **partial positive and negative charges** due to differences in electronegativity between atoms.
2. Polar molecules can form **hydrogen bonds** with water, making them **hydrophilic** (water-loving).

2.Uncharged:

1. A molecule or molecular group is **uncharged** when it does not carry a **net** positive or negative charge at physiological pH (~7.4).
2. This means that it **does not gain or lose protons (H^+) under normal biological conditions**, so it does not contribute to the overall charge of the protein or solution.

Polar but Uncharged Amino Acids:

•Some amino acids (Serine, Threonine, Tyrosine, Cysteine, Glutamine, Asparagine) have side chains containing electronegative atoms (O, N, or S) that can form **hydrogen bonds** (making them polar).

•However, these side chains **do not ionize** (lose or gain protons) under normal conditions, meaning they remain **uncharged**.

3 Based on Nutritional Requirement

A. Essential Amino Acids (Must be obtained from diet)

•**PVT TIM HALL** (Mnemonic)

- **P**henylalanine
- **V**aline
- **T**hreonine
- **T**ryptophan
- **I**soleucine
- **M**ethionine
- **H**istidine
- **A**rginine (Essential for growing individuals)
- **L**ysine
- **L**eucine

B. Non-Essential Amino Acids (Can be synthesized in the body)

•Glycine, Alanine, Serine, Cysteine, Aspartate, Glutamate, Glutamine, Asparagine, Proline, Tyrosine

4 Based on Metabolic Fate

A. Ketogenic (Forms Ketone Bodies)

•**Leucine, Lysine**

B. Glucogenic (Forms Glucose via Gluconeogenesis)

•**Most amino acids** (e.g., Alanine, Aspartate, Serine)

C. Both Glucogenic & Ketogenic

•**Phenylalanine, Isoleucine, Threonine, Tryptophan, Tyrosine**

- **Ketogenic Amino Acids**: Leucine,Lysine
- **Glucogenic & Ketogenic Amino Acids:**
  Phenylalanine, Isoleucine, Tyrosine, Tryptophan, Threonine
  - **Glucogenic amino acid:** Rest all other

  - **Essential amino acid: (By W.C. rose)-** Can not synthesise in body
  - Pig: Lysine
  - Poultry: Glycine
  - Sheep: Methionine
  - Cat: Taurine
  - Critical amino acid: Low in practical diet e.g.- Lysine, Methionine

1. Aliphatic Amino Acids

- Aliphatic amino acids have **non-aromatic, open-chain (linear or branched) hydrocarbon side chains**.
- **A. Simple Aliphatic Amino Acids**
- **Glycine (Gly)** → Smallest amino acid, has only a **hydrogen (-H) side chain**.
- **Alanine (Ala)** → Contains a **methyl (-CH_3) group**.
- **B. Branched-Chain Aliphatic Amino Acids (BCAAs)**
- **Valine (Val)** → Branched hydrocarbon side chain.
- **Leucine (Leu)** → Similar to valine but with a longer side chain.
- **Isoleucine (Ile)** → Structural isomer of leucine.
- **C. Sulfur-Containing Aliphatic Amino Acids**
- Sulphur containing: Methionine, Cystine, Cysteine

2. Aromatic Amino Acids

- Aromatic amino acids contain a **benzene ring (aromatic ring) in their side chain.**
- **Phenylalanine (Phe)** → Contains a benzene ring.
- **Tyrosine (Tyr)** → Has a hydroxyl (-OH) group attached to the benzene ring.

Amino Acid	Heterocyclic?	Aromatic?	Ring Type
Histidine	✅ Yes	✅ Yes	**Imidazole** (conjugated, follows Hückel's rule)
Tryptophan	✅ Yes	✅ Yes	**Indole** (conjugated, follows Hückel's rule)

3. Heterocyclic amino acids

- Heterocyclic amino acids contain a **ring structure in their side chain that includes at least one non-carbon atom (such as nitrogen, oxygen, or sulfur).**
- **E.G. Proline, Histidine**, and **Tryptophan**.

Amino Acid	Heterocyclic?	Aromatic?	Ring Type
Proline	✅ Yes	❌ No	**Pyrrolidine** (saturated, no conjugation)
Histidine	✅ Yes	✅ Yes	**Imidazole** (conjugated, follows Hückel's rule)
Tryptophan	✅ Yes	✅ Yes	**Indole** (conjugated, follows Hückel's rule)

- **Proline is only heterocyclic but NOT aromatic** (no conjugation).
- **Histidine is both heterocyclic and aromatic** (imidazole ring is conjugated).
- **Tryptophan is both heterocyclic and aromatic** (indole ring is conjugated).

- **Points to remember:-**
- **Casein** is a **phosphoprotein** found in milk, containing **phosphorus** in the form of **phosphate groups**.

- **Basic amino acids** have **positively charged side chains** (**Arginine, Histidine, Lysine**).
  Valine is a **neutral**, **non-polar amino acid**.

CLASSIFICATION OF FATTY ACID

- Fatty acids are classified by:
- **Saturation level** → Saturated, MUFA, PUFA.
  Chain length → SCFA, MCFA, LCFA, VLCFA.
  Essentiality → Essential (EFA) vs. Non-essential.
  Bond configuration → Cis vs. Trans.
  Biological function → Omega-3, Omega-6, Omega-9.

1. Based on Saturation

Type	Description	Example
Saturated Fatty Acids (SFA)	No double bonds, fully saturated with hydrogen.	Palmitic acid, Stearic acid
Unsaturated Fatty Acids	Contain one or more double bonds.	Oleic acid, Linoleic acid
- Polyunsaturated Fatty Acids (PUFA)	**Two or more** double bonds	Linoleic acid (C18:2), DHA (C22:6)

2. Based on Chain Length

Type	Carbon Chain Length	Example
Short-Chain Fatty Acids (SCFA)	**≤6 carbons**	Acetic acid (C2), Butyric acid (C4)
Medium-Chain Fatty Acids (MCFA)	**6–12 carbons**	Caprylic acid (C8), Lauric acid (C12)
Long-Chain Fatty Acids (LCFA)	**13–21 carbons**	Palmitic acid (C16), Arachidonic acid (C20)
Very Long-Chain Fatty Acids (VLCFA)	**≥22 carbons**	Nervonic acid (C24)

3. Based on Essentiality

Type	Description	Example
Essential Fatty Acids (EFA)	Cannot be synthesized by the body, must be obtained from diet.	Linoleic acid (Omega-6), Alpha-linolenic acid (Omega-3)
Non-Essential Fatty Acids	Can be synthesized by the body.	Oleic acid, Palmitic acid

4. Based on Configuration of Double Bonds

Type	Description	Example
Cis-Fatty Acids	Hydrogen atoms are on the **same side** of the double bond (naturally occurring).	Oleic acid
Trans-Fatty Acids	Hydrogen atoms are on **opposite sides** of the double bond (mainly in processed foods).	Elaidic acid (found in hydrogenated oils)

5. Based on Nutritional & Biological Role

Type	Function	Example
Omega-3 Fatty Acids	Anti-inflammatory, supports brain & heart health.	EPA, DHA, ALA
Omega-6 Fatty Acids	Important for skin, hair, and immune function.	Linoleic acid, Arachidonic acid
Omega-9 Fatty Acids	Supports heart health, but non-essential.	Oleic acid

EPA – Eicosapentaenoic Acid, DHA – Docosahexaenoic Acid, ALA – Alpha-Linolenic Acid

Classification	Type	Example
Saturation Level	Saturated Fatty Acid (SFA)	Stearic acid (C18:0)
	Monounsaturated Fatty Acid (MUFA)	Oleic acid (C18:1, Omega-9)
	Polyunsaturated Fatty Acid (PUFA)	Linoleic acid (C18:2, Omega-6)
Chain Length	Short-Chain Fatty Acid (SCFA)	Butyric acid (C4:0)
	Medium-Chain Fatty Acid (MCFA)	Caprylic acid (C8:0)
	Long-Chain Fatty Acid (LCFA)	Palmitic acid (C16:0)
	Very Long-Chain Fatty Acid (VLCFA)	Nervonic acid (C24:1)
Essentiality	Essential Fatty Acid (EFA)	Alpha-linolenic acid (ALA, C18:3, Omega-3)
	Non-Essential Fatty Acid	Oleic acid (C18:1, Omega-9)
Bond Configuration	Cis-Fatty Acid	Oleic acid (C18:1, cis)
	Trans-Fatty Acid	Elaidic acid (C18:1, trans)
Biological Function	Omega-3 Fatty Acid	Docosahexaenoic acid (DHA, C22:6, Omega-3)
	Omega-6 Fatty Acid	Arachidonic acid (C20:4, Omega-6)
	Omega-9 Fatty Acid	Oleic acid (C18:1, Omega-9)

CLASSIFICATION OF FATTY ACID

Saturated Fatty acid- butyric acid, caproic acid, lauric acid, Palmitic acid

Unsaturated Fatty acid- Palmitoleic acid, Oleic, linoleic, Linolenic, Arachidonic acid

Essential fatty acid in cat- Arachidonic acid _and in pig & Poultry- linoleic acid

Points to remember :-

- Acetic acid is the **primary precursor** for **fatty acid synthesis** in ruminants, contributing to **milk fat production**.

- Acetic to acetyl-co A to palmitic acid

1. Which is an example of heterocyclic amino acid?

(1) Proline (2) Glycine (3) Aspartic acid (4) Lysine

2. Which is the only naturally occurring ketohexose?

(1) Glucose (3) Galactose

(2) Fructose (4) Mannose

3. Which volatile fatty acid is responsible for milk fat synthesis in cows?

(1) Propionic acid (3) Buteric acid

(2) Acetic acid (4) None of the above

4. The major end products of rumen carbohydrate digestion in buffaloes are: **(UK, 2024)**

a) Volatile fatty acids
b) Glucose
c) Sucrose
d) Maltose

5. Protein that contains phosphorous in its structure is: **(UK, 2024)**

a) Hemoglobin
b) Xanthene oxidase
c) Catalase
d) Casein

6. A carbohydrate commonly known as dextrose: opsc 2021-22
   (A) Glucose
   (B) Galactose
   (C) D-Glucose
   (D) Sucrose
7. The number of molecules of ATP produced by the total oxidation of acetyl CoA in TCA cycle is: opsc 2021-22
   (A) 08
   (B) 10
   (C) 12
   (D) 16
8. Sulphur containing amino acid is: opsc 2021-22
   (A) Leucine
   (B) Methionine
   (C) Valine
   (D) Asparagine
9. Which one is not polysaccharides? opsc 2021-22
   (a) Raffinose
   (B) Dextrins
   (C) Inulin
   (D) Cellulose
10. Which is not classified as Basic amino acid ? opsc 2021-22
   (A) Arginine
   (B) Valine
   (C) Histidine
   (D) Lysine

4. Classification of Feed and fodder

Feeds and Fodders

1. Common Feeds and Fodders, Classification & Importance

- 1.1 Why Classify?
- Grouping of similar feedstuffs
- Facilitates ration formulation
- Allows for substitution based on price and availability

1.2 Basis for Classification :

Physical characteristics (Bulkiness): Roughages & Concentrates

Chemical characteristics: Proximate principles (6): Moisture, Crude Protein (CP), Crude Fiber (CF), Ether Extract (EE), Total Ash, Nitrogen-Free Extract (NFE)

Roughages vs Concentrates

S.no	Item	Roughage	Concentrate
1	Crude Fiber	CF>18%	CF<18%
2	TDN	TDN<60%	TDN>60%
3	Energy Content	Low	High
4	Digestibility	Low	High
5	Function	Bulk	Energy
6	Example	Straw, hay, silage	Grains, meal, cake

Classification of Roughages

A. By Moisture Content :

Dry Roughages: Less than 15% moisture (e.g. hay, straw, chaff)

Green/Succulent Roughages: 80-85% moisture (e.g. fresh grass, tree leaves, silages, roots, tubers)

B. By Type :

Legume Roughages: High protein, used for production (e.g. berseem, lucerne, cowpea)

Non-Legume Roughages: Lower protein than legumes (e.g. maize, bajra, sorghum, oat)

C. By Nutritional Value :

Non-Maintenance Type: Less than 3% DCP (e.g. straw, stover)

Maintenance Type: 3-5% DCP (e.g. non-leguminous cereal fodder)

Production Type: More than 5% DCP (e.g. legume fodders)

D. By Season :

Rabi Season Roughages: Grown in winter (e.g. oats, lucerne, berseem)

Kharif Season Roughages: Grown in summer (e.g. maize, cowpea, bajra, sorghum)

E. By Life Cycle :

Annual Forages: (e.g. maize, sorghum, berseem, cowpea)

Perennial Forages: (e.g. hybrid napier, para grass, stylo, Lucerne)

Examples & Common Terms Related to Dry Feeds

1. **Forages/Fodder:** Plant materials used for feeding animals (e.g. hay, straw, silage, pasture)
2. **Roughages**: Feedstuffs with higher fibre content (e.g. husk, shells)
3. **Hay:** Dried product of thin-stemmed crops (e.g. alfalfa hay, timothy hay)
4. **Straw:** Byproduct of cereals/legumes after grain/pulse removal (e.g. wheat straw, gram straw)
5. **Fodder:** Aerial parts including ears/heads (e.g. corn fodder)
6. **Stover:** Aerial parts without ears/heads (e.g. corn stover)
7. **Bagasse:** Leftover of sugarcane after juice extraction
8. **Hull:** Outer covering of beans/peas (e.g. cottonseed hull, soybean hull)
9. **Husk:** Outer covering of grains and legumes (e.g. rice husk, gram husk)
10. **Shell:** Hard covering of nuts (e.g. groundnut shell)

Advantages of Dry Roughages

- Helps satisfy animal hunger
- Maintains dry matter intake (DMI)
- Cheaper source of dry matter

Disadvantages of Dry Roughages

- Poor digestibility due to high lignin content
- Low nutritional value

Green/Succulent Forage and Pasture

High moisture content (80-85%). Types include :

1. **Pasture:** Natural or cultivated plants used for browsing/grazing (e.g. grasses and legumes)
2. **Fodder:** Crops harvested for stall feeding (e.g. maize, sorghum)
3. **Top Feeds**: Tree leaves, top cuttings of plants and agricultural crops (e.g. babul, neem, subabul leaves)

1. Energy Feeds

Characteristics : CP: <20%
CF: <18%
TDN: 75-80%

Main Types

a) Cereal Grains :

1. **Main component: Starch (60-65%)**
2. CP: 8-12%
3. Fat: 2-5% (mostly unsaturated fatty acids)
4. Deficient in lysine and methionine
5. Calcium deficient, phosphorus rich (in phytate form)
6. Deficient in vitamins D and A (except maize)
7. Risk of Subacute Ruminal Acidosis (SARA)

Key cereals: maize, barley, oats, wheat, millets (sorghum, bajra)

b) Molasses:

1. Instant energy source (sugar)
2. Rich in minerals
3. CP: up to 5-6%
4. Used with urea in ruminant diets
5. Can be included up to 10% in concentrate mix
6. Higher levels may cause digestive issues

c) Fat:

1. Highest energy yield (2.25 times carbohydrates)
2. Limitations in ruminants: Not more than 6% of DMI
3. May be given in bypass form for high-yielding animals
4. No major digestive issues in monogastrics

Protein Supplements

1.Characteristics : CP: Greater than 20%

2.CF: Less than 18%

3. Protein Types: True protein or Non-Protein Nitrogen (NPN)

A. Plant Origin :

1) Cottonseed Cake
2) Groundnut Cake (GNC)
3) Soybean Meal (SBM)
4) Mustard Cake
5) Guar Meal
6) Sesame Cake
7) Gram
8) Guar

B. Animal Origin:

1) Fishmeal
2) Meat and Bone Meal (MBM)
3) Blood Meal (BM)
4) Feather Meal
5) Hatchery Byproducts

C. Single Cell Protein (SCP) Sources

1) **Bacteria:** Methanomonas methanica
2) **Yeast:** Spirulina
3) **Algae:** Torulopsis utilis

Important Notes :

1. Sesame Cake: Very rich in calcium
2. Soybean Meal (SBM): Low in methionine, often requires synthetic amino acid supplementation
3. Meat and Bone Meal (MBM): Banned in some regions due to **BSE risk**
4. Mustard Cake: Contains erucic acid, limiting inclusion to 10-12% of concentrate mix
5. Blood Meal: Poor digestibility, palatability, and low in calcium and phosphorus

Methods of Making Vegetable Protein

1. **Hydraulic/Ghani Method**: Produces cake with about 8% fat
2. **Expeller Method:** Produces cake with about 6% fat, with some bypass protein
3. **Solvent Extraction:** Produces meals with less than 1% fat using ether or benzene

Non-Protein Nitrogen (NPN) Sources

Definition: Nitrogen in forms other than true protein and
peptide
Examples: Urea (46% N), Biuret (38.5% N)
Main Function: NPN provides nitrogen for rumen microbes to synthesize microbial protein, which is later digested and absorbed as amino acids.

Urea Products :

Examples : Uromol, Urea-
Molasses Mineral Block (UMMB),
Urea- Molasses Liquid Feed

Issues with Urea Supplementation :

Rapid Hydrolysis can lead to toxicity

Requires energy (e.g. starch) for effective utilization
Optimal Starch to Urea Ratio: 10:1 (1 kg starch per 100 g urea)
Optimal N:S Ratio for rumen function: 10:1

- Urea/NPN Supplementation Guidelines :
- Concentrate Mix: Up to 3% (1-1.5% Usual)
- Total DMI: Up to 1%
- Total Nitrogen/Protein Need: Up to 33% (one-third)
- Straw Treatment: 4%
- Not Beneficial if Total Mixed Ration (TMR) CP is greater than 13%
- Maximum Permissible Level (MPL): 27 g/100 kg body weight or 100 g/day for adult cow.
- 10 g/day for goats
- Toxicity Treatment: 45 liters cold water followed by 2-6 liters 5% acetic acid

Agro-Industrial By-Products

- Derived from agricultural product processing
- Cheaper than primary feed ingredients
- Rich in fiber and minerals
- Protein Content: 12-14% CP
- Energy Value: Moderate

Examples :

- Bran: Outer covering of grains like rice and wheat, rich in phosphorus and fiber
- Rice Polish: Byproduct of rice milling, rich in energy and B-complex vitamins
- Hulls: Outer coverings of beans and peas, like soybean hulls
- Distillers Dried Grains with Solubles (DDGS): Byproduct of ethanol production, rich in protein and fiber
- Gluten: Protein-rich byproduct from starch extraction in grains

Mineral Supplements

- Categorized into macro-minerals and micro-minerals based on required quantities
- Mineral Mixture (MM): Typically 2% of concentrate mix
- Salt: Usually 1% of concentrate mix, encourages water intake, helps manage heat stress

Vitamin

- Categorized based on solubility :

1. Water-Soluble Vitamins: B-Complex, Vitamin C
2. Fat-Soluble Vitamins: A, D, E, K

Additives

- Non-nutritive substances added to improve performance and health
- Examples: Antibiotics, antioxidants, buffers, colors & flavors, enzymes, hormones, medicines

Feature	Perennial Fodder 🌱	Annual Fodder 🌾
Definition	Fodder crops that grow for **multiple years** without replanting.	Fodder crops that complete their **life cycle in one season** and need replanting.
Lifespan	**3-5 years or more**	**One season (3-6 months)**
Harvest Frequency	Multiple harvests per year for several years.	Only one or two harvests, then replanting is needed.
Maintenance	Requires periodic cutting, but no replanting needed.	Needs re-sowing every season.
Examples	- **Napier Grass (Elephant Grass)** 🏆	- **Berseem** 🌱 (Winter fodder)
	- **Lucerne (Alfalfa)** 🌿	- **Maize** 🌽
	- **Guinea Grass**	- **Sorghum** 🌾
	- **Stylo (Legume Fodder)**	- **Oats** 🌾
Best for?	Continuous fodder supply over years	Seasonal green fodder

Characteristics of Lucerne (Alfalfa)

1. High Protein Content (16-22% CP) – Excellent for dairy animals & growth.
2. Rich in Vitamins & Minerals – Contains calcium, phosphorus, and vitamins A, D, E, and K.
3. High Digestibility – Improves feed efficiency and milk production.
4. Drought Resistant – Deep root system allows survival in dry conditions.
5. Nitrogen Fixation – Improves soil fertility by fixing atmospheric nitrogen.
6. Lucerne contains **phytoestrogens**, mainly **coumestrol**, which can mimic the action of **estrogen** in animals.
7. Leguminous perennial fodder
9. Suitable for Silage & Hay – Can be stored and used in all seasons.

Note: Lucerne is the "Queen of Forages," making it ideal for livestock nutrition and sustainable farming!

Tannin-ANF

High tannin plants (should be fed in limited amounts):

- **Neem Leaves** 🌿
- **Guava Leaves** 🍃
- **Mango Leaves** 🥭
- **Acacia Leaves & Pods**

Low tannin, safe plants:

- **Moringa Leaves** 🌿 ✅ (Best alternative, high protein, low tannins)
- **Lucerne (Alfalfa), Berseem, Napier Grass** ✅ (Safe for livestock)

Tree Leaves Containing Tannins (High to Low):

1. **Neem Leaves** – High tannin (antimicrobial but can reduce digestibility).
2. **Guava Leaves** – Moderate to high tannin.
3. **Mango Leaves** – Moderate tannin.

Tree Leaves with High Crude Protein (CP) & Negligible Tannins:

- **Moringa Leaves** – **25-30% CP**, very low tannins (best for livestock feed).

📌 **Moringa is the ideal protein-rich, low-tannin tree fodder!** 🌿🐄

Tannins form **complexes with iron (Fe), calcium (Ca), and zinc (Zn)**, reducing mineral absorption

1. Which of the following green fodder is rich in protein content **UTTARAKHAND VO – 2024**

a) Maize
b) Oat
c) Sorghum
d) Lucerne

2. Following tree leaves are very rich in crude protein and negligible in tannin content **UTTARAKHAND VO – 2024**

a) Mango leaves
b) Neem leaves
c) Guava leaves
d) Moringa leaves

3. Which one of the following does not serve as a source of phosphorous for the animals **JKPSC - 2019**

(A) Bone meal
(B) Meat meal
(C) Limestone
(D) Wheat bran

4. The following ingredient can be used as source of protein in animal feed. **(Punjab 2023)**

(a) Wheat
(b) Barley
(c) Maize
(d) Soya bean Meal

5. Urea should be incorporated in concentrate mixture at rate of (Punjab 2023)

(a) 2%
(b) 1%
(c) 3%
(d) 4%

6. One of the following is a source of vegetable protein used for feeding buffaloes: Opsc 2018-19

(A) De oiled rice bran
(B) Tallow
(C) Groundnut oil
(D) Groundnut oil cake

7. Which of the following is an example for leguminous perennial fodder variety? Opsc 2013 -14

(a) Hybrid Napier
(b) Lucerne
(c) Colonial grass
(d) Para grass

8. A feedstuff classified as roughage if it contains Uppsc 2022

(a) More than 3% EE
(b) Less than 16% crude protein
(C) Less than 3% lignin
(d) More than 18% crude fibre

5. Anti-nutritional factors in Feed

- Substances present in the diet which by themselves or their metabolic products interfere with the feed utilization, reduce production or affects the health of animal
- They are often referred to as “toxic factors” because of the deleterious effects they produce when eaten by animals
- Toxic substances of natural origin can be classified based on their chemical properties and on the basis of their effect on utilization of nutrients

1. Types of Anti-Nutritive Substances (Based on Chemical Properties)

Category	Examples	Effects
Proteins	Protease inhibitors, Haemagglutinin (Lectin/Ricin), Enzymes, Lipo-oxidase, Amino acids, Glyco-protein	Affects digestion, inhibits enzymes
Glycosides	Saponins, Cyanogens, Glucosinolate	Causes bloating, hemolysis, and reduces nutrient absorption
Phenols	Gossypol, Tannins	Binds proteins, reduces digestibility
Miscellaneous	Antimetals, Antivitamin, Carbohydrate & fat	Interferes with metabolism and nutrient utilization

Note: **Glycosides =sugar (glycone) + non-sugar part (aglycone/genin)** linked via a **glycosidic bond**.
Phenols =aromatic benzene ring + hydroxyl (-OH) group

2. Anti-Nutritive Factors Affecting Protein Digestion & Utilization

ANF	Action	Source	Effects	Treatment
Protease inhibitors	Inhibits digestion	Soybean & other beans	Reduces protein absorption	Heat treatment
Haemagglutinin (Lectin/Ricin)	Clumps RBCs	Soybean, Castor bean(ricin)	Damages cell membranes	Heat treatment
Tannin (Polyphenolic compounds)	Inhibits digestion	Sorghum, Fodder tree, Mango seed,	Reduces fiber digestibility	Detannification (PEG), Physical & chemical methods
Saponin	Causes hemolysis, bloat	Legume fodder: Lucerne, Soybean, Berseem	Leads to tympany/bloat	Water soaking, Cottonseed oil addition

Types of Protease Inhibitors

1. **Kunitz Inhibitor** – Inhibits trypsin, heat-labile, found in soybeans.
2. **Bowman-Birk Inhibitor** – Inhibits trypsin & chymotrypsin, heat-stable.

3. Anti-Nutritive Factors Interfering with Mineral Utilization

ANF	Effect	Sources	Harmful Effects	Treatment
Phytic acid	Binds phosphorus, zinc, iron	Cereals, Legume seeds, Oilseeds, Nuts	Reduces mineral absorption	Phytase enzyme
Oxalic acid	Forms insoluble salts Ca & Mg	Spinach, Beet, Millet, Paddy straw	Causes oxalate poisoning	Water soaking, Calcium treatment
Glucosinolates (Goitrogenic)	Lowers thyroid function	Brassica family (Cabbage, Mustard, Rapeseed)	Ruminants are less susceptible,Causes iodine deficiency	Iodine supplementation, Heat Treatment
Gossypol	**Binds iron**, toxic to non-ruminants	Cotton seed	Causes weight loss, cardiac failure	Calcium & iron salts, Heat treatment

4. Anti-Vitamins Affecting Vitamin Absorption & Metabolism

ANF	Effect	Source	Impact	Treatment
Anti-vitamin A	Destroys Vitamin A precursors	**Raw soybean**	Affects vision, growth	Heat treatment
Anti-vitamin D	Inhibits Vitamin D synthesis	Soy protein	Increases requirement 10x	Autoclaving
Anti-vitamin E	Lowers plasma Vitamin E, inhibit amylase	Raw kidney bean	Leads to Vitamin E deficiency	Autoclaving
Anti-vitamin K	Lowers blood clotting	Sweet clover (Dicoumarol)	Causes bleeding issues(reduce prothrombin)	Water soaking, Autoclaving
Anti-pyridoxine	Reduces Vitamin B6 activity	Linseed	Affects metabolism	Water soaking, Autoclaving
Anti-niacin	Niacytin binds niacin	Maize, Wheat bran	Pellagra ,perosis, Black Tongue Disease	Autoclaving

Perosis (Slipped Tendon) – Cause

Perosis is a **nutritional disorder** in poultry, mainly affecting **young chicks and turkeys**, causing **malformation of the legs and slipped tendons**.

Main Cause:

- **Manganese (Mn) Deficiency (Primary Cause)**
  - Manganese is essential for **cartilage and bone development**.
  - Deficiency leads to **poor tendon formation**, causing the gastrocnemius tendon to slip from its normal position.

Other Possible Causes:

- **Choline Deficiency** → Impairs cartilage formation.
- **Biotin Deficiency** → Affects tendon strength.
- **Folic Acid Deficiency** → Can worsen symptoms.
- **Zinc Deficiency** → Involved in bone and cartilage growth.

- Perosis is **primarily caused by manganese deficiency**, but **niacin deficiency** can **worsen the condition** by affecting **collagen synthesis** and **bone health**.

Anti-Nutritional Factors (ANFs) and Their Effects

ANF	Action	Source	Susceptible Animals	Treatment
Mimosine *(Tyrosine analogue)*	Inhibits thyroxine hormone synthesis	**Subabul (Leucaena)**	Monogastrics (e.g., pigs, poultry)	Ferrous sulfate supplementation
Cyanogen *(Amygdalin, Linamarin)*	Hydrolyzed into **hydrogen cyanide (HCN) or prussic acid**	**Sorghum, Sudan grass, linseed, cassava root**	Ruminants (death due to anoxia)	Sodium nitrate & sodium thiosulfate
Nitrates and Nitrites	Forms **methemoglobin** (brown color, reduces oxygen transport)	**Contaminated water, hay, straw**	Ruminants (more susceptible)	**Methylene Blue**, vit-A

Additional Treatments for Nitrate Toxicity

- **Methylene Blue:** Helps convert methemoglobin back to hemoglobin.
- **Sodium Bicarbonate:** Reduces acidity in the rumen, slowing nitrite formation.

Points to Remember

1. Gossypol , Glucosinolate , Mimosine(GGM)– Interfere with thyroid metabolism

2. Nitrate poisoning occurs when animals consume excessive nitrates from plants or water.

- In **ruminants**, nitrates are converted to **nitrites** in the rumen, which are much more toxic.
- **Nitrites** oxidize hemoglobin to **methemoglobin**, reducing its oxygen-carrying capacity, leading to **oxygen deprivation**.
- **Nitrite oxidizes Fe^{2+} in hemoglobin to Fe^{3+}**, forming **methemoglobin**, which cannot carry oxygen.
- Leads to **oxygen deprivation (hypoxia)** → symptoms like **bluish mucous membranes, respiratory distress, and sudden death**.

- **Monogastric animals (like pigs and horses)** are less affected because they do not efficiently convert nitrates to nitrites in their digestive system.
- **Treatment** involves **methylene blue**

Hydrogen Cyanide (HCN) or Prussic Acid Poisoning

Causes:

•Ingestion of plants with **cyanogenic glycosides** (e.g., **Sorghum, Sudan grass, Linseed, Cassava**).
•Drought, frost, or wilting increases **HCN levels**.

Symptoms:

•**Rapid breathing, muscle tremors, excess salivation**.
•**Bright red blood**, convulsions, sudden death.

Mechanism:

•**HCN blocks cellular respiration**, causing **oxygen starvation**.

Treatment:

•**Sodium thiosulfate & Sodium nitrite** as antidotes.

Prevention:

•Avoid feeding **immature or stressed sorghum**.
•**Ensiling/drying reduces HCN**.
•**Sulfur supplementation** aids detoxification.

Mechanism of Toxicity

1.Blocks Cytochrome c Oxidase

1. HCN **binds to cytochrome c oxidase (Complex IV)** in the mitochondria.
2. This prevents **oxygen utilization** in cells, **stopping ATP (energy) production**.
3. As a result, cells **suffocate**, even though oxygen is present in the blood.

2.Leads to Histotoxic Hypoxia

1. Oxygen remains in the bloodstream but **cannot be used by cells**.
2. Blood appears **bright red** due to the failure of oxygen release.

3.Rapid Systemic Effects

1. **Brain & heart are most affected** due to their high oxygen demand.
2. **Leads to rapid breathing, muscle tremors, convulsions, and death** if untreated.

Substances with a Negative Effect on Digestion of Carbohydrates

Amylase inhibitors

- Responsible for the impaired digestion of starch
- Found in kidney beans

Flatulence factors

- Due to lack of appropriate enzymes (α1,6-galactosidase), oligo-saccharides are not broken down in small intestine.
- The monomers of these sugars are converted into VFA, CO_2, hydrogen,methane, resulting in flatulence, diarrhea, nausea, cramps and discomfort.

Substances That Stimulate the Immune System

Antigenic proteins:

- Macromolecular proteins or glycoproteins capable of inducing a humoral response
- Polyclonal antibodies are secreted in body fluids to eliminate the antigenic protein.
- Feed antigens are exposed continuously to increase the chance that the immune system develops into an acute/chronic hypersensitivity reaction.
- Antigenic globulins of soyabean are glycinin and β– conglycinin.

Effect of Feed Antigens

- Increased maintenance requirement due to activation of the immune system

Inactivation of feed antigens:

- Chemical or enzymatic treatments
- Hydrolysis of proteins utilizing acid or proteases results in products free of antigenic proteins.

MCQ

1. Which plant is a major source of Mimosine?

A) Cassava
B) Sorghum
C) Subabul (Leucaena)
D) Linseed

2. What is the major effect of nitrate toxicity in ruminants?

A) Reduced protein absorption
B) Formation of methemoglobin
C) Bloating due to gas accumulation
D) Calcium deficiency

3. Which toxic compound is found in cassava and linseed?

A) Mimosine
B) Amygdalin
C) Trypsin inhibitor
D) Oxalates

4. Which anti-nutritional factor in kidney beans affects starch digestion?

A) Trypsin inhibitor
B) Oxalates
C) Amylase inhibitors
D) Saponins

MCQ

5. A polyphenol present in cotton seeds which interferes with utilization of metal ions is: PUNJAB 2016

a)Propofol
b)Gossypol
c)Mimosine
d)Thioglucoside

6. Maximum level of inclusion of maize in poultry ration is RPSC 2019

(1) 50%
(2) 60%
(3) 70%
(4) 80%

7. Anti-nutritional factor present in groundnut cake is RPSC 2013

(1)aflatoxin
(2)glycogen
(3)glucosinolate
(4)None of the above

MCQ

8. Heat treatment can destroy which anti- nutritive factor found in soybean cake. Rpsc 2013

(1)Glucosinolate
(2)Aflatoxin
(3)Trypsin inhibitor
(4)Ricin

9. Babul seeds contain an anti nutritive factor Rpsc 2013

(1)Tannin
(2)Ricin
(3)Aflatoxin
(4)Oxalic acid

10. Which of the following is a cyanogenic plant? Mppsc 2021

(A)Maize (Zea Mays)
(B)Wheat (Triticum Aestivum)
(C)Sorghum (Sorghum Sudanense)
(D)Oats (Avena Sativa)

MCQ

10. Plants which contain significant amount of saponins are Mppsc 2023

A. mustard and rapeseed
B. sorghum and sudan
C. lucerne and soybean
D. subabul and sweet clover

11. Which of the following is a "Goitrogenic agent"? Opsc 2021-22 2nd

(A) Gossypol
(B) Glucosinolate
(C) Mimosine
(D) All of these

12. Anti-nutritional factor present in the Subabul leaves is: Opsc 2013 -14 2nd

(a) Mimosine
(b) Lucine
(c) Gossypol
(d) Nimbidin

13. Aflatoxin is most commonly found in the following feedstuff: Opsc 2013 -14 2nd

(a) Maize grain
(b) Rice bran
(c) Groundnut cake
(d) Til cake/sunflower cake

MCQ

14. Which anti-nutritional factor inhibits thyroxine hormone synthesis?
A) Tannin
B) Mimosine
C) Trypsin inhibitor
D) Saponins

15. Which sugars are responsible for flatulence factors in legumes?
A) Glucose and fructose
B) Oligosaccharides like raffinose and stachyose
C) Sucrose and maltose
D) Galactose and mannose

16. What is the effect of trypsin inhibitors in soybean?
A) Blocks the digestion of proteins
B) Prevents starch breakdown
C) Causes bloating in ruminants
D) Reduces calcium absorption.

17. What happens when cyanogenic glycosides break down in the digestive system?
A) They release hydrogen cyanide (HCN)
B) They improve protein metabolism
C) They increase milk production
D) They reduce fiber digestion

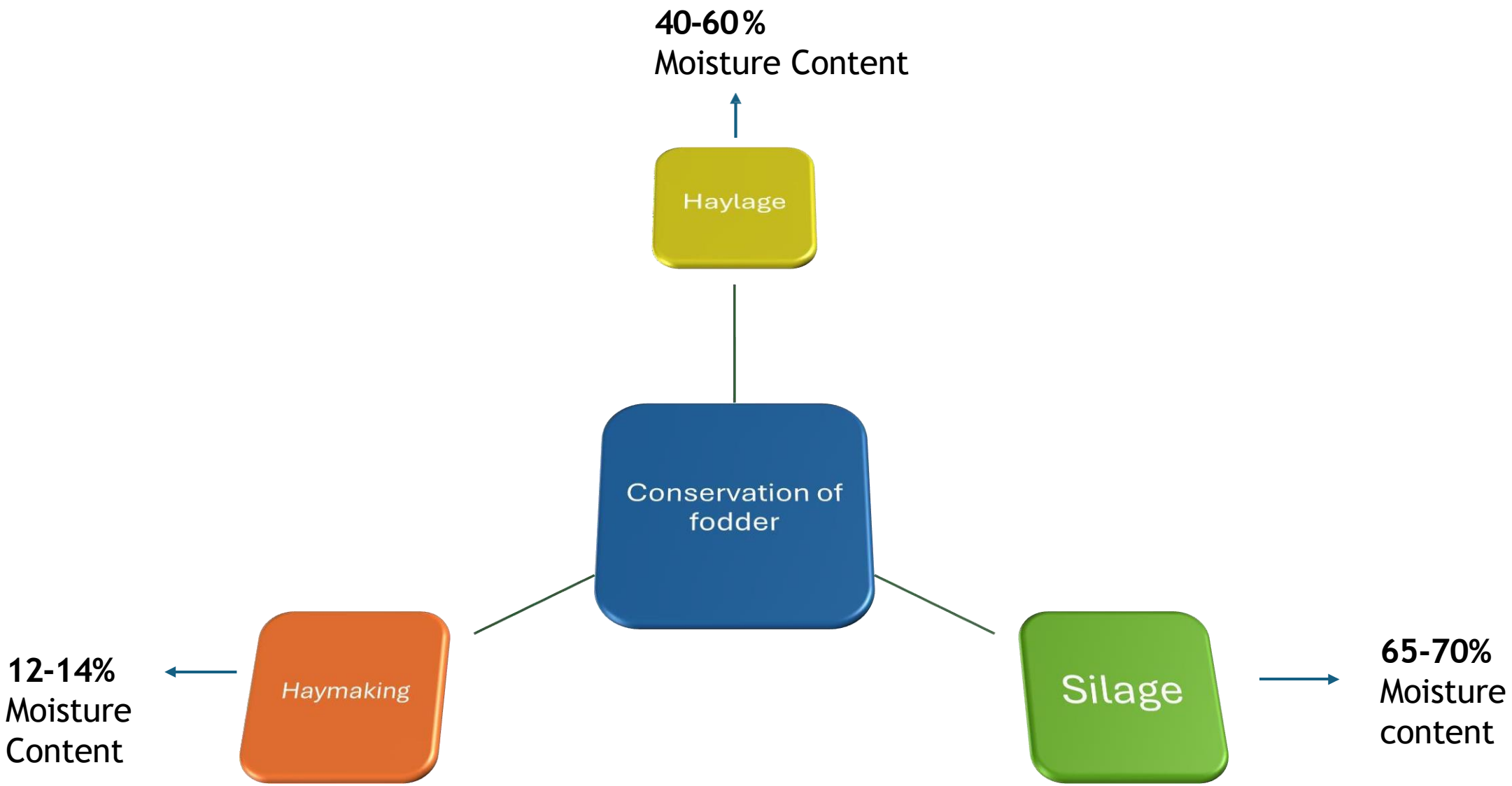
MCQ

18. Which feed antigen in soybean triggers an immune response and reduces protein digestibility?
A) Tannins
B) Glycinin and β-Conglycinin
C) Amygdalin
D) Oxalates

19. Which of the following statements is true regarding nitrate poisoning?
A) It mainly affects monogastric animals.
B) It leads to oxygen deprivation due to methemoglobin formation.
C) It enhances protein digestion in ruminants.
D) It can be treated with ferrous sulfate.

20. Why are ruminants more susceptible to nitrate poisoning?
A) They convert nitrates into more toxic nitrites in the rumen.
B) They have a higher oxygen demand.
C) Their digestive enzymes are weaker.
D) They excrete more nitrogen in urine.

5. Conservation of Feed and Fodder



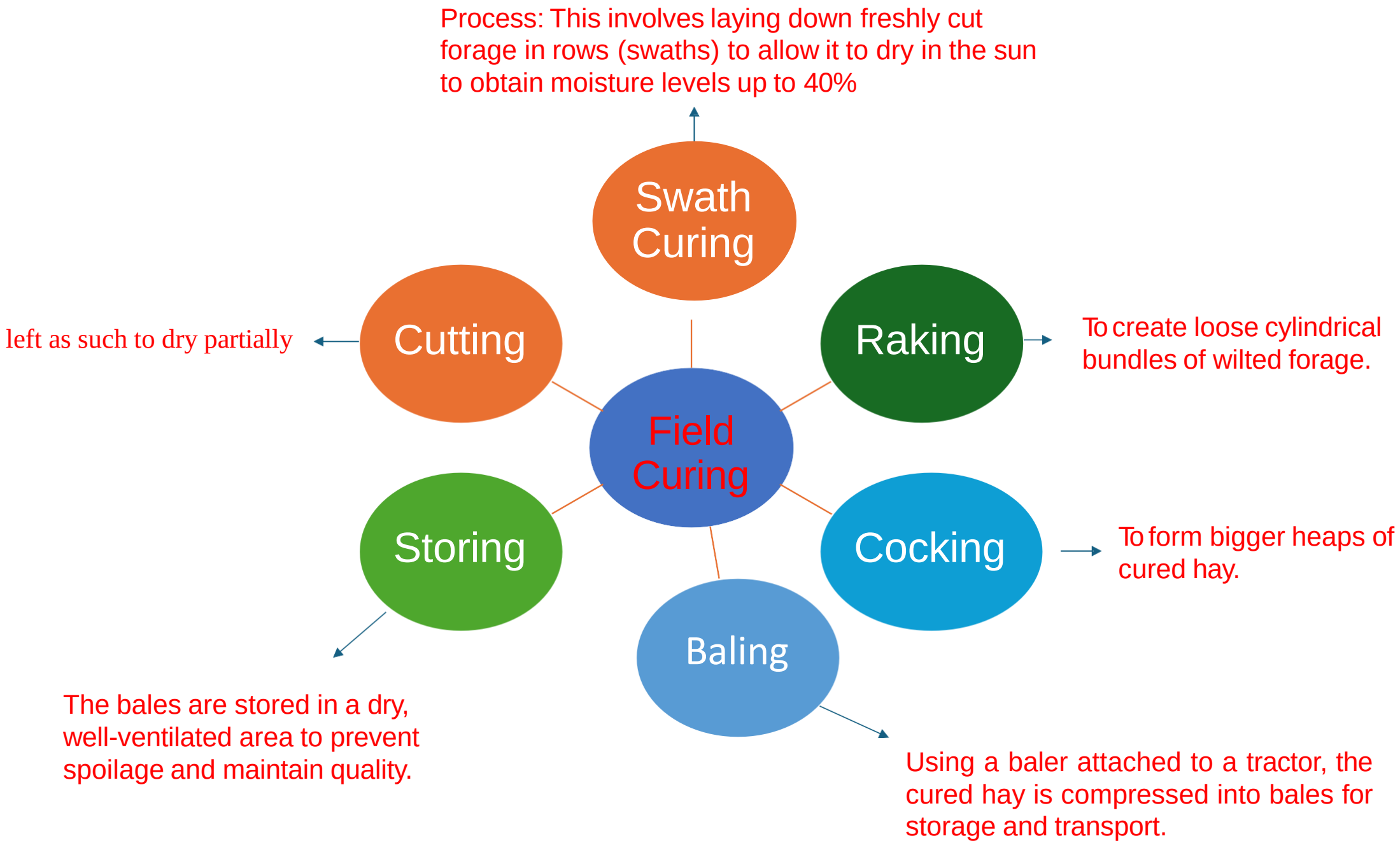
Haymaking is the process of cutting, drying, and gathering grass or other **Haymaking** plants, typically referred to as "hay," to be used as fodder or feed for livestock, particularly cattle, horses, and other herbivorous animals.

Aim of Haymaking

- reduce the moisture content around 12-14%
- less susceptible to spoilage, molds, and microbial degradation
- Allowing it to be stored for extended periods without losing nutritional value.

Methods of Drying

1. **Field curing:** sun drying
2. **Barn drying:** using fan/ air duct to reduce moisture to 20-25%.
3. **Artificial drying :** hot air-expensive but superior quality


Process: This involves laying down freshly cut forage in rows (swaths) to allow it to dry in the sun to obtain moisture levels up to 40%
Swath Curing
Cutting
left as such to dry partially
Raking
To create loose cylindrical bundles of wilted forage.
Field Curing
Storing
The bales are stored in a dry, well-ventilated area to prevent spoilage and maintain quality.
Cocking
To form bigger heaps of cured hay.
Baling
Using a baler attached to a tractor, the cured hay is compressed into bales for storage and transport.

A-Dry processing methods

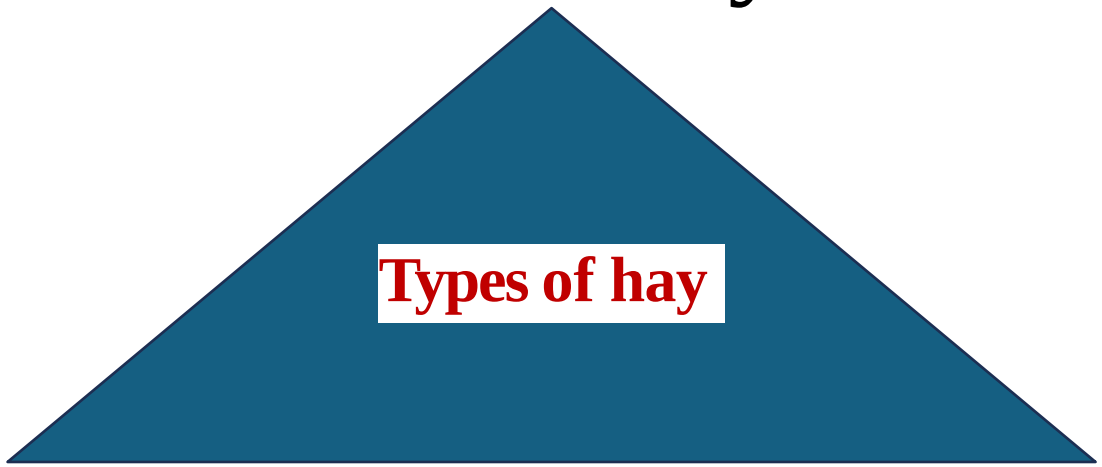
- *In these methods water content is reduced to a desired level.*

Baling

- The forage is cut and dried in the field condition.
- Dried forage is then baled or bundled with Baler
- By this method we make storage and handling of forage easy and convenient.

The nutritive value of mixed hay depends upon the type of legume and non legume crops used in mixed hay

Mixed hay

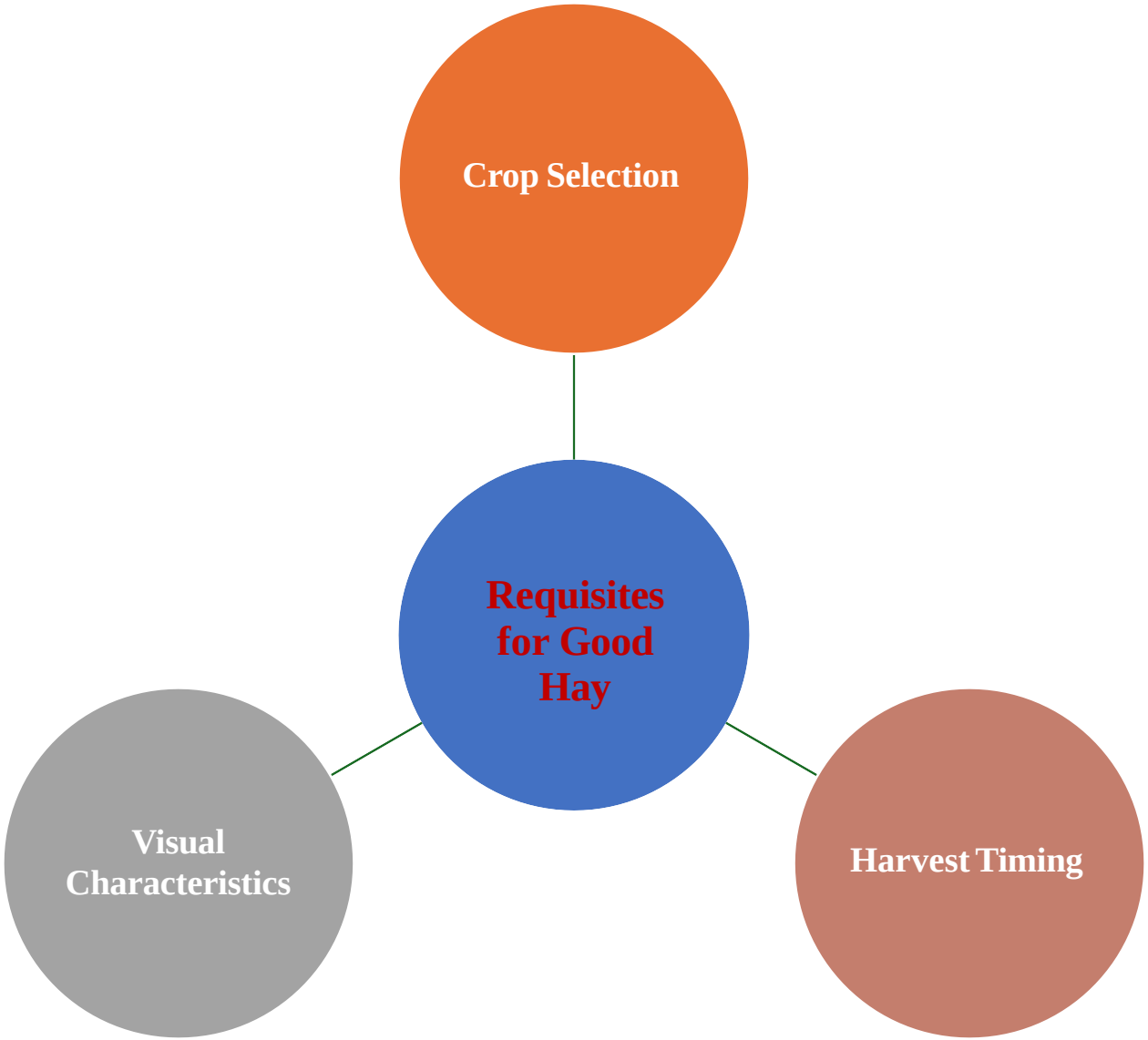


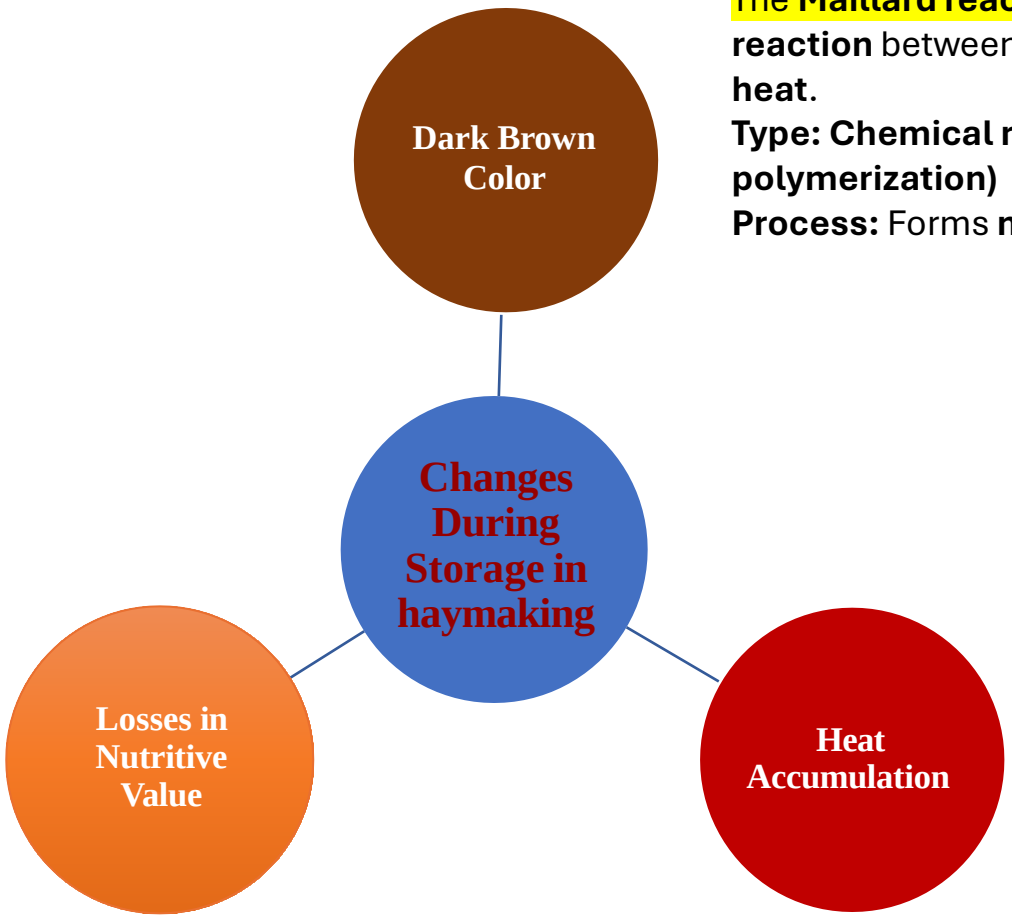
Legume hay

It has got a higher TDN and DCP and is rich in protein & minerals. Crops –Lucerne, Cowpea, Berseem.

Non – legume hay:

It is less palatable and has less amount of protein, vitamins and nutrients than legume hay but rich in carbohydrates. Crops – Oat, barley, Bajra, sorghum and grasses


Crop Selection
Requisites for Good Hay
Visual Characteristics
Harvest Timing



The **Maillard reaction** is a **non-enzymatic browning reaction** between **reducing sugars and amino acids** under **heat**.
Type: Chemical reaction (condensation + polymerization)
Process: Forms **melanoidins (brown pigments)**

Biochemical Changes During Storage

Carbohydrates

Plant respiration continues after harvest, leading to the **oxidation of sugars** to CO2 and H2O. Organic acids' concentration decreases during wilting.

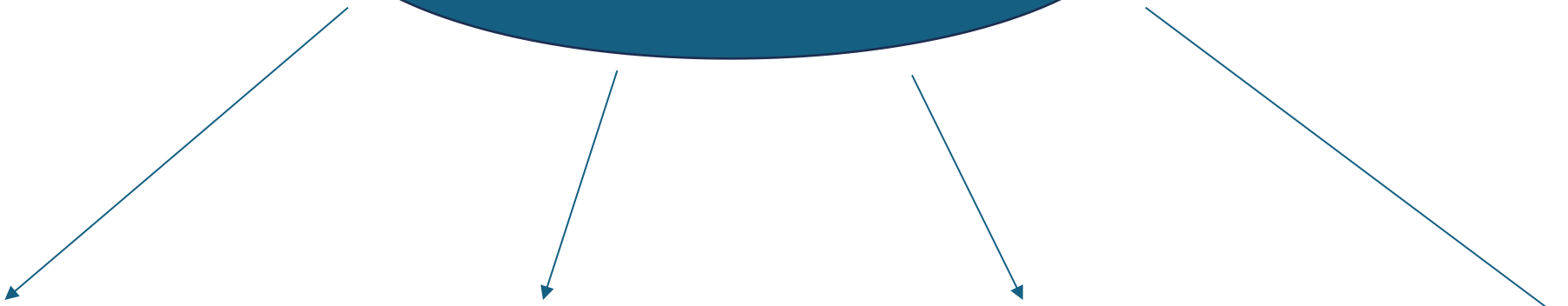
Nitrogenous Constituents

Plant enzymes can **proteolyzed** proteins, resulting in the formation of free amino acids.

Vitamins

During sun drying, **oxidation can lead to a reduction in carotene** concentration. However, sun drying can also **enhance the vitamin D** content in hay due to irradiation of ergosterol present in green plants.

Nutrient losses during hay making



Losses by shattering

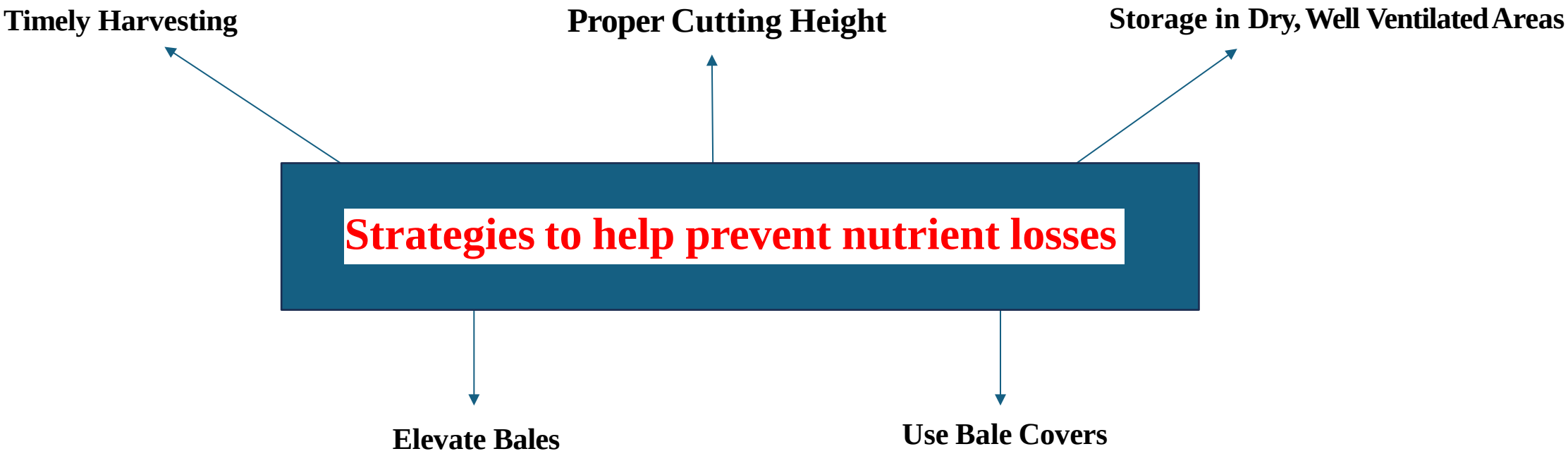
Losses due to fermentation

Losses of vitamins due to oxidation

Losses due to leaching

Total loss estimated in hay making

- Loss of DM – 20-30% in legumes and 10-15%in grasses
- Loss of protein – 28%
- Loss of carotene- 90%
- Loss of energy - 25%


Timely Harvesting
Proper Cutting Height
Storage in Dry, Well Ventilated Areas
Strategies to help prevent nutrient losses
Elevate Bales
Use Bale Covers

Fermentation

Fermentation is a metabolic process that cells use to generate energy in the absence of oxygen. It involves breaking down sugars (usually glucose) into simpler molecules, such as acids, gases, or alcohol, while regenerating **NAD+** (nicotinamide adenine dinucleotide) so that glycolysis (the breakdown of glucose) can continue to produce a small amount of energy in the form of ATP (adenosine triphosphate).

- **Lactic acid fermentation**: Produces lactic acid from pyruvate (e.g., *Lactobacillus*).
- **Alcohol fermentation**: Produces ethanol and CO_2 from pyruvate (e.g., *Saccharomyces cerevisiae*—yeast, not bacteria, but similar principles apply).
- **Butyric acid fermentation**: Produces butyric acid from pyruvate(complex), CO_2, and hydrogen (H_2) (e.g., *Clostridium* species).

- In **lactic acid fermentation**, NADH donates its electrons to pyruvate, forming lactate and regenerating NAD^+.
- In **alcoholic fermentation**, NADH transfers its electrons to acetaldehyde (derived from pyruvate), producing ethanol and regenerating NAD^+.

•**Acetaldehyde**: In **alcohol fermentation** (in yeast and some bacteria), pyruvate is first converted to **acetaldehyde**, which then acts as the electron acceptor, being **reduced by NADH** to produce ethanol. This process regenerates NAD^+.

•**Nitrates (NO_3^-)**: In **denitrifying bacteria**, **NADH can donate electrons to nitrates**, reducing them to nitrogen gas (N_2) or nitrous oxide (N_2O) in a process known as **denitrification.**

•**CO_2**: In **methanogens** (a type of archaea), carbon dioxide **(CO_2) acts as the electron acceptor and is reduced to methane (CH_4)** during **methanogenesis**, using NADH or similar carrier

Note: **Heterofermentation** is a specific type that produces **multiple byproducts (lactic acid, ethanol/acetic acid, and CO_2)** instead of just lactic acid.
•It is different from **homofermentation**, which only produces lactic acid.

Silage

Green succulent fermented material produced by controlled anaerobic fermentation of the green fodder crop retaining the high moisture content. This process of making silage is called ensiling.

Advantages of Silage Making:

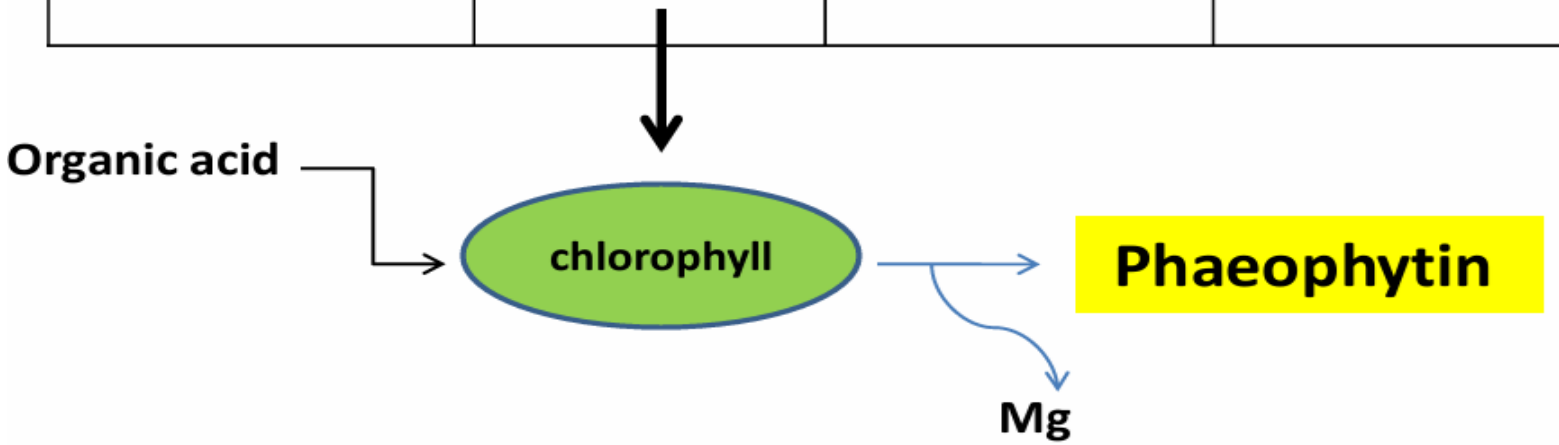
1. **Year-Round Feed Supply**
2. **Weather Independence**
3. **Increased Livestock Capacity**

Disadvantages of Silage Making:

1. **Equipment and Infrastructure:** e.g., choppers, compactors, silos and infrastructure (e.g., silo structures)
2. **Labor-Intensive:** labor-intensive
3. **Fermentation Odor**
4. **Risk of Spoilage:** Inadequate packing or sealing

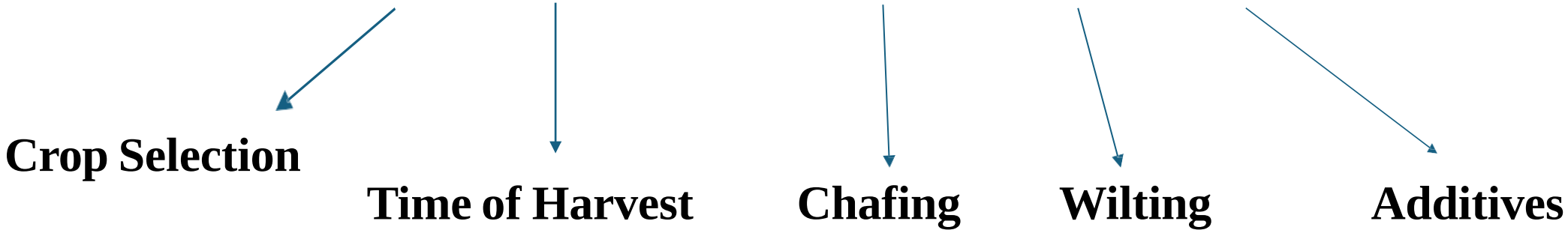
Silage quality- Flieg index (butyric acid)

parameters	Very Good	Good	Fair	Poor
Butyric acid	Absence	Traces	Little	High
pH	3.8-4.2	4.2-4.5	4.5-4.8	>4.8
Ammonia Nitrogen	<10%	10-15%	15-20%	>20%
Colour	Greenish brown	Brownish	Tobacco brown	Blackish



Hppsc 2017, VMO

Factors to Consider in Silage Making



Principles of Fermentation in Silo

Aerobic Phase

(Phase 1)

- **Objective:** Eliminate oxygen.

Anaerobic Phases (Phases 2-4)

- **Phase 2**: **Lag Phase**
  - **Objective**: Break down plant cells.

Phase 3: **Lactic Acid Fermentation**

Objective: Produce lactic acid.

- **Phase 4**: **Spoilage Prevention**
- **Objective**: Prevent spoilage.

Heterofermentation by enterobacteria in silage refers to the fermentation process where enterobacteria (a group of bacteria commonly found in the intestines and environment) metabolize plant sugars in silage to produce multiple end products, including lactic acid, acetic acid, carbon dioxide (CO_2), and ethanol.

(Phase 1)

- **Objective:** Eliminate oxygen.
- **Process**: Initial phase where aerobic bacteria break down sugars, producing CO2, water, and heat. This phase lasts a few hours to a couple of days and is critical for setting the stage for anaerobic fermentation.

Anaerobic Phases (Phases 2-4)

- **Phase 2**: **Lag Phase**
  - **Objective**: Break down plant cells.
  - **Process:** Plant cells are broken down by enzymes, providing nutrients for bacteria. This phase lasts 24 to 96 hours and involves hetero-fermentation by bacteria like Enterobacteria.

Phase 3: **Lactic Acid Fermentation**

Objective: Produce lactic acid.

Process: Lactic acid bacteria (LAB) dominate, producing lactic acid and lowering the pH. This phase is critical for preserving nutrients and preventing spoilage. Lactic acid is typically produced by **lactic acid bacteria** (LAB) like:

- **Lactobacillus**
- **Streptococcus**
- **Lactococcus**

- **Phase 4**: **Spoilage Prevention.**
  - **Objective**: Prevent spoilage.
  - **Process**: Minimize oxygen ingress during feedout by maintaining an airtight silo and using additives to prevent spoilage by undesirable microorganisms

Methods of Preparing Silage:

1. **Chopping**
2. **Moisture Management**
3. **Sealing**
4. **Fermentation**
5. **Fermentation Period**

particular	silage	Hay
DM Loss (%)	30-35	20-30
Type of crop Difference in silage and Hay	Non leguminous type. Maize ,jowar,sorghum, bajra	Leguminous type Lucerne, oats berseem
Texture OF CROP	Thick stemmed, carbohydrate rich	Thin stemmed, protein rich
Method utilised	Fermented product	Sun dried product
Losses of nutrients	less	more
Time of harvest of crop	between flowering and milk stage	2/3rd flowering stage
digestibility	Partially digested during fermentation so more digestible	Not digested during drying. Less digestible.
Drying	Crop is not dried and used after cutting only	it is dried first
Air	Complete exclusion of air	Openly dried in air

- Haylage (hay+silage): Dry matter in crops used for haylage making is 40-45%. (**water makes up 55-60%**.)
- Wastelage: Anaerobically fermented animal waste like poultry droppings, poultry litter, swine excreta and bovine dung along with other feed ingredients with the help of lactic acid producing bacteria.

Forage Type	Dry Matter (DM) %	Water Content %
Hay	85-90%	10-15%
Haylage	**40-45%**	**40-60%**
Silage	30-35%	65-70%

Feeding Standards

Feeding standards are statements or quantitative descriptions of the amounts of one or more nutrients needed by animals.
Requirement is expressed in quantities of nutrients required per day or as a percentage of diet.

Objectives of feeding standards:

- To guide farmers to formulate properly balanced rations for their livestock.
- Estimate the adequacy of feed/ nutrient intake for various spp. of animals.
- To classify the nutrient requirement according to different physiological functions like growth, maintenance, lactation, egg production and wool growth.

Limitation of feeding standard:

- No standard can be a complete guide to feeding because some other factors like palatability and physical nature of ration can play significant roles.
- Environmental conditions

Expressions of nutrients requirements in different standards are:

DE, ME, NE, TDN, CP, DCP, MP.

Feeding standards		
A. *Comparative type*	**B. *Digestible- Nutrient system***	**C. *Production-value type***
Compare different feeds to a standard one	**Feeding based upon digestible portions of nutrients in different feed.**	**Based upon efficiency of feed to increase productivity.**
1. Hay standard 2. Scandinavian feed Unit" Standard	1. Grouven's Feeding standard 2. Wolff's feeding standard 3. Wolff's Lehmann feeding standard 4. Haeckers's Feeding standard 5. Savage feeding standard 6. Morrison standard 7. National Research Council standard 8. Indian standard	1. Kellner-feeding standard 2. Armsby feeding standard 3. Agricultural and Food Research Council standard.

A. Comparative Type	B. Digestible-Nutrient System	C. Production-Value Type
Compares different feeds to a single standard.	**Feeding is based on the digestible portions of nutrients in various feeds.**	**Based on feed efficiency to enhance productivity.**
1. Hay Standard	1. Grouven's Feeding Standard	1. Kellner Feeding Standard
2. Scandinavian Feed Unit Standard	2. Wolff's Feeding Standard	2. Armsby Feeding Standard
	3. Wolff-Lehmann Feeding Standard	3. Agricultural and Food Research Council (AFRC) Standard
	4. Haecker's Feeding Standard	
	5. Savage Feeding Standard	
	6. Morrison Feeding Standard	
	7. National Research Council (NRC) Standard	
	8. Indian Feeding Standard	

A. COMPARATIVE TYPE

1. Hay standard: suggested by Thaer In 1810

•Different feeds should be compared using **meadow hay** as a unit.
•The only measure was the practical feeding experience.
•Nothing was known of the chemical value of feeds and the physiological requirements of the animals.

•**Comparing Feed Intake to Hay** → If **5 kg of oats** provided the same animal performance as **10 kg of hay**, then oats were considered **twice as valuable as hay**.

Note: The goal was **not to measure efficiency in production**, but to create a relative comparison between feeds.

2. Scandinavian "feed unit" standard: By Professor Fjord In 1884

•only the feed **unit** was taken.
• The value of one pound of common grain such as corn, barley or wheat, is given as one unit value and the value of all other foods is based upon this.
•**1 feed unit** is required per 150 lbs of body weight → This covers the basic energy needs **(maintenance)** of the animal.
•**1 additional feed unit** is needed for every 3 lbs of milk production → This accounts for extra energy **required to produce milk.**

Application and Precision:

•The **Meadow Hay Standard** Based on practical experience rather than precise measurements of energy or nutrients.

•The **Scandinavian Feed Unit Standard** introduced a slightly more quantitative approach, attempting to match energy intake more closely with animal needs based on body weight and milk.

B. DIGESTIBLE NUTRIENT SYSTEM

1. Grouven's feeding standard

•Feeding standard with **crude protein, carbohydrates and fat** contained in the feed as the basis of the standard.

2. Wolff's feeding standard: by Dr. Emil Von Wolff In 1864

•Based on **digestible protein, digestible carbohydrates and digestible fats**.
•This standard is an improvement over the standard of Grouven,
•It does not consider the quantity and quality of milk produced.

3. Wolff's Lehmann feeding standard:

•Dr. G. Lehmann of Berlin modified Wolff's standard in 1896.
•He took into account the **quantity of milk** produced, but he failed to take into account the quality of milk.

4. Haecker's feeding standard

•First time considered the **quantity as well as the quality of milk** produced in formulating a milk standard.
•First to separate the requirements for maintenance from the requirements of production.
•His standards included digestible crude protein, carbohydrates and fats.
•Later it was expressed in digestible crude protein and total digestible nutrients.

5.Savage feeding standard

•Based on nutritive ratio

Nutritive ratio: Also called as albuminoid ratio.

The **Nutritive Ratio (NR)** represents the balance between **Digestible Crude Protein (DCP) and Non-Protein Nutrients** (**Total Digestible Nutrients (TDN) - DCP**). It helps determine whether a feed is **balanced, too wide, or too narrow**.

The **nutritive ratio** should not be wider than 1:6 or narrow than 1 : 4.5

$$NR = DCP : (TDN - DCP)$$

Ideal Nutritive Ratio = Between 1:4.5 and 1:6
Below 1:4.5 = Too much protein (expensive, wasteful)
Above 1:6 = Too little protein (poor performance, lower milk/meat production

- Protein rich feeds: Narrow NV e.g. protein cakes.
- Poor protein feeds: wider nutritive ratio e.g. roughages.

6. Morrison feeding standard

- First presented in the 15th edition of "Feeds and Feeding" published in 1915
- Also called "Modified Wolff and Lehmann standard".
- These standards were expressed in terms of **Dry Matter (D.M.), Digestible crude Protein (DCP) and Total Digestible Nutrients (TDN).**
- After revision, **net energy values instead of TDN** in computing rations were also included.
- In the year 1956, Morrison included in the standard the allowances for calcium, Phosphorus and Carotene
- The average of Morrison standards has been accepted for Indian livestock.

7. National Research Council (NRC) standard: First published in 1945

•The standard includes **digestible protein and total digestible nutrients (TDN)**

•Also includes the recommended**requirementsfor calcium, phosphorus, carotene and vitamin D** for most animals.

•They use ME for poultry, DE for swine and horses, DE, ME and TDN for sheep, ME, TDN and NE*m* and NE*g* for beef cattle and for dairy cattle, values are given for DE, ME, TDN, NE*m* and NE*g* for growing animals with additional values as NE*l* for lactating cows.

8. Indian standards

•Sen and Ray standards**:** he adopted the **average of maximum and minimum values recommended by Morrison**.

•**Indian Council of Agricultural Research:** considered the fact that nutrient needs of livestock and poultry breeds under tropical environments are different from those developed in temperate climate.

C. PRODUCTION VALUE TYPE

1. Armsby feeding standard

•Based on **true protein and net energy** values.

2. Kellner feeding standard

Based upon **"Starch" as a standard unit of measurement (Starch equivalent)**.

•**Starch equivalent:**

•Fat producing power of feed (A production type/ NE system).

• SE of a feed is the number of Kg of starch that produces the same amount of fat as 100 kg of the test feed.

•This starch equivalent in turn can be converted into energy by a method worked out by Armsby and Kellner.

3. Agricultural and Food Research Council (AFRC)

•Nature: The AFRC was a former research council in the United Kingdom that focused on agricultural and food research.

•Function: It aimed to promote and coordinate research in agriculture and food sciences across various institutions in the UK.

Topic 4 MCQs

1. Feeding standards do not consider **JKPSC-2020**

A) Production Level of Livestock
B) Nutrients Requirement of Livestock
C) Nutritive Value of Feed Ingredients
D) Economics of Livestock Production

2. Starch equivalent system is based on **JKPSC-2020**

A) NE & Digestible True Protein
B) DCP, TDN & NE
C) DCP & TDN
D) DM,DCP & TDN

3. Who developed the starch equivalent value of feed **JKPSC - 2019** 2019

(A) Atwater
(B) Morrison
(C) Armsby
(D) Kellner

4. Which one of the following is the Digestible-Nutrient system type feeding standard? RPSC 2019

(1) Hay standard
(2) Armsby feeding standard
(3) Scandinavian "Feed unit" standard
(4) Morrison standard

5. Starch equivalent based energy system was given by Rpsc 2013

(1) Morrison
(2) Armsby
(3) Kellner
(4) Dubois

6. In 1890, a feeding standard based on the "available fuel values of the feeds" was proposed by Mppsc 2021

(A) Armsby
(B) Atwater
(C) Kellner
(D) Lehmann

7. Wolff-Lehman feeding standard developed in the year: Opsc 2013 -14 2nd

(a) 1903
(b) 1896
(c) 1884
(d) 1907

Balanced Ration and Its Characteristics

Ration: feed offered to an animal for 24 hours.

- Diet: feed eaten at a time
- **Balanced ration:** nutrients in proper proportion & proper amount according to physiological requirement for 24 hours.

Characteristics of a balanced ration:

1. **properly balanced**.
2. The Food must be **Palatable**
3. **Variety** of Feed in the Ration: A better and balanced mixture of proteins, vitamins and other nutrients. Variety of feed in the ration makes it more palatable.
4. The Ration should contain enough mineral **matter**.
5. The Ration should be **fairly laxative**.
6. The Ration should be **fairly bulky**.
7. Allow much of **Green Fodder**: because of their cooling and slightly laxative action.
8. Avoid **sudden changes** in the Diet: SARA, LDA etc.
9. Maintain **Regularity** in Feeding
10. The Feed must be **Properly Prepared**: should be grounded, Soaking, chopping before feeding

Computation of Ration

Computation of ration" means calculating or determining the correct amount of feed for animals based on their nutritional requirements. This process involves figuring out the amount and type of food each animal needs to stay healthy, grow, produce milk or meat, or perform well if they’re working animals.

Methods of ration formulation

1. **Linear programming**/ computer method/ least cost-ration ruminants and poultry
2. **In hand calculation** – ruminants

A. Pearson square method - ruminants and poultry

B. Algebraic method - ruminants and poultry

C. Trial and Error Method

Algebraic Method - A Ration Formulation Technique

The **Algebraic Method** is used to formulate balanced rations for **ruminants and poultry** by solving equations based on **nutrient requirements** and **feed composition**.

Simple Example of the Algebraic Method

Problem:

Formulate a 100 kg feed mixture with **corn (10% CP)** and **soybean meal (40% CP)** to get a final **20% CP** feed.

Step 1: Define Variables

- Let **x = kg of corn**
- Let **y = kg of soybean meal**
- Total feed = **100 kg**, so:

$$x + y = 100$$

- Protein equation:

$$(10x + 40y)/100 = 20$$

Step 2: Solve Equations

1. Express **x** in terms of **y**:

$$x = 100 - y$$

2. Substitute in protein equation:

$$(10(100 - y) + 40y)/100 = 20$$

3. Expand and simplify:

$$1000 - 10y + 40y = 2000$$

$$30y = 1000$$

$$y = 33.3 \text{ kg} \quad (\text{Soybean Meal})$$

$$x = 100 - 33.3 = 66.7 \text{ kg} \quad (\text{Corn})$$

Computer-Formulated Rations: 'Least cost' ration/ Linear Programming:

If a ration is balanced using a combination of ingredients with the lowest possible total cost, the resulting mixture is called a "least cost" ration.

Formulating a ration to fulfill the nutrient needs of the animal at the lowest possible cost is difficult by hand. Therefore, computer based models called linear programming are used to formulate the ration with least possible cost.

Accuracy and **speed** of calculation are the major advantages of computer formulation.

Limitations of Computer method:

1. **Nutrient density within the mix**
2. **The 'Associative effects'** of feeds are not considered

In-hand calculation method for Ration formulation: Ruminants

Dry matter intake (DMI) calculation:

For indigenous cows, DMI = 2.5% of body weight (BW).

- For crossbred cows and buffalo, DMI = 3% of BW.
- For milking animals, add 10% of their milk yield (MY) to the DMI.

Partitioning DMI:

- Divide the DMI between roughages (forage like hay, grass) and concentrate (high-energy feed).
  - Roughages = 2/3 of the total DMI.
  - Concentrate mixture = 1/3 of total DMI.

Types of Roughages: Dry Roughage & Green Roughage

Types of Roughage:

- **Dry Roughage**: Feeds like hay or straw, which have low moisture content.
- **Green Roughage**: Fresh, green plants that are more moist, like grass or green fodder.

Partitioning of Roughage:

- If **non-legume green fodder** is available (e.g., grass or maize), the roughage should be split as follows:
  - **2/3** of the total roughage should be **dry roughage**.
  - **1/3** of the total roughage should be **green roughage**.
- **Partitioning e.g.**
  - **Dry roughage (e.g., wheat straw, hay- low in protein) → 6.7 kg (2/3)**
  - **Green fodder (e.g., maize, napier grass) → 3.3 kg (1/3)**

- If **legume green fodder** is available (e.g., alfalfa or clover), which is usually higher in protein:
  - **3/4** of the total roughage should be **dry roughage**.
  - **1/4** of the total roughage should be **green roughage**.
- **Partitioning e.g.**
  - **Dry roughage (e.g., wheat straw, hay- high in protein) → 7.5 kg (3/4)**
  - **Green fodder (e.g., alfalfa, clover) → 2.5 kg (1/4)**

- **Milking Animals' DMI Calculation**:
- For animals that are producing milk, their **DMI (Dry Matter Intake)** is calculated as:

$$DMI = 2.5\% \times \text{Body Weight (BW)} + 10\% \times \text{Milk Yield (MY)}$$

- This formula accounts for the animal's body weight and adds extra dry matter to support milk production.

Maintenance Requirement for Milch (Milking) Animals:

- Milking animals need **10-15% more dry matter intake** than non-milking (dry) animals. This means their maintenance needs are higher due to the extra metabolic activity involved in producing milk.

DMI as % of Body Weight (BW) = 120 / NDF percentage

120 - Empirical Value: (means a number or constant **derived from experiments, observations, or real-world data)**

•Studies on **ruminant feeding behavior** found that when **NDF increases, DMI decreases in a predictable pattern**.

•**120 was established as a standard constant** based on **average intake capacity of dairy and beef cattle**.

• **DMI as % of BW** refers to the amount of Dry Matter Intake (DMI) expressed as a percentage of the animal's body weight.

• **NDF percentage** is the percentage of Neutral Detergent Fiber in the feed.

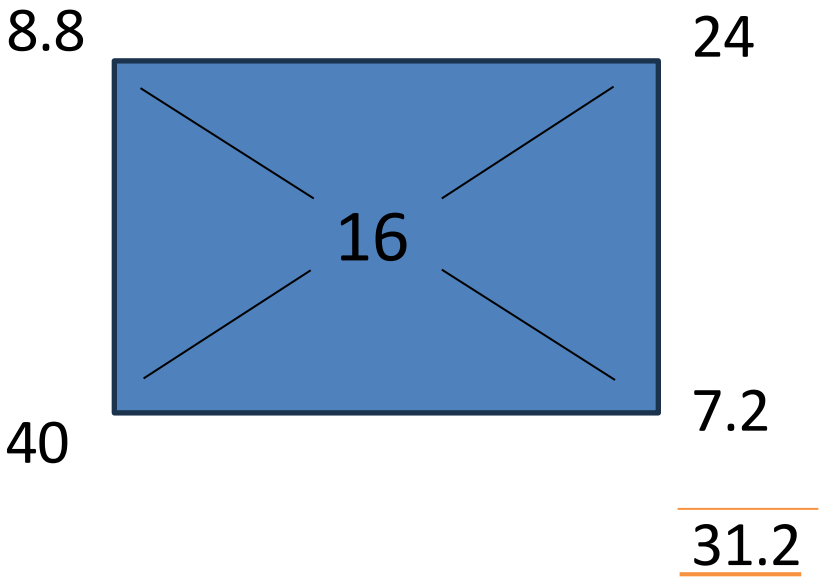
How It Works:

As the **NDF percentage** in the feed increases, the **DMI as a percentage of BW** decreases, because higher fiber content tends to reduce how much an animal can consume. NDF measures the fiber content that fills the stomach but is slower to digest, so more NDF means less capacity for other feed.

Pearson square method - ruminants and poultry

Formulating Concentrate mixture/ complete feed by using the pearson square method and Alzebric Method

Example1 : When only 2 feeds are involved: A farmer has home grown maize(8.8%) and he purchases a protein supplement(40% CP) containing minerals, vitamins. Formulate a concentrate mixture with 16 % CP.



Maize: 24/31.2 = 76.92%

Supplement: 7.2/31.2 = 23.08%

Pearson square method - ruminants and poultry

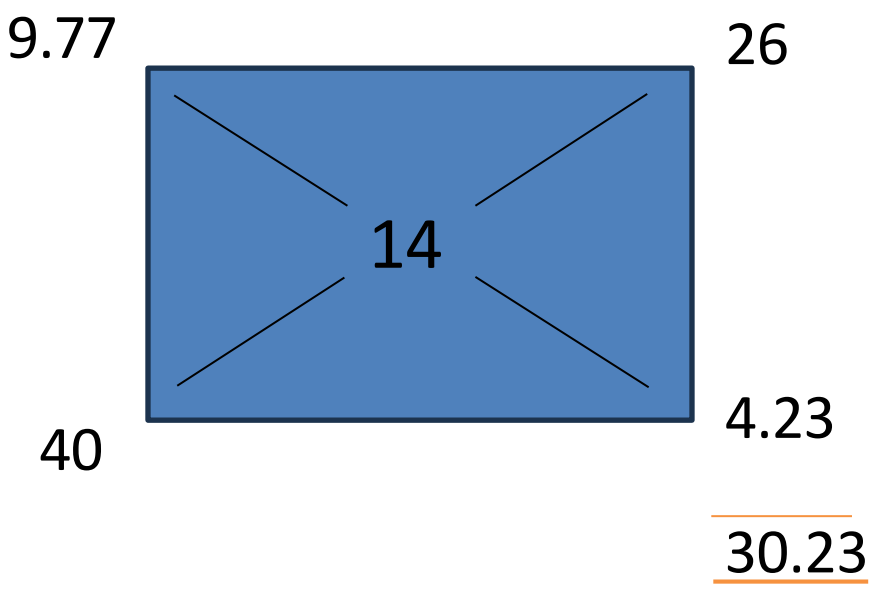
Example 2 : When 2 or more feeds are involved: In formulating a pig feed, grains like maize and oats are used in a **2:1 ratio** to circumvent the higher crude fibre level of oats. Formulate the pig feed using maize, oats and a protein supplement.

Calculate the crude protein (CP) content of the maize-oat mixture.(Using a **2:1 ratio of maize and oats**)

Determine how much of the protein supplement is needed to achieve the final CP of **14%**.

Find the percentage contribution of each ingredient (Maize, Oats, and Supplement) in the final feed mix.

Note: Maize: 8.8 % CP & Oat = 11.7% CP. (**2 part** of maize & **1 part** of oat)



29.3/3 = 9.77 %

Maize + oat = 26/30.23 x 100 = 86.01%

Supplement = 4.23/30.23 x 100 = 13.99%

Maize = 2/3 x 86.01=57.34

Oats = 1/3 x 86.01 = 28.67 %

Factor	Pearson Square Method	Algebraic Method
Best for	Simple **2-ingredient** feed balancing	**Multiple ingredients** in one equation
Complexity	**Stepwise calculations** for >2 ingredients	Solves all at once
Ingredients	Works best with **2 feeds**	Works with **any number of feeds**
Flexibility	Mainly for **Crude Protein (CP) balancing**	Works for **CP, Energy, Fiber, Minerals, etc.**
Speed	**Quick** for 2 ingredients, but slow for more	Faster for **complex rations**
Accuracy	Requires **repeated calculations** for more than 2 ingredients	**More precise** for multiple feed components
Ease of Use	Easy for beginners, no complex math	Requires solving equations, **needs more math**

Mixing of Rations

Different methods for mixing animal rations ensure a balanced diet, prevent selective feeding, and improve feed efficiency. Here are the primary methods used:

1. TMR Mixer Wagon (Vertical or Horizontal Mixer)
- Specialized **TMR machines** mix roughages, concentrates, and additives.
- Ensures **thorough mixing** and prevents feed sorting.
- Used in **large dairy and beef farms**.

2. Batch Mixing (Manual or Mechanical)
- Feed ingredients are weighed and mixed in batches.
- Can be done using tractors, loaders, or stationary mixers.
- Suitable for medium-sized farms.

3. Pelleting:

1. Ingredients are ground, mixed, and pressed into pellets.
2. Reduces feed wastage and prevents animals from selectively eating only preferred ingredients.
3. Common in poultry, swine, and some dairy feeding systems.

1) A method of determining the least-cost ration using a series of mathematical equations. **JKPSC-2020**

A) Pearson Square method
B) Algebraic method
C) Linear Programming
D) Two by Two Matrix method

2. A farmer has home-grown **wheat (12% CP)** and purchases a **protein supplement (36% CP)** containing essential minerals and vitamins. Formulate a concentrate mixture to achieve a **final feed CP of 18%** using the **Pearson Square Method**.

What is the correct proportion of wheat and supplement in the final mix?

A) **Wheat: 75%, Supplement: 25%**
B) **Wheat: 60%, Supplement: 40%**
C) **Wheat: 50%, Supplement: 50%**
D) **Wheat: 80%, Supplement: 20%**

3. Which technique is employed in computer analysis to calculate least cost ration? Uppsc 2022

a. Linear programming
b. Nonlinear programming
c. Curvi-linear programming
d. Integer-linear programming

4. Consider the following statement regarding ration formulation: **JKPSC - 2019**

1) Age, Pregnancy, milk Product and Physical activity must considered when formulating ration
2) It should contain all essential vitamins and minerals
3) It should contain balance of protein carbohydrates and fats

Which of the statements given above are correct?

(A) 1 and 2 only
(B) 1 and 3 only
(C) 2 and 3 only
(D) 1, 2 and 3

5. The collection period for digestibility trial of large ruminant should be (J&K 2012)
   (A) 7-10 days
   (B) 10-14 days
   (C) 5-7 days
   (D) 20-22 days
6. The technique employed to calculate least cost and profit maximizing rations is called as Mppsc 2019
   (A) Trial and Error method
   (B) Pearson's Square method
   (C) Linear Programming
   (D) Algebraic method
7. Collection period (no. of days) followed in conducting digestibility trial by direct in vivo method in ruminants are: Opsc 2014
   (a) 21
   (b) 7
   (c) 2
   (d) 60
8. Following is the internal indicator for determination of digestibility of a feed in cattle: Opsc 2013 -14
   (a) Chromic oxide
   (b) Lignin
   (c) (a) & (b)is correct
   (d) cellulose

9. For determining the digestibility of a feed by conducting digestion trial in ruminants, the optimum length of 'preliminary period' followed is: Opsc 2013 -14

(a) One week
(b) Two weeks
(c) Three weeks
(d) 60 days

10. The amount of feed an animal needs to maintain its body mass and composition without any weight loss or gain: Opsc 2021-22

(A) Balanced ration
(B) Ideal ration
(C) Maintenance ration
(D) Production ration

11. The feed allowed for a given animal during a day of 24 hours is called as Mppsc 2021

(A) Ration
(B) Diet
(C) Balanced feed
(D) Complete feed

Q12. A dairy cow is offered two different types of feed:

- Feed X with 40% NDF
- Feed Y with 60% NDF

Calculate the Dry Matter Intake (DMI) for each feed and determine which feed allows for higher intake. Why?
What is the correct DMI (% of BW) for each feed?

A) Feed X: 3% BW, Feed Y: 2% BW
B) Feed X: 2% BW, Feed Y: 3% BW
C) Feed X: 4% BW, Feed Y: 1% BW
D) Feed X: 3.5% BW, Feed Y: 2.5% BW

Role of minerals, vitamins and their deficiency disorders. Feed supplements and feed additives

Classification of Minerals:

Two type:

Major(Macro) mineral (>100mg/day)

1. Calcium (Ca)
2. Phosphorus (P)
3. Sodium (Na)
4. Chlorine (Cl)
5. Potassium (K)
6. Magnesium (Mg)
7. Sulphur (S)

Minor(Micro) mineral (<100mg/day in humans almost same in animals aswell)

1. Zinc (Zn)
2. Copper (Cu)
3. Cobalt (Co)
4. Iron (Fe)
5. Iodine (I)
6. Manganese (Mn)
7. Selenium (Se)
8. Molybdenum (Mo)

Newer Trace Minerals

1. Chromium (Cr)
2. Fluorine (F)
3. Nickel (Ni)
4. Arsenic (Ar)

Minerals as Enzyme Components

Mineral	Enzyme	Function
Iron	Cytochromes	Electron transport and energy production
Copper	Cytochrome oxidase, Ceruloplasmin	Electron transport, iron metabolism
Zinc	Carbonic anhydrase, Carboxypeptidase	**CO_2 transport,** protein digestion
Manganese	Pyruvate carboxylase	Gluconeogenesis
Molybdenum	Xanthine oxidase (uric acid)	Purine metabolism
Selenium	Glutathione peroxidase	Antioxidant defence

Key Points

- **Calcium and Phosphorus:** Vital for bone structure and metabolic processes.
- **Sodium, Potassium, and Chlorine:** Crucial for maintaining fluid balance and nerve function.
- **Zinc, Copper, and Iron:** Essential for enzyme function and metabolic processes.
- **Selenium and Vitamin E:** Work together as antioxidants to protect cells from oxidative damage.

Key Points

1. Macrominerals and their deficiency system

1. Calcium (Ca)

Importance and Functions of Calcium

Approximately **99% of the calcium is found in bones and teeth**, where it provides structural integrity. The remaining **1% is involved in vital metabolic functions.**

Structural Role: Bones and Teeth-Provides strength and structure.

- **Metabolic Functions:**
  - Blood Coagulation: Essential for the clotting process.
  - Nerve Impulse Transmission: Facilitates the transmission of nerve impulses.
  - Muscle Contraction: Crucial for muscle function.
- **Blood Calcium Levels:**
  - **Normal Blood Concentration: 9-11 mg/dl**.
  - **Layers (Egg-Laying Birds)**: Higher concentration, **around 30-40 mg/dl.**
- **Hormonal Regulation:**
  - Parathormone (PTH): Increases blood calcium levels by mobilizing calcium from bones and enhancing the activation of vitamin D (1,25 di-hydroxy cholecalciferol) in the kidneys.
  - Calcitonin: Decreases blood calcium levels by inhibiting bone resorption.

Deficiency Symptoms

- **Young Animals:**
  - **Rickets-**weak and deformed bones due to inadequate mineralization.
- **Adult Animals:**
  - **Osteomalacia**-Softening of the bones caused by defective bone mineralization.
  - **Milk Fever (Parturient Paresis)-** In lactating animals characterized by low blood calcium levels, leading to muscle weakness and paralysis.

2. Phosphorus (P)

It is a component of phosphoproteins, nucleic acids (nucleotides), and phospholipids, which are essential for various physiological functions.

Key Functions **Structural Role:**

Phosphoproteins, Nucleic Acids, and Phospholipids-Integral components of cell membranes and genetic material.

Metabolic Functions:

Energy Metabolism-Vital for the formation of ATP (adenosine triphosphate), the primary energy carrier in cells.

Form in Feed:

Phytate/Phytic Acid-The primary storage form of phosphorus in cereal grains, which is less available to non-ruminant animals

Environmental Impact:

High Levels of Phosphorus-Can contribute to environmental pollution by promoting the growth of algae in water bodies.

Health Issues:

High Phosphorus Intake-In combination with magnesium, can lead to urolithiasis (urinary stones).

Blood Concentration : Normal Levels-4-8 mg/dl.

Deficiency Symptoms

- **Pica (Depraved Appetite/Allotriophagy):**
  - Abnormal cravings and eating non-food items such as wood, soil, and bones.
- **Post-Parturient Hemoglobinuria (PPH):**
  - A condition in cows characterized by the breakdown of red blood cells after calving, leading to hemoglobinuria (presence of hemoglobin in urine).
- **Ca: P Ratio:**
  - The optimal calcium to phosphorus ratio is 2:1. An **imbalance can lead to conditions such as "Big Head Disease" in horses**, where excessive phosphorus intake relative to calcium causes bone deformities.

3. Potassium (K)

Chief Intracellular Cation: Potassium is the primary cation inside cells, playing a crucial role in maintaining cellular function.

Functions:

- Nerve and Muscle Activity: Essential for normal nerve impulse transmission and muscle contraction.
- Enzyme Activation: Activates various enzymes involved in carbohydrate and protein metabolism.

Sources:

Natural Conditions: Grass and green fodder are rich sources of potassium.

Deficiency Symptoms

Synthetic Milk: Potassium deficiency can occur in animals fed synthetic milk, leading to reduced nerve and muscle activity, and in severe cases, paralysis.

4. Sodium (Na)

Chief Extracellular Cation: Sodium is the primary cation outside cells, crucial for maintaining fluid balance and nerve function.

Functions:

Na Intake Increases water intake, which is particularly important during heat stress. Acid-Base Balance: Helps maintain acid-base balance in the body.

Sources:

Common Salt (NaCl): The primary source of sodium in animal diets.

Deficiency Symptoms

- General: Slow growth, keratinization of corneal epithelium, impotency in males, delayed sexual maturity, and impaired estrus.
- **Poultry: Feather picking and cannibalism.**
- Salt Poisoning: Common in pigs and poultry when excessive salt is consumed.

5. Chlorine (Cl)

Importance and Functions

Functions:

Acid-Base Balance: Helps maintain the acid-base balance in body fluids.
Electrolyte Balance: Works with sodium to regulate osmotic pressure and fluid balance.

Sources

Common Salt (NaCl): The primary source of chlorine in animal diets.

Deficiency Symptoms

- General**: Deficiency of chlorine** can lead to an abnormal **increase in the alkali reserve**, resulting in **alkalosis.**
- Poultry: Deficiency can lead to feather picking and cannibalism.

6. Sulphur (S)

- Amino Acids: Integral component of sulphur-containing amino acids such as cystine, cysteine, and methionine.
- Vitamins: Essential for the synthesis of vitamins like biotin and thiamin.
- Hormones: Part of important hormones like insulin and oxytocin.
- **Wool: Rich in cysteine, wool contains about 4% sulphur. The nitrogen to sulphur (N:S) ratio in wool is typically 5:1.**
- NPN Supplementation: For non-protein nitrogen supplementation in ruminants, the N:S ratio should be 10:1 (or up to 15:1)

Deficiency Symptoms

- Reduced Feed Intake: Lowered appetite and feed intake.
- Poor Wool Quality: Reduced wool growth and quality due to insufficient sulphur for cystine synthesis.

Wool Composition:

•Wool is made up of **keratin**, a fibrous protein rich in amino acids.
•**Sulphur-containing amino acids**, especially **cysteine**, are a major component of keratin.
•These amino acids form **disulfide bonds (-S-S-),** which give wool its strength and elasticity.
•As a result, wool contains around **4% sulphur** by weight.
✓ **Wool contains about 4% sulphur** due to its high cysteine content.
✓ **Cysteine is rich in sulphur**, but its own sulphur content is not specifically 4%.

7 Magnesium (Mg)

- Enzyme Activation: Acts as a **cofactor for enzymes such as pyruvate carboxylase and pyruvate oxidase.**
- Energy Metabolism: Essential for **the tricarboxylic acid (TCA) cycle,** which is crucial for carbohydrate and lipid metabolism.
- ATP Synthesis: Necessary for the production and utilisation of ATP.
- Normal Blood Levels: 2-4 mg/dl.

Deficiency Symptoms

- **Hypomagnesemic Tetany:** Also known as **grass tetany or lactation tetany**, characterised by muscle spasms, convulsions, and potentially death due to respiratory failure.
- Lactation Tetany: Occurs in lactating animals.
- **Grass Staggers:** A condition in grazing animals, particularly ruminants, due to low magnesium levels in lush, fast-growing pastures.

Microminerals and their deficiency system

1. Iron (Fe)

- Transport: Iron is transported in the body by **transferrin.**
- Storage: Stored in the form of **ferritin and hemosiderin**
- Enzyme Component: Integral part of various enzymes and proteins involved in oxygen transport and metabolism.

Deficiency Symptoms

- Piglet Anaemia: Known as **"thumps,"** characterised by laboured breathing due to iron deficiency in young pigs.
- Iron Absorption: Governed by the mucosal block theory, where ferritin saturation in the intestinal mucosa regulates iron absorption.
- Microcytic anemia or hypochromic anemia

The **mucosal block theory** is a key regulatory mechanism of iron absorption. **Ferritin (iron storage protein) saturation in intestinal mucosal cells determines how much iron is absorbed.** If ferritin is full, further absorption is **blocked**, and excess iron is lost when mucosal cells are shed. This prevents iron overload and maintains **iron homeostasis** in the body.

•If iron stores are low → More iron is absorbed.

•If iron stores are full → Absorption is blocked, and excess iron is lost as enterocytes shed.

•Dietary iron exists in two forms:

• **Heme iron** (from animal sources) – more easily absorbed.

•Non-heme iron (from plant sources) – requires conversion from Fe^{3+} to Fe^{2+} for absorption.

•Transported into the bloodstream via **ferroportin**.

🚫 **Inhibitors of Iron Absorption:**

•Phytates (grains, legumes), tannins (tea, coffee), and calcium – Bind iron and reduce absorption.

•Excessive ferritin storage in mucosal cells – Triggers the mucosal block.

2. Copper (Cu)

- Essential for normal pigmentation of hair, fur, and wool
- Component of turacin, a pigment found in feathers
- Involved in various enzyme systems and **oxidation-reduction reactions**

Deficiency Symptoms:

1. **Lambs: Muscular incoordination leading to sway back condition (enzootic ataxia)**
2. Wool: Loss of crimp, resulting in stringy or steely wool due to disruption of disulfide linkages between cysteine molecules
3. Falling disease: **Degeneration of heart muscle (myocardium)**
4. Microcytic anaemia in pigs, poultry, and calves

How Copper Deficiency Causes Microcytic Anemia ?

Copper is essential for the proper utilization of iron in the body. Its deficiency can lead to anemia in the following ways:

1.Impaired Iron Absorption & Transport

1. Copper is needed for the function of **ceruloplasmin**, an enzyme that **oxidizes iron (Fe^{2+} to Fe^{3+})**.
2. This oxidation is essential for iron to **bind transferrin** and be transported to the bone marrow for RBC production.
3. Without enough copper, **iron cannot be effectively mobilized**, leading to a functional **iron deficiency** and microcytic anemia.

3. Cobalt (Co)

- Essential component of cyanocobalamin (vitamin B12)
- Required by rumen microbes for the synthesis of vitamin B12

Deficiency:

- **"Pining"** condition in ruminants, characterised by :
  - Loss of appetite
  - Wasting
  - Anaemia
  - Reduced growth and milk production

4. Iodine (I)

- Essential component of thyroid hormones (thyroxine and triiodothyronine)
- Increases basal metabolic rate, accelerating growth

Deficiency:

- **Goiter (enlarged thyroid gland)**
- Reduced growth rate
- Reproductive problems
- Hairless, weak, or stillborn offspring

Note : Goitrogenic Compounds:

- **Found in Brassica genus plants (e.g., cabbage)**
- **Inhibit iodination of tyrosine**, interfering with thyroid hormone synthesis

5. Manganese (Mn)

- **Activates glycosyl transferases**, important for bone formation
- Component of various enzyme systems

Deficiency Symptoms:

1. Poultry:
    - **Perosis (slipped tendon)** - malformation of leg bones Reduced hatchability and eggshell thickness
    - **Head retraction in chicks**

Other animals

- Impaired growth
- Skeletal abnormalities
- Reproductive problems

6. Zinc (Zn)

- Component of numerous enzymes: **Carbonic anhydrase**
- Pancreatic carboxypeptidase
- Lactate dehydrogenase
- Alcohol dehydrogenase
- Alkaline phosphatase
- Thymidine kinase

Deficiency Symptoms:
Skin disorders: Parakeratosis in pigs (thickening and hardening of skin)
Bone abnormalities : 'Swollen hock syndrome' in poultry

7. Molybdenum (Mo)

- Known for its interaction with copper (Cu)
- Acts as an **antagonist** to **Cu, Zn, and sulphur (S)**

Toxicity/Deficiency:

- **Teartness or peat scour**: **Can be caused by either Mo toxicity or acute Cu deficiency**

7. Selenium (Se)

- Considered one of the most toxic minerals when in excess
- **Component** of **'glutathione peroxidase'** enzyme
- Works **synergistically with Vitamin E as an antioxidant**

Toxicity Symptoms:

1. **Alkali disease**
2. **Blind staggers**
3. **Degnala disease**
4. Hoof deformity

9. Fluorine (F): Bureau of Indian Standards (BIS) recommends that F concentration **in mineral mixtures should not exceed 0.06%.**

Functions: Prevention of dental caries

10. Chromium (Cr)

- Acts as a glucose tolerance factor
- Functions similar to insulin-like growth factor (IGF-1)
- Carcass modifying effects : Enhances nitrogen (N) retention
- Helps reduce stress and metabolic disorders

11. Nickel (Ni)

- Important for urease activity in the rumen

Fat Soluble vitamin and their role

1. **Vitamin A**
2. **Vitamin D**
3. **Vitamin E**
4. **Vitamin K**

Vitamin A (Retinol)

Vitamin A, also known as **retinol**. It is derived from carotenoids, such as carotenes and xanthophylls, which are precursors of vitamin A.

Sources

- Carotenoids: Found in plant-based foods, including carotenes (e.g., beta-carotene) and xanthophylls.
- Animal-Based Sources: Liver, fish oils, egg yolk, and dairy products.

Conversion in the Body

- Intestinal Mucosa: Carotenoids are converted into retinol in the intestinal mucosa.
- **1 Molecule of Beta-Carotene: Yields 2 molecules of Vitamin A (Retinol).**

Functions

- Anti-Infective Vitamin: Enhances immune function and helps in the maintenance of epithelial tissues.
- **Vision:** Essential for the synthesis of **rhodopsin**, a pigment in the retina that is necessary for night vision.

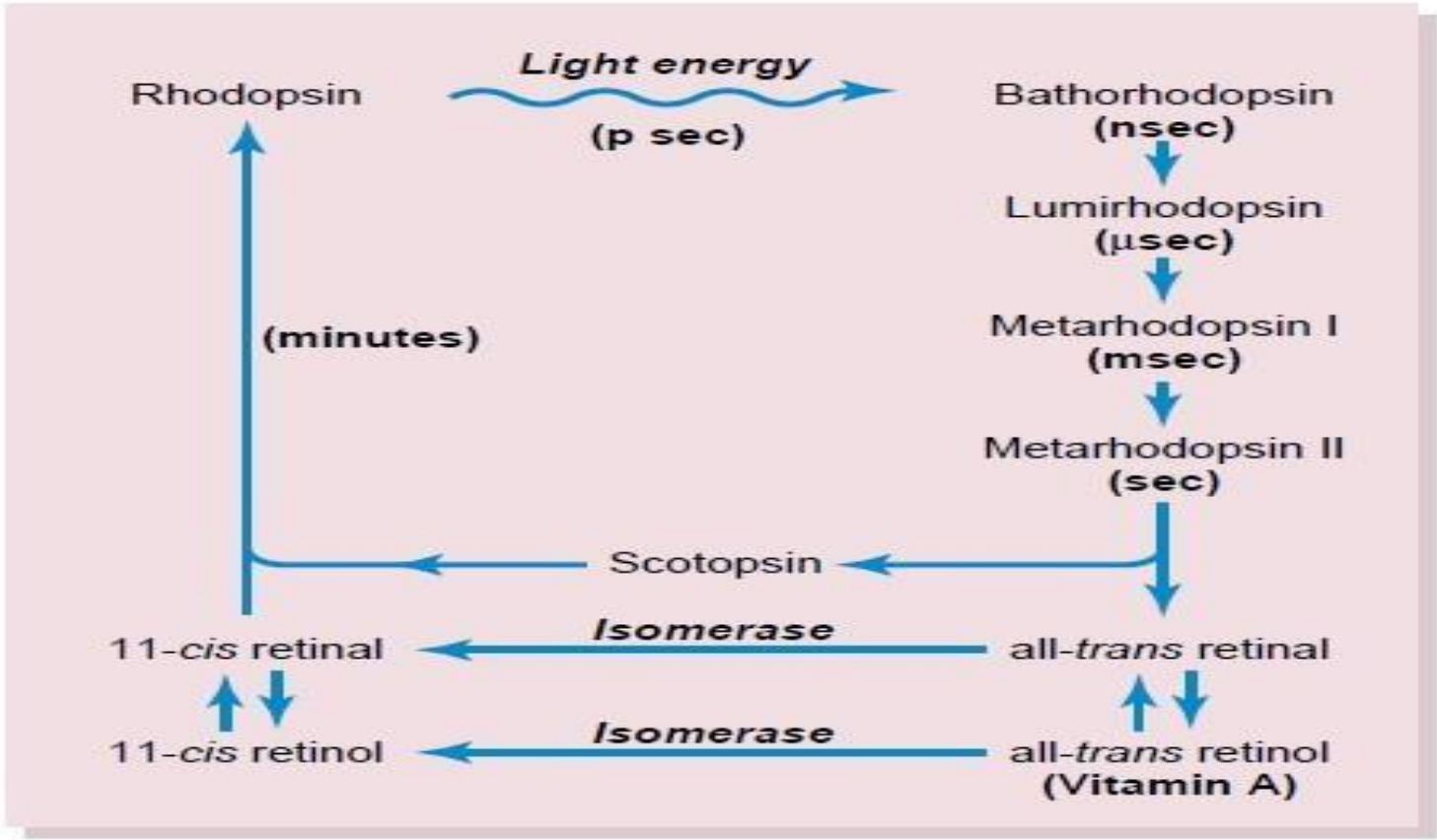


Figure 50–5

Rhodopsin-retinal visual cycle in the rod, showing decomposition of rhodopsin during exposure to light and subsequent slow re-formation of rhodopsin by the chemical processes.

Vitamin A is essential for regenerating rhodopsin, preventing night blindness

Loss of Vitamin A in the Cycle

•Not all **all-trans retinal** from rhodopsin breakdown is recycled into **11-cis retinal**.

•Some **Vitamin A is lost** or used in other body functions, so it must be replenished.

Photoreceptors in the Eye:

•**Rod cells** → Use **Rhodopsin** (for night vision, low light).

•**Cone cells** → Use **Iodopsin (Photopsins)** (for daylight, color vision).

What Happens in Bright Light?

•**Rhodopsin is broken down and not active in daylight**.

•**Only cone photopsins work** to provide sharp, color vision.

•**Rods need time to recover in the dark** because rhodopsin must be rebuilt.

•**Cones rest in darkness but don't degenerate** — they're just on standby.

👁️ **What Happens When You Go From Light to Dark?**

✅ **First 30 seconds:**

•**Cone cells** (used in daylight & bright light) still work a little, even in dim conditions.

•You can see **some shapes or movement**, especially if the area isn't pitch black.

•Your brain also **adjusts quickly** to lower light.

🕐 **After 5 minutes and beyond:**

•**Rods (night vision)** start kicking in.

•**Rhodopsin** begins regenerating.

•Vision becomes **much more sensitive**, allowing you to see in **very dark conditions.**

- Reproduction: Supports normal reproduction and embryonic development.
- Growth and Development: Important for bone growth and development.
- Skin Health: Maintains the integrity of skin and mucous membranes.

Deficiency Symptoms

1. Night Blindness: Impaired synthesis of **rhodopsin** leads to difficulty seeing in low light conditions.
2. Xerophthalmia: Dryness of the conjunctiva and cornea, which can lead to blindness.
3. Infertility: Reproductive issues due to impaired development and function of reproductive organs.
4. **Nutritional Roup in Poultry:** Respiratory infection characterised by nasal discharge, swollen eyes, and reduced egg production.
5. **Bitot's Spots:** Foamy patches on the conjunctiva, indicative of severe vitamin A deficiency.

Bitot's Spots:

Vitamin D

Types of Vitamin D

1. Vitamin D2 (Ergocalciferol)Source
2. Vitamin D3 (Cholecalciferol)Source

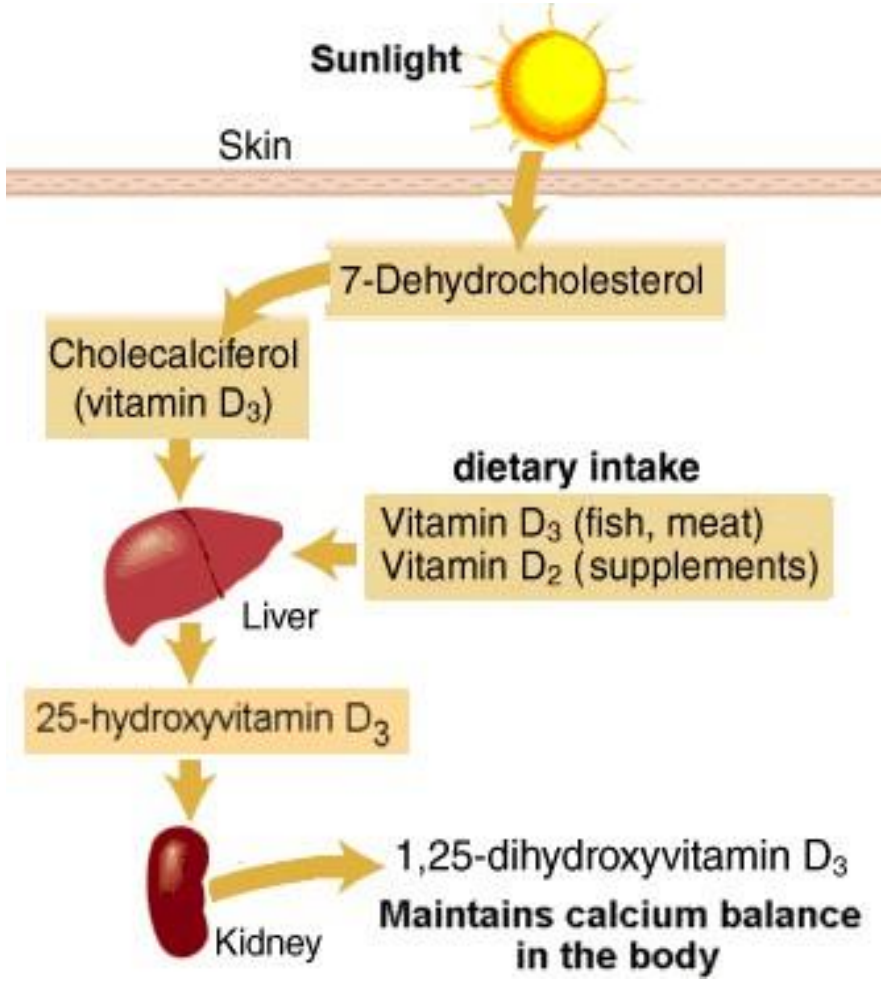
- Hormone-Like Activity: Vitamin D acts like a hormone in the body, regulating calcium and phosphorus metabolism.
- Antirachitic Activity: Prevents rickets, a disease characterised by softening and weakening of bones in young animals.

Deficiency Symptoms

1. Young Animals: Rickets-Characterised by weak and deformed bones due to inadequate mineralization.
2. Adult Animals : Osteomalacia-Softening of the bones caused by defective bone mineralization.

Sources

- Vitamin D2: Found in plants, particularly in fungi and yeast.
- Vitamin D3: Found in animal products such as fish liver oils, egg yolk, and synthesised in the skin upon exposure to sunlight.



Vitamin K

1. Synthesis of Prothrombin: Vitamin K is essential for the synthesis of prothrombin in the liver, a protein and clotting factor that is crucial for blood coagulation.
2. Blood Clotting: It plays a vital role in the blood clotting process by activating clotting factors that help in the conversion of prothrombin to thrombin.
3. Bone Health: Vitamin K is also involved in the regulation of calcium in bones and other tissues.

Deficiency Symptoms

1. **Hemorrhagic Conditions:** Deficiency in vitamin K can lead to bleeding disorders due to impaired blood clotting. This can manifest as excessive bleeding from wounds, bruising, and internal bleeding.
2. Sweet Clover Poisoning: In cattle, sweet clover poisoning occurs when the plant becomes mouldy and produces dicoumarol, a compound that antagonises vitamin K. This leads to a decrease in prothrombin levels, resulting in hemorrhagic disease.

Sources

- Green Leafy Vegetables: Such as spinach, kale, and broccoli.
- Animal Products: Liver, egg yolk, and fish.
- Synthesised by Gut Bacteria: In the intestines of animals.

Types of Vitamin K

1. Vitamin K1 (Phylloquinone): Found in green plants.
2. Vitamin K2 (Menaquinone): Produced by bacteria in the intestines.
3. Vitamin K3 (Menadione): A synthetic form of vitamin K.

Vitamin E (Tocopherols)

- Antioxidant: Vitamin E acts as a powerful antioxidant, protecting cell membranes from oxidative damage. It works in association with the selenium-containing enzyme glutathione peroxidase.
- **Free Radical Scavenging: Vitamin E is the first line of defence against free radicals**, neutralising them before they can cause harm.
- Glutathione Peroxidase: This enzyme destroys any remaining peroxides, preventing further oxidative damage.

Deficiency Symptoms

Calves:

Nutritional Myopathy: Also known as muscular dystrophy or white muscle disease, characterised by muscle degeneration and weakness.

Fatal Syncope: Sudden death due to heart failure.

Lambs:

Stiff Lamb Disease: Muscle stiffness and weakness due to nutritional myopathy.

Pigs:

Mulberry Heart Disease: sudden death due to heart muscle degeneration. Fatal Syncope: Similar to calves, sudden death due to heart failure.

Chicks:

Encephalomalacia: Also known as "crazy chick disease," characterised by neurological symptoms such as incoordination and convulsions.

Exudative Diathesis: Edema and haemorrhages due to increased capillary permeability.

Cats:

Yellow Fat Disease: Also known as steatitis, characterised by inflammation of fatty tissues.

Sources

- Green Fodders: Rich in vitamin E.
- Cereal Grains: Good sources of tocopherols.
- Vegetable Oils: High in vitamin E.
- Nuts and Oil Seeds: Rich in tocopherols.

Vitamin C (Ascorbic Acid)

Sources

- Primary Sources: Citrus fruits and green leafy vegetables are rich sources of vitamin C.
- Synthesis: Most animals can synthesise vitamin C in their bodies from glucose using the enzyme **gluconolactone oxidase**. However, humans, guinea pigs, and some other species lack this enzyme and must obtain vitamin C from their diet.

Functions

1. **Antioxidant:** powerful antioxidant, protecting cells from oxidative damage
2. Collagen Synthesis: Protein that helps maintain the integrity of skin, blood vessels, bones, and connective tissues.
3. Intercellular Cement Substance: Plays a crucial role in the formation of intercellular cement substances, which are important for the maintenance of capillaries, teeth, and bone.
4. Immune Function: **Enhances the immune response** and helps in the absorption of iron from plant-based foods.

Deficiency Symptoms

1. **Scurvy:** A disease caused by severe vitamin C deficiency, characterised by symptoms such as:
    - Anaemia , Dry rough skin covered with reddish spots
    - Weakness and fatigue
    - Swollen and bleeding gums
    - Loosening of teeth
    - Joint pain and swelling

Poor Wound Healing: Due to impaired collagen synthesis, wounds may heal slowly.

Increased Susceptibility to Infections: Weakened immune response can lead to a higher risk of infections.

Water soluble vitamin and their role

1. Vitamin B Complex
    a. Thiamin (Vitamin B1)
    b. Riboflavin (Vitamin B2)
    c. Niacin (Vitamin B3)
    d. Pantothenic Acid (Vitamin B5)
    e. Pyridoxine (Vitamin B6)
    f. Folic Acid (pteroylmonoglutamic acid)
    g. Cyanocobalamin (Vitamin B12)
    h. Biotin (Vitamin B7)
    i. Choline
    j. P-Amino Benzoic Acid
    k. Inositol
2. Vitamin C (Ascorbic Acid)

Thiamine (Vitamin B1)

- Energy/Carbohydrate Metabolism: Thiamine is essential for the oxidative decarboxylation of pyruvate to acetyl-CoA and of α-ketoglutarate to succinyl-CoA in the tricarboxylic acid (TCA) cycle. These reactions are crucial for energy production from carbohydrates.

Sources

- Natural Sources: Yeast, bran, rice polish, egg yolk, liver, pork.
- Anti-thiamine Factors:

  Thiaminase: Found in raw fish and bracken fern, this enzyme breaks down thiamine, leading to deficiency.

Deficiency Symptoms

1. Accumulation of Pyruvic Acid: Without sufficient thiamine, pyruvate cannot be converted to acetyl-CoA, leading to an accumulation of pyruvic acid, which is then converted to lactic acid. This results in muscular weakness.
2. Excess Polished Rice Consumption: Diets high in polished rice, which is low in thiamine, can lead to deficiency.
3. Polyneuritis: Inflammation of multiple nerves leading to paralysis.
4. **Chastek Paralysis(foxes):** A specific type of paralysis seen in animals, particularly in those consuming raw fish containing thiaminase.
5. **CCN & PEM (STAR GRAZING & OPISTHOTONOUS)**

Riboflavin (Vitamin B2)

- **Component of flavoproteins**, flavin mononucleotide **(FMN)**, and flavin adenine dinucleotide (FAD)
- Involved in protein and carbohydrate metabolism
- Used by cells to transport hydrogen in metabolic pathways

Sources:

Synthesised by yeast, bacteria and fungi

- Rich sources include liver, yeast, milk, eggs, and green leafy vegetables

Deficiency Symptoms:

1. Curled Toe Paralysis

- Occurs in poultry, especially chicks
- Caused by **peripheral nerve degeneration**
- Characterised by **curling of the toes inward**, making it difficult for birds to walk

2. Clubbed Down Syndrome/Condition

- Feathers **continue to grow within the follicle, leading to curled feathers**
- **Affects the appearance and health of the bird's plumage**
- Degeneration of myelin sheath in nerves
- Loss of integrity of epithelial tissues

In swine: stiff legs, nerve degeneration, corneal opacity, cataracts

Importance:

- Essential for proper nervous system function
- Critical for energy metabolism in cells
- Necessary for normal growth and development
- Important for maintaining healthy skin, eyes, and mucous membranes

Niacin (Vitamin B3)/ Nicotinamide/nicotinic acid

Niacin can be synthesised in the body from the amino acid tryptophan.

- Part of Enzyme Systems: A component of the coenzymes NAD (Nicotinamide Adenine Dinucleotide) and NADP (Nicotinamide Adenine Dinucleotide Phosphate), which are crucial for hydrogen transfer in metabolic reactions.
- Energy Metabolism: Involved in the metabolism of carbohydrates, proteins, and fats.

Deficiency Symptoms

- Pellagra or blue tongue in man (predominant in maize based diet cosnuming population)
- Black tongue in dog

Pantothenic Acid (Vitamin B5)

Functions: Component of Coenzyme A: Essential for acyl transfer and fatty acid metabolism.

Deficiency Symptoms

- Pigs: Goose-stepping gait, characterised by a peculiar high-stepping walk.
- General: Poor growth and skin lesions.

Vitamin B6 (Pyridoxine)

- Functions: Protein and Amino Acid Metabolism: Acts as a coenzyme in the metabolism of amino acids and proteins.
- Deficiency Symptoms: Convulsions, anaemia, slow growth, and hatchability issues in poultry(rise in iron & fall in coper haemosiderosis- dark yellow iron pigment on autopsy)

Biotin (Vitamin B7)

Functions: Carboxylation Reactions: Acts as a coenzyme for carboxylase enzymes involved in fatty acid synthesis and gluconeogenesis.

Deficiency Symptoms

- Raw Eggs: Contain avidin, which binds biotin and leads to deficiency.
- Poultry: Fatty liver and kidney syndrome (FLKS), characterised by fat accumulation in the liver and kidneys.(parrot beak in embryo of birds)
- General: Dermatitis, poor growth, and cracked feet.

- **Biotin anti-metabolit - Avidin(raw egg white)**

Choline

1. Methyl Donor: Choline **acts as a methyl donor in transmethylation reactions, which are crucial for fat mobilisation**.
2. Transition Animals: Helps prevent metabolic diseases such as ketosis in transition animals (e.g., dairy cows around calving).
3. Poultry Chicks: Prevents perosis (slipped tendon), a condition also influenced by manganese (Mn).

Deficiency Symptoms

- Perosis in Poultry: Characterised by slipped tendon, where the tendon slips from its normal position, leading to leg deformities.

Vitamin B12 (Cyanocobalamin)

1. Synthesis: Vitamin B12 is synthesised exclusively by microorganisms.
2. Mineral Requirement: **Requires cobalt (Co) for synthesis**.
3. **Absorption: Absorbed in the gut when bound to a glycoprotein called intrinsic factor, which is produced in the stomach.**

Sources

- Microbial Synthesis: Synthesised by microorganisms in the gut.
- Animal Products: Found in liver, kidney, and other animal products.
- Not Present in Plants: Vitamin B12 is not found in plant-based foods.

Deficiency Symptoms

- Pernicious Anaemia: A type of anaemia characterised by the inability to absorb vitamin B12 **due to the lack of intrinsic factor**. Symptoms include weakness, fatigue, and neurological issues.

Perosis in Poultry

- Caused By: Deficiency in manganese (Mn), biotin, choline, and folic acid.

Feed Additives in Livestock Nutrition

Feed additive:

Non-nutritive product added to a basic feed in small quantities that affects utilisation of the feed or productive performance of the animal.

Advantages:

- Increase feed quality and feed palatability
- Improve animal performance
- Improve the final product
- Economise the cost of animal protein

Disadvantages:

- May leave their residues
- May favour the proliferation of antibiotic resistant microorganisms

Types of feed additives:

- Additives that promotes growth and production: antibiotic, probiotic, prebiotics
- Additives that alter metabolism: Hormone (estrogens, androgens, progesterone, GH, thyroxine, glucocorticoids)
- Additives that enhance feed intake: antioxidants, flavouring agents
- Additives that enhance the colour: food colour, pigments
- Additives that facilitate digestion and absorption: grits, enzymes
- Additives that affect the health status of livestock: antifungals, Anticoccidials/coccidiostat, acidifiers

Antibiotics

•bacteriostatic or bactericidal properties.
•Prevent subclinical infections

Bactericidal (Kills bacteria):
•Penicillin
•Bacitracin
•Streptomycin
•Neomycin

Bacteriostatic (Stops bacteria from growing):
•Oxytetracycline
•Chlortetracycline
•Erythromycin

Mechanism of action of antibiotics includes:

•Nutrient sparing effect by increasing growth of vitamin and protein synthesising microorganism

•Reduces the thickness of the intestinal wall of birds, which enhances absorption of nutrients.

•Reduce or eliminate the activity of pathogens causing "subclinical infection."

•Reduce the growth of microorganisms that compete with the host for supplies of nutrients.

• Antibiotics alter intestinal bacteria so that less urease is produced and thus less ammonia is formed. Ammonia is highly toxic and suppresses growth in poultry (NH3 concentration in poultry shed: <25ppm).

•Antibiotics appear to spare the dietary requirement of the chick for unidentified growth factors.

Probiotics:

direct fed microbials

- Live non-pathogenic microbial feed supplement, which beneficially affects the host animals by improving its intestinal microbial balance, facilitating digestion and absorption.
- Species: Lactobacilli, saccharomyces and Streptococci spp. (30×10^9 CFU/g)

- Mechanism of action:
- Having a direct effect against undesirable or harmful organisms through production of antibacterial compounds, eliminating or minimising their competition of nutrients.
- Stimulation of the immune system.
- Neutralisation of toxins formed by pathogenic organisms.

Prebiotics:

- Non-digestible food ingredients that benefit the host by selectively stimulating the growth of desirable bacteria in GIT.
- They modify the balance of the microflora population by promoting the growth of beneficial bacteria & thereby provide a healthier intestinal environment.
- Examples:

Oligosaccharides (Mannan-oligosaccharides, fructo- oligosaccharides).

Soya bean meal, rapeseed meal & legumes contain-galactooligosaccharides (GOS) Cereals contain fructo-oligosaccharides (FOS);

Milk products have trans-galactooligosaccharides (TOS); Yeast cell walls contain mannan-oligosaccharides (MOS).

Synbiotics: probiotics & prebiotics

Antioxidants:

•Prevent oxidative rancidity of polyunsaturated fats and enhance feed intake
•Example: Vit. E, Se, Ethoxyquin or BHT (butylated hydroxytoluene).

Flavouring Agent:

•Increase palatability and feed intake e.g. Monosodium glutamate (MSG).
•Flavouring agents are needed

- When highly unpalatable medications are being mixed During attacks of diseases.
- When animals are under stress
- With less palatable feedstuffs is being used Food

Colours:

•Make food more attractive and pleasing.
•Examples: acid fuchsin, brilliant blue, β-carotene, saffron, beetroot red, chlorophyll, etc.

Pigments:

•Examples: Carotenoids/ xanthophyll
•Enhance the colour of the marketed product.
•Colour of an egg yolk due to carotenoids
•Carotenoids in alfalfa produce yellow pigmentation of skin and fat of chicken.
•Xanthophylls are not stable compounds and can be lost by oxidation so antioxidants must be added in poultry feed.

Grit:

• Function: facilitates the digestion and absorption in poultry because poultry do not have teeth to grind any hard grain, most grinding takes place in the **thick muscular gizzard for increasing the surface area for digestion** and subsequent absorption.

• Oyster shells and limestone are used as grit.

Enzymes:

• Enzymes are biological catalyst

• Examples: beta-glucanase and xylanase, cellulose, Phytase.

• Improve the efficiency of the utilisation of the feed.

• Upgrade cereals by-products or feed components that are poorly digested

• Provide additional digestive enzymes to help poultry to withstand stress conditions.

Antifungal additives:

• Mould inhibitors are added to feed liable to be contaminated with various types of fungi such as *Aspergillus* and *Penicillium* spp.

• Propionic, formic acid and acetic acid are added in high moisture grain to inhibit mould growth.

• **Antifungals such as Nystatin and copper sulfate preparations** are also in use to concentrate feeds to prevent moulds.

Acidifiers:

• As preservative and prevent attaching of microbes with gut walls.

• Organic acids like formic acid, propionic acid, fumaric acid etc. are used as acidifiers

💊 Ionophore Antibiotics

Examples: Monensin, Lasalocid, Salinomycin

- Disrupt ion balance in microbes.
- Kill **Gram +ve bacteria**, support **Gram -ve** → improve **gut fermentation** and energy (propionate).
- Improve **feed efficiency** and **growth**.
- **Monensin** is made by *Streptomyces cinnamonensis*.
    - **Rumensin** = brand name for monensin (dose: 50–100 mg/head/day)

Nutrient Partitioning Agents

Example: Phenylethanolamine

- Push nutrients toward **muscle** growth instead of fat.
- Improves **lean meat production**.

🌿 Deodorizing Agents

Example: Yucca schidigera

- Blocks **urease enzyme** → less **ammonia** in feces → reduces **bad smell**.

💥 Methyl Donors

Examples: Methionine, Choline

- Donate **methyl groups** for metabolism.
- Help with **liver function**, **fat breakdown**, and **growth**.

🧪 Biopreservatives

Example: **Nisin (from *Lactococcus lactis*)**

•Natural antibacterial protein.

•Inhibits **both G+ve and G−ve bacteria**.

•Used to **preserve feed** and prevent spoilage.

Defauning Agent

Example: Copper sulfate

•Removes or reduces **protozoa (fauna)** in the rumen.

•Improves microbial balance and **feed digestion**.

🧱 Pellet Binder

Example: Sepiolite (a clay mineral)

•Helps keep feed pellets **firm and stable**.

•Reduces **dust** and **waste** during feeding.

⚖️ Buffer

Examples: Sodium bicarbonate ($NaHCO_3$), Magnesium oxide (MgO)

•Maintains **stable pH** in the rumen.

•Prevents **acidosis** in high-grain diets.

🧲 Mycotoxin Binder

Examples: Zeolite, Mineral clay

•Binds harmful **mycotoxins** in feed (toxins from molds).

•Prevents their absorption → **protects animal health**.

Name	Function	Type of Substance
Monensin	Kills Gram+ bacteria, improves digestion & propionate	**Ionophore antibiotic** (produced by *Streptomyces*)
Lasalocid	Same as monensin	**Ionophore antibiotic**
Salinomycin	Same as monensin	**Ionophore antibiotic**
Phenylethanolamine	Shifts nutrients to muscle growth	**Beta-agonist / Nutrient repartitioning agent**
Yucca schidigera	Reduces ammonia by blocking urease	**Natural plant extract / Deodorizer**
Methionine	Supports metabolism, donates methyl groups	**Amino acid / Methyl donor**
Choline	Similar to methionine, supports liver	**Vitamin-like nutrient / Methyl donor**
Nisin	Inhibits spoilage bacteria	**Bacteriocin / Natural biopreservative**
Copper sulfate	Removes rumen protozoa (defauning)	**Mineral salt / Defauning agent**
Sepiolite	Holds pellets together	**Clay mineral / Pellet binder**
Sodium bicarbonate	Buffers rumen pH, prevents acidosis	**Chemical buffer**
Magnesium oxide (MgO)	Also buffers rumen pH	**Mineral buffer**
Zeolite	Binds mycotoxins in feed	**Natural mineral / Mycotoxin binder**
Mineral clay	Same role as zeolite	**Inorganic binder / Mycotoxin binder**

Feature	**Bacteriocins**	**Antibiotics**
Producer	Made **only by bacteria**	Made by **bacteria, fungi**, or synthetically
Structure	Mostly **proteins or peptides**	Usually **non-protein molecules** (e.g. penicillin)
Target Range	**Very narrow** (even strain-specific)	Can be **narrow or broad** spectrum
Mode of Action	Often target cell walls or membranes precisely	Can have various complex mechanisms
Usage	Mostly in **food/feed preservation**	Used for **disease treatment or growth**

Compound	Used As
$NaHCO_3$ (sodium bicarbonate)	Fast-acting **mineral buffer**
MgO (magnesium oxide)	Slower-acting **mineral buffer**
$CaCO_3$ (calcium carbonate)	Also acts as a buffer & mineral source

Metabolic disorders

Metabolism

Metabolism is the total of all **physical (movement & transport) and chemical processes** in the body.
These processes help:

- **Break down food**
- **Absorb nutrients**
- **Build or repair body parts**

What Are Metabolic Disorders?

A **metabolic disorder** happens when something goes wrong in these processes.
This usually means the body can't properly control certain **important substances** (like sugars, fats, or proteins) in the blood. Eg Ketosis, Milk Fever (Hypocalcemia)

What Causes Nutritional Diseases?

- **Lack, excess, or imbalance** of nutrients in the diet.
- These problems affect metabolism and may lead to **metabolic disorders**.
- Eg Milk fever (Nutrit. + metabolic)
- Eg Vitamin-A deficiency (only Nutritional)

Influencing factors are

1. Hormonal changes
2. Moving from non-lactating to lactating stage- lactation stress
3. Changing of diet from roughages to highly fermentable CHO.

Disease Name	Cause Summary	Nutritional?	Metabolic?	Category
Vitamin A Deficiency	Lack of vitamin A in diet	✅	❌	Nutritional Only
Iron Deficiency Anemia	Low iron intake → poor hemoglobin synthesis	✅	❌	Nutritional Only
Diabetes Mellitus	Hormonal problem (insulin dysfunction)	❌	✅	Metabolic Only
Fatty Liver Syndrome	Liver fails to process fat	✅	✅	Metabolic Only
Milk Fever (Hypocalcemia)	Caused by low calcium + poor regulation	✅	✅	Nutritional + Metabolic
Ketosis (in dairy cows)	Low energy intake + excessive fat breakdown	✅	✅	Nutritional + Metabolic

Metabolic Diseases

1)Fatty liver

2)Ketosis

3)Acidosis (SARA)

4)Laminitis

5)Milk fever

6)Downer cow

7)Retained placenta

8)Bloat

9)Grass tetany

10)LDA

1. 🐄 Fatty Liver in Dairy Cows

🧬 What is it?

•A **common metabolic disorder** during transition period

•Up to **65% of cows** may have **moderate to severe fatty liver**.

⚠️ Why does it happen?

1.Too Fat Before Calving:

1. If cows are **overfed during the dry period**, they get too fat (**Body Condition Score > 4.5**).

2.Energy Shortage After Calving:

1. After giving birth, cows **need a lot of energy** for milk. (NEBAL)
2. But they **can't eat enough**, so their body starts using **fat from storage** (called **NEFA** – non-esterified fatty acids).

3.Liver Overload:

1. The liver **takes in too much fat (NEFA).**
2. But it **can't process it all**, so it stores it as **triglycerides**.
3. This buildup = **Fatty Liver**.

How to Prevent Fatty Liver

🥗 **Feeding & Management:**

•Avoid **overfeeding** during the dry period.

•Feed **low-energy, low-protein forages** (except last few weeks before calving).

💊 **Supplements:**

•**Propylene glycol, glycerol, monensin**: Help cows get more energy and reduce fat mobilization.

•**B-complex vitamins**: Help with metabolism and **improve appetite**.

•**Vitamin E + Selenium**: Protect the liver with their **antioxidant** effects.

•**Choline & Methionine** (lipotropic agents): Help **remove fat from the liver** and **prevent fat buildup**.

2. 🐄 What is Ketosis (Acetonemia)?

- In dairy cows, ketosis is a lactation disorder usually associated with intense milk production and NEBAL (6-8 wk postpartum)
- An increase of "ketone bodies" in blood until they eventually begin to spill over into urine and (or) milk.
- Acetone, Acetoacetate, and β-Hydroxybutyrate Acetone: smell from breath

Butyrate is turned into BHB in the rumen wall so it can be absorbed into the blood and used as an energy source — it's a normal part of energy metabolism in ruminants.

Preventatives for fatty liver:- Almost same as Fatty Liver

Treatment

- Intravenous injection of glucose (50% dextrose)
- Intramuscular glucocorticoid (Isoflupredone)
- Gluconeogenic precursor- Sod. Propionate, glycerol, propylene glycol
- Supportive- vitamins

- **Note: Isoflupredone helps in ketosis by increasing glucose production in the liver (GLUCONEOGENESIS) and reducing fat breakdown.** This helps lower ketone levels and supports recovery.

🚨 After Calving
↓
🐄 Energy Demand ↑ (for milk production)
↓
🥗 Feed Intake ↓ (Appetite drops)
↓
⚖️ NEBAL (Negative Energy Balance)
↓
🔥 Body fat is broken down → NEFA released into blood

NEFA taken up by **Liver**

⚠ Excess NEFA stored in liver
→ Triglyceride buildup
→ Fatty Liver

NEFA → Acetyl-CoA

🧪 Acetyl-CoA enters Krebs Cycle

But Krebs Cycle needs Oxaloacetate (from glucose)

🛑 Glucose is low → Krebs Cycle slows down

🚧 Acetyl-CoA builds up (can't enter cycle)

Liver shifts to backup pathway → Ketogenesis

Acetyl-CoA → Acetoacetate → Acetone & β-Hydroxybutyrate (BHB)

⚠ Ketone levels ↑ in blood, urine, milk

→ Clinical Ketosis

3. Ruminal Acidosis

•Important nutritional metabolic disorder common in the field especially in high yielding cows with high grain ration.

•Grain engorgement

•Sudden change in diet- Dry cow is fed a high forage ration that is less energy dense and higher in NDF than the lactating animal

•Ruminal populations ill-suited to energy rich ration

	SARA (Subacute Ruminal Acidosis)	Acute Ruminal Acidosis
🔥 **Type of Acid**	**VFAs** (Volatile Fatty Acids)	**Lactic Acid**
⏱️ **Speed of onset**	**Gradual** (over days/weeks)	**Very sudden** (within hours)
💧 **Rumen pH**	**5.5 – 6.0**	**< 5.5**
📉 **Effect on papillae**	VFAs build up faster than they can be absorbed → **mild acid stress**	Extreme drop in pH → **kills rumen microbes**, damages lining
🐄 **When it happens**	Around calving, diet changes, improper transition	Grain overload, sudden grain feeding
🚨 **Danger level**	Subtle but chronic damage (SARA)	Emergency (Acidosis)

😬 In SARA:

- High grain → rapid fermentation → lots of **VFAs** (like acetate, propionate, butyrate)
- Rumen can't **absorb them fast enough** → pH drops slightly → mild acidosis

😵 In Acute Acidosis:

- **Too much grain all at once** → explosion of **Streptococcus bovis** bacteria
- These make **lactic acid**, which is **way stronger** than VFAs
- pH crashes below 5.5 → rumen becomes toxic → emergency!

🧠 Easy Analogy:

🔄 **SARA = slow leak** → you get problems over time

💥 **Acidosis = tire blowout** → sudden crash

4. 🐄 Laminitis

🔷 **What is it?**

👉 Inflammation of the hoof's inner tissues (laminae) — causes pain and lameness.

🔷 **Main Cause:**

🍞 High-grain diet →

💥 Rumen acidosis →

☠️ Bacteria die →

🧪 Endotoxins & histamine enter blood →

🦶 Damage hoof blood vessels → laminitis

🔷 **Signs:**

🚶 Lameness

🐌 Reluctance to walk

📉 Drop in milk and feed intake

🔷 **Prevention:**

🥗 Balanced diet (fiber + energy)

🧴 Foot baths (copper sulfate)

💊 Biotin, zinc, vitamins A & E

🧬 Trace minerals (Se, Cu, Mn, Co)

5. 🐄 Milk Fever (Parturient Paresis / Hypocalcemia)

When?

- Usually within **72 hours after calving**
- Caused by **low blood calcium** (↓ from ~10 to ~ 5 mg/dL)
- Common in **older, high-yielding cows**

🧪 Why it happens:

- Sudden calcium demand for milk exceeds body's supply
- **Poor Ca mobilization** due to:
  - Parathyroid hormone inactivity
  - High Ca diet in dry period

🩺 Clinical Signs:

- Cold ears & extremities ❄️
- Neck bent toward flank 🦢
- Weak, wobbly, lying down 🐄
- Low body temp (100–101°F) 🌡️
- Sometimes excitable or trembly ⚡

🛡️ Prevention & Treatment:

✅ Prevention:

- **DCAD diet** (anionic salts before calving) 🧂
- Avoid prepartum diets high in **Na+ and K+**
- **Calcium gel**: 1 day before & 1 day after calving
- **Vitamin D**: 8 days before calving (s.c.)
- Use **anionic mineral mixture** during transition

💉 Treatment:

- Give **calcium**: half **IV**, half **subcutaneous**
- Repeat in 8–12 hrs if needed
- Support and keep cow warm

6. 🐄 Downer Cow Syndrome (Downer Cow Complex)

🛏️ What is it?

- A cow that **remains down >24 hrs** after milk fever or calving
- Muscles and nerves get **damaged from pressure**

🔄 Caused by:

- **Milk fever**, **fatty liver**, **acidosis**, **displaced abomasum**, etc.
- All these are **interrelated** → grouped as **"downer cow complex"**

7. 🌿 Grass Tetany (Hypomagnesemia)

🧪 What is it?

A **metabolic disorder** in ruminants caused by **low blood magnesium (Mg)** levels. It usually occurs in animals grazing on **lush, fast-growing pastures**, especially in spring.

⚠️ Causes / Risk Factors:

- **Mg-deficient soils** (common in cool, wet climates)
- **High K^+ & N fertilizers** → interfere with Mg absorption
- **Rapid grass growth** (low Mg content)
- **Older or lactating animals** = higher risk

🐄 Clinical Signs:

- Muscle twitching, tremors
- Stiff gait or uncoordinated walking
- Hyperexcitability or aggression
- Collapse → convulsions → death if untreated

💉 Prevention & Treatment:

✅ **Prevention:**

- Supplement Mg (e.g., **Mg oxide** in feed or blocks)
- Avoid excessive use of **K or N fertilizer**
- Feed **hay or dry forage** alongside lush pasture

💊 **Treatment:**

- **Magnesium sulfate ($MgSO_4$)** injection (IV or subcutaneous)
- Act quickly — it's an emergency!

8. 🐄 Displaced Abomasum (DA)

🩺 What is it?

Movement of the **abomasum (true stomach)** from its normal position to the **left (LDA)** or **right (RDA)** side of the abdomen.

- **LDA = 80–90% cases**
- Most common in **high-yielding cows** during the **first 4 weeks after calving**

⚠️ Causes / Risk Factors:

- **High grain, low roughage diets**
- **Sudden diet change**
- **Low calcium (hypocalcemia)** after calving
- **Low feed intake during transition** → rumen shrinks, space for abomasum to move
- **Low VFA absorption** → affects motility → abomasal atony (loss of tone)

🔄 What happens?

- Abomasum fills with gas
- Doesn't contract properly (reduced motility)
- It floats and gets **displaced**, leading to **indigestion, reduced appetite, and milk drop**

✅ Prevention:

- Maintain **forage-to-concentrate balance** during transition
- Feed **TMR (Total Mixed Ration)**
- Increase grain intake **slowly after calving** (~0.25 kg/day)
- Avoid sudden dietary changes
- Monitor calcium status in early lactation

Invitro Digestibility

Tilley and Terry **two-stage in vitro digestibility method**, which simulates the digestion process of a ruminant animal in the lab using:

1. **Rumen fluid** → to mimic microbial fermentation (Stage 1)
2. **Pepsin-HCl solution** → to simulate stomach digestion (Stage 2) Apparent Digestibility (if ndf used then tell us about True Digestibility)

Stage 1: Simulated Rumen Digestion

- **Purpose**: Mimics microbial fermentation in the rumen.
- **How**:
  - Incubate the feed sample with **rumen fluid** + **buffer solution + saliva**
  - **Anaerobic conditions** (no oxygen)
  - Temperature: **39°C**
  - Duration: **48 hours**
- **Result**: Microbes break down digestible carbohydrates and protein.

Stage 2: Simulated Abomasal Digestion

- **Purpose**: Mimics enzymatic digestion in the stomach (abomasum).
- **How**:
  - After 48 hrs, add **acid-pepsin solution**
  - Incubate for **another 48 hours**
- **Result**: Simulates further digestion of remaining feed by gastric enzymes.

After using Pepsin: A.D.

$$\text{Apparent Digestibility (\%)} = \left(\frac{\text{Initial Dry Matter} - \text{Residue After Pepsin}}{\text{Initial Dry Matter}} \right) \times 100$$

After using NDF:- T.D

$$\text{True Digestibility (\%)} = \left(\frac{\text{Initial Feed} - (\text{Residue After Pepsin} - \text{Microbial Contamination})}{\text{Initial Feed}} \right) \times 100$$

Type	Based on	Includes Microbial Residue?	More Accurate?
Apparent Digestibility	Total residue after pepsin	✅ Yes	❌ No
True Digestibility	Corrected residue using NDF	❌ No	✅ Yes

Physical processing of roughages

1. Physical Processing of Roughages

a. Dry Processing:

1. **Dehydration**: Drying forage at high temperatures (600–1500°F); **carotene content reduced by 5–15%**.
2. **Baling**: Forage is cut, dried, and bundled for easy storage/handling.
3. **Chopping**: Increases bulk density, improves digestion. Best particle size: **0.25–0.50 inch**.
4. **Grinding**: Fine grinding reduces transit time, contractions, and salivation.
5. **Pelleting**: Compressing ground feed into pellets; reduces chewing, buffering → lowers pH.
6. **Cubing/Wafering**: High-pressure compression of chopped forage → less waste, more intake.

b. Wet Processing:

- **Soaking/spraying** roughages with water to **soften texture**, improve **palatability**, and **digestibility**.

2. Chemical treatment of roughages

Treated with chemicals such as sodium or potassium hydroxide and urea to increase the availability of the nutrients to livestock.

i.Urea treatment: Urea treatment is most economical and easiest.

Method: 4 kg urea dissolved in 40 litres of water and sprayed over 100 kg of straw.

- Urea hydrolysis by urease: Ammonia ^ breakage of lignocellulose bond by ammonia thereby releasing cellulose from lignin bondage for digestion and utilization.
- After 21 days the urea treated paddy straw is ready for feeding.

Advantages:

- Increase the CP and TDN content from 2% to 10% and 45 to 60%, respectively.
- It improves the palatability.
- **Special consideration while feeding urea treated straw:**
  - Not advisable to feed the urea treated straw for calves below 6 months of age.
  - Adaptation period is required.

ii. Beckmann's method. NaOH treatment: 1.2-1.5% sol.

Steps of Beckmann's Method:

1. **Prepare a solution** of **1.2% to 1.5% NaOH**
(That means 1.2–1.5 kg of NaOH in 100 liters of water)
2. **Spray the NaOH solution** evenly over **100 kg of straw**
3. **Mix thoroughly** so all parts are soaked
4. **Stack the treated straw** and cover it (with a plastic sheet or tarp)
5. **Keep it covered for 1–3 days**
(this allows NaOH to react and break lignin bonds)
6. After the treatment period, **air it out or rinse lightly** before feeding (optional if NaOH level is low)

Feature	**Urea Treatment**	**Beckmann's (NaOH) Method**
Chemical used	Urea (4%)	Sodium hydroxide (1.2–1.5%)
Main Action	Releases ammonia → breaks lignin-cellulose bonds	Strong alkali → directly breaks lignocellulose
Improves	Protein content + digestibility	Digestibility only
CP increase	✅ Yes (2% → up to 10%)	❌ No increase in protein
TDN increase	✅ (up to 60%)	✅ (also increases fiber digestibility)
Safety	Safer for handlers and animals	More corrosive & caustic (NaOH) ⚠️
Cost	Cheaper & easier	Slightly costlier + needs caution
Feeding	Not for calves <6 months	Can be used carefully for adults
Field use	Easier for farmers	Needs more handling care & safety