Dairy Cattle Nutrition and Reproduction

REFERENCE MODULE

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Abhay Kumar Dubey

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Importance of Animal Nutrition in Dairy Production

Definition:

- **Nutrients:** The chemical substances found in feedstuffs that can be used and necessary for animal maintenance, production, and health.

The chief classes of nutrients are:
Carbohydrates, Fats, Proteins, Minerals, Vitamins and Water.

- **Nutrition:** Nutrition involves various chemical reactions and physiological processes which transform food into the body tissues and activities.
  It involves digestion, absorption of the various nutrients, their transport to all body cells, and the removal of unstable elements and waste products of metabolism.

Father of Nutrition: Antoine Laurent Lavoisier

The objective of nutrition:

To provide all essential nutrients in adequate amounts and optimum proportions.

Importance of Animal Nutrition in Dairy Reproduction:

- Livestock animals need a balanced diet containing all the necessary nutrients, fluids, minerals, and vitamins.
- Proper nutrition gives your animals the vigour to grow, develop, and reproduce and strong immunity to fight infections.
- Nutrition influences both the quality and composition of milk fat.

Soil, Plant and Animal relationship:

Plant use CO_2, H_2O, Nitrate, and Minerals to form CHO, Fat & Protein and animal build their body. Plants store energy, and animals dissipate energy.

Plants remove minerals from the soil, and animals eat plants, then minerals are returned to the soil via the animal's manure and dead bodies.

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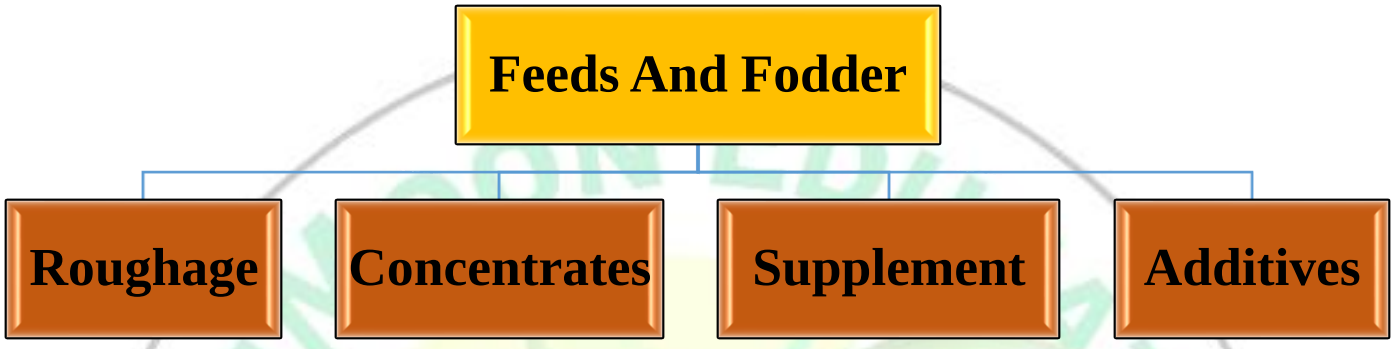
Common feeds and fodder, their classification

Definition:

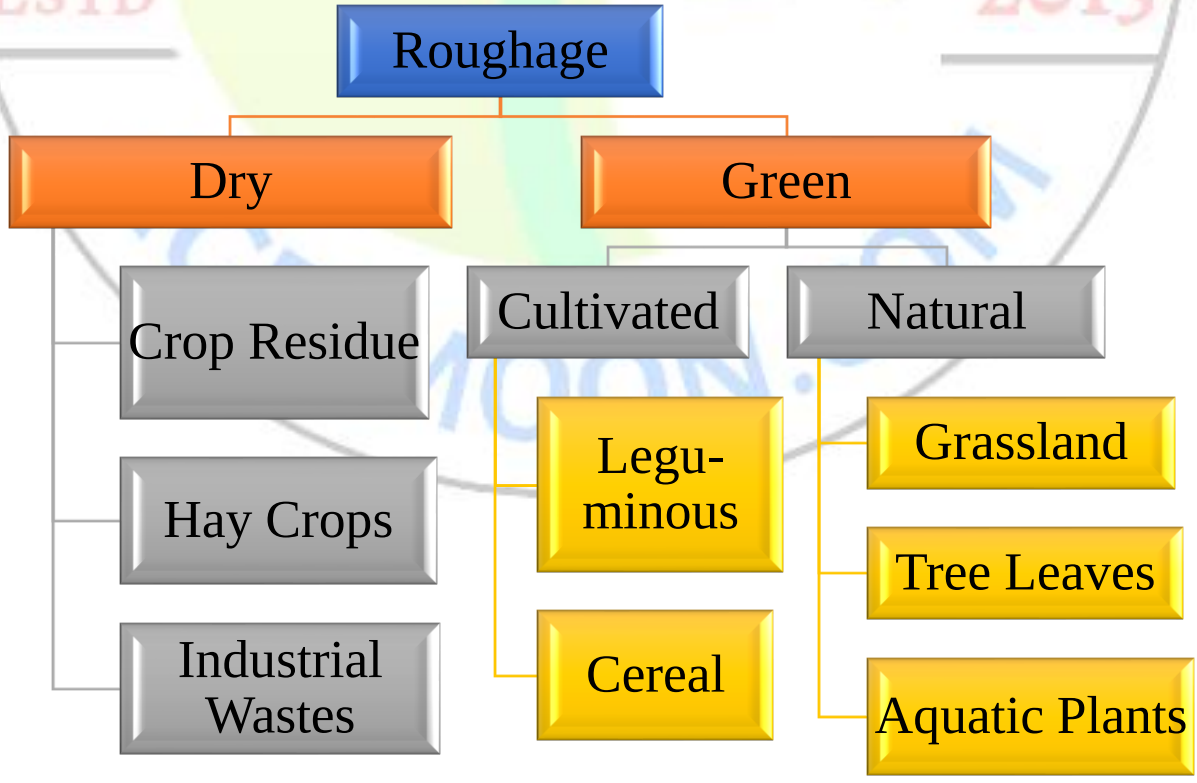
- **Additives:**
  An ingredient or combination of ingredients added to other essential feed mixtures for specific purposes increases feed efficiency or alters metabolism.
- **Complete Feed:**
  A mixture of different feed ingredients formulated to meet all essential nutrient requirements for a given class of livestock.
- **Concentrates:**
  A classification of feedstuffs high in energy and low in fibre is called concentrate.
- **Dry matter:**
  Feed residue is left after all moisture has been removed by drying.
- **Feed:**
  Food of animals comprises any naturally occurring ingredients or materials fed to animals to sustain growth and development.
- **Feedstuff:**
  An ingredient used in formulating a ration
- **Fodder:**
  Fodder is something which is fed to domestic animals.
- **Gluten:**
  The tough nitrogen-containing substance remains after the flour is washed free of starch.
- **Minerals:**
  Inorganic feed elements are essential for life.
- **Oil Cake:**
  Solid residues of oil seeds are known as oil cake.
- **Roughage:**
  Feed high in fibre tends to be bulky, coarse and low in energy is called Roughage.
- **Supplement:**
  Feed or feed mixture is used to improve the nutritional value of basal feeds.
  A supplement is rich in one or more nutrients combined with other feeds to produce a complete feed.

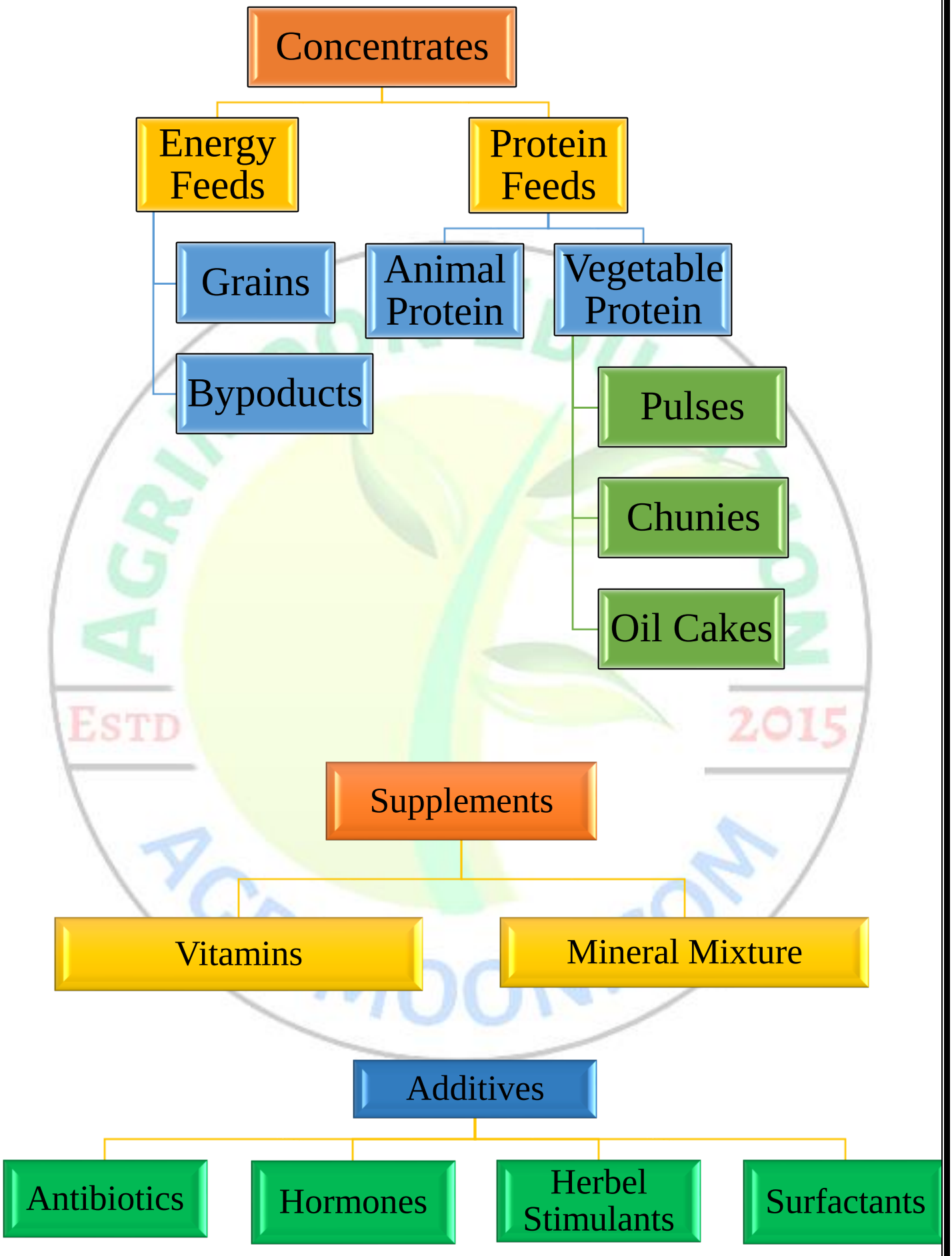
Classification of Feeds:

Classification of feeds is based on bulkiness, which depends upon crude protein content.



- ☞ Roughage is bulky and contains more than 18% crude fibre.
- ☞ The concentrate contains less than 18% crude fibre.




Concentrates
Energy Feeds
Protein Feeds
Grains
Bypoducts
Animal Protein
Vegetable Protein
Pulses
Chunies
Oil Cakes
Supplements
Vitamins
Mineral Mixture
Additives
Antibiotics
Hormones
Herbel Stimulants
Surfactants

Advantages of Feed/Fodder Classification:

- Feed with similar nutritional characteristics is grouped.
- It helps in the selection of feedstuffs for formulating Ration.
- It helps to substitute one feed with another feed from the same group.

Examples of some feed and fodder:

- ☞ Dry Roughage
  - Crop residue: Paddy Straw, Maize Stover
  - Hay Crops: Oats, Cowpea, Berseem, Lucerne
  - Industrial Wastes: Bagasse, Sunflower head, Tea leaves wastes
- ☞ Green Roughage
  - Leguminous: Lucerne, Berseem, Cowpea
  - Cereal: Grasses, Maize, Oats
  - Grassland & Pasture Dub grass
  - Tree leaves: Poplus, Subabul
  - Aquatic Plants: Water hyacinth, Duckweed
- ☞ Energy Feeds
  - Grains: Maize, Oats, Barley
  - By-products: Wheat bran, Rice bran, Rice polish, Molasses
- ☞ Protein Feeds
  - Animal Protein: Meat meal, Bone meal, Blood meal, Fish meal
  - Vegetable Protein:

    Pulses: Gram, Pea, Moth, Cowpea etc.

    Chunnis: Arhar Chunni, Gram Chunni, Moong Chunni

    Oil Cakes: Ground nut cake, Til cake, Mustard Cake

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Seasonal availability of feeds and fodder and its importance for livestock production.

Introduction:

India has a wide variety of climatic conditions. Different areas of our country face many variations in climate in a day. So, feed and fodder are significant problems for our livestock. Mainly during the dry season (July to October), there is a lack of availability of green feeds to animals. Dairy farmers usually store maize stover for the dry season for their cattle.

In the wet season, grasses like Natural pasture and Napier grass are the most important feed for our livestock.

Some Seasonal Fodder Crops:

- **Kharif Crops** : Jowar, Bajra, Maize, Cowpea
- **Rabi Crops** : Oats, Berseem
- **Fodder Grasses** : Napier, Guinea, Para, Anjan
- **Fodder Trees** : Babul, Subabul, Sesbania
- **Improved Begums :** Berseem, Lucerne

Importance of Feed and Fodder for livestock:

Dairy farmers keep livestock to obtain milk, wool, meat etc. Feed is the source for production for all such products and for producing offspring. As we know, food is vital for all living organisms. Such as feed and fodder as necessary for keeping our cattle healthy and strong.

Without proper feed, animals cannot grow well, cannot keep good health, nor can they produce products and young ones properly. That is why we must feed animals with nutritionally balanced and adequate quantities of feedstuffs.

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Weende system of analysis of feeds & fodder.

Introduction:

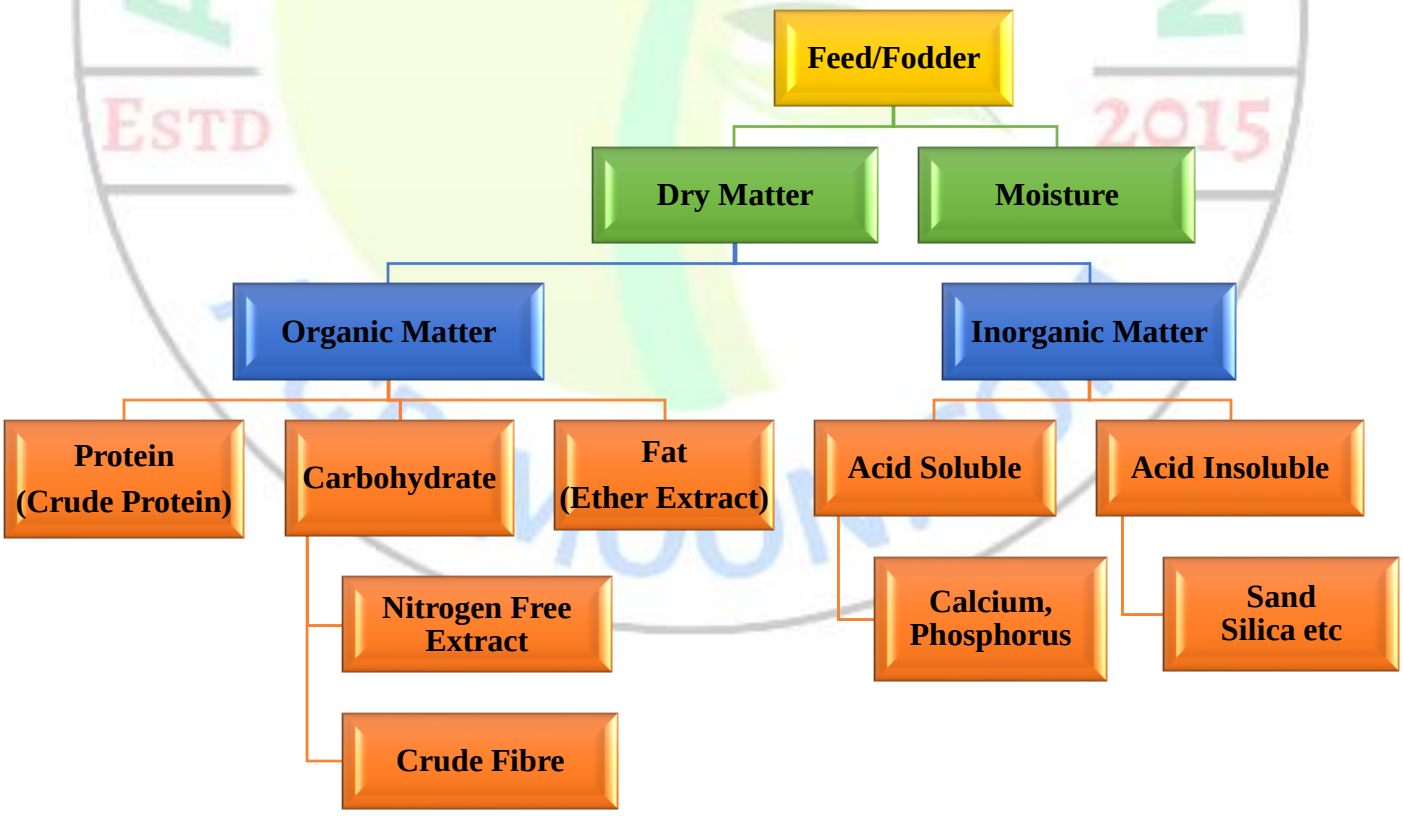
Henneberg (1825-1890) and Stohmann (1832-1897) at the Weende experiment station in Germany proposed a method for chemical analysis of feeds and fodders around 1860.

In this method, various nutrients with some common properties were grouped together and analyzed. These nutrients are known as "Proximate Principles of Feeds"; the method is known as Proximate analysis of feeds.

In this method, feedstuff is analyzed into six fractions, namely:

1. Moisture
2. Crude protein
3. Ether extract
4. Crude fibre
5. Nitrogen free extract
6. Total ash

Proximate Analysis of Feeds/Fodders



1. **Moisture (Water):**
   The moisture is determined as the loss in weight, which results from drying a known weight of feed to constant weight.
   - ★ It gives information about bulk storage of feed. (Feed containing more than 15% water is unsuitable for bulk storage. Because there will be the growth of moulds.)
   - ★ It gives information about feeds' characteristics, whether succulent or dry.
   - ★ It helps in the purchase of feed material.
   - ★ It helps in the preparation of good fodder.
2. **Crude Protein:**
   The nitrogen content of the feed is determined for the estimation of crude protein. The percentage of nitrogen is multiplied by a factor of 6.25 to get the amount of protein present in the feed.
   Generally, protein contains 16% nitrogen.
   - ★ Determination of crude protein in fed is important because feedstuffs are classified based on protein content as leguminous or non-leguminous.
   - ★ It gives information about the digestible energy content of the feed.
3. **Ether Extract:**
   The ether extract fraction is determined by subjecting the feed to a continuous extraction with petroleum ether or other fat solvents for a definite period.
   - ★ By determining ether extract, we can know the relative energy value of feed. Besides giving energy value, it also supplies essential fatty acids like linoleic, linolenic and arachidonic acid.
4. **Crude Fibre:**
   Crude fibre is determined by boiling the residue left after estimating ether extract from the feed sample. The residue is first boiled in 1.25% acid for ½ hour. Then, dry the residue in 1.25% alkali for ½ hour and ignite it. The loss in weight during ignition is the amount of crude fibre present in a sample.
5. **Total Ash:**
   It is determined by ignition of a known sample quantity at 600°C for 2 hours. The residue left after ignition is the total ash present in the sample.
   - ★ It helps in the estimation of NFE by subtraction.
   - ★ By determining insoluble acid ash, we can know the quality of a feed.
6. **Nitrogen Free Extract:**
   It is determined by subtracting the total of % moisture, %CP, %CF, %EE and %Total Ash from 100.
   - ★ It is the soluble portion of carbohydrates.
   - ★ It gives information about the soluble portion of carbohydrates.

Limitation of Weende's System of Feed Analysis:

- It does not partition biological materials into well-defined chemical constituents.
- The fibrous fraction lignin is partly dissolved in sodium hydroxide solution and hemicellulose by both acids and alkali solution.

Balanced Ration and its characteristics.

Introduction:

1. **Balanced Ration:** A 24-hour feed allowance that provides an animal with appropriate amounts and proportions of all nutrients to keep the animal in its form to perform best in respect of production and health.
2. **Ration:** The 24-hour feed allowance for an individual animal.
3. **Diet:** A regulated selection of feed ingredients or a mixture of ingredients, including water, which animals consume on a prescribed schedule.

Characteristics of a ration:

- Liberal feeding
- Individual feeding
- Properly balanced
- Palatable
- Variety of feed in the ration
- The ration should be excellent and sound
- Contain enough mineral matter
- Avoid sudden changes in the diet
- Feed must be adequately prepared
- It should not be too bulky
- The economy in labour and cost

Ration Formulation:

Ration formulation is a process by which different fed ingredients are combined in a proportion necessary to provide the animal with the proper amount of nutrients needed at a particular production stage.

It requires the knowledge about

- Nutrients
- Feedstuffs
- Animal

Factors to be considered in ration formulations:

- Acceptability to the animal- the Ration formulated has to be palatable.
- Digestibility- The nutrients in the feed should be digestible and released into the gastrointestinal tract to be utilized by the animal.
- Cost- The requirement of the animal can be met through several combinations of feed ingredients. The minor cost ratio should ensure that the tile requirements of the animal are met, and the desired objectives are achieved.
- Presence of anti-nutritional factors and toxins. The presence of anti-nutritional factors in the feed affects the digestion of some nutrients and makes them unavailable to the animal.

Scientific Method for Ration Formulation of Cattle:

Cattle will generally consume 2.0 to 2.5Kg of Dry Matter per 100Kg Body Weight.

Buffalo and cross breed will generally consume 2.5 to 3.0 Kg of Dry Matter per 100Kg Body Weight.

1Kg Milk needed 400g of extra concentrate for a cow.

For buffalo, every 2kg of milk needed 1kg of concentrate.

In the scientific feeding system, we have to feed only two times because our dairy cattle do rumination for at least 8hrs and a maximum of 12 hours.

For the scientific method, we first need to remember the following points:

- Specie of cattle
- Weight of cattle

% Body weight plays a significant role in finding the percentage of dry matter for 24 hours.

Requirement of per cent dry matter for different species:

- Zebu: 2%
- Cross Breed: 2.5%
- Buffalo: 3%

★ For every 10kg of dry matter, we feed 1/3 concentrate (3.33 Kg) and 2/3 (6.66Kg) Roughage.

★ In 2/3 of Roughage, we have to feed 2/3 Dry roughage (4.44Kg) and 1/3 Green Roughage (2.22Kg)

Question:

1. A zebu cow has a body weight 400Kg and gives 10Kg Milk (Milk fat 3.5%). Then formulate a ration with wheat straw and concentrate feed.

Solution:

Given,

Weight of cow = 400Kg
Milk Production = 10Kg
Milk Fat = 3.5%

We know that we require 2% of dry matter of its body weight for zebu cow.

∴ DM = 400 x 2/100 = 8Kg

Partitioning of dry matter:

As we know that for every 10kg of dry matter, we feed 1/3 concentrate and 2/3 Roughage.

∴ DM from concentrate = 8 x ⅓ = 2.6 Kg

Further, we feed (8 – 2.6 = 5.4) Kg of Roughage.
Roughage is also partitioned into Dry and Green.

∴ For Dry Roughage

5.4 x ⅔ = 3.6 Kg

∴ For Green Roughage

5.4 x ⅓ = 1.8Kg

So, we need 3.6Kg Dry and 1.8Kg Green Roughage in Dry form in ration Formulation.

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Storage and conservation of Roughage through silage and Hay and their uses in livestock feeding.

Introduction:

Feed quantity and quality fodder to the livestock. In the rainy season, green forage is abundant in quantity, which is not adequately utilized. Green forages can be conserved in the form of Hay and silage to feed greens during the lean period.

1. **Hay:** Hay is the product obtained by drying in the sun or shade, tender stemmed leafy plant material in such a way that they contain not more than 12-14% moisture.
2. **Hay Additives:** Organic acids or acid-forming compounds designed to allow Hay to be harvested at higher-than-normal moisture contents by preventing the microbial activity responsible for spoilage.
3. **Ingredients:** Any of the feed items that a mixture is made of.
4. **Silage:** Feed preserved by an anaerobic fermentation process.
5. **Silage Additives:** Substances are added during the ensiling process to enhance the correct and rapid fermentation of the feed.

Silage Preservation:

Silage is the material produced by controlled fermentation of forages or crop residue with high moisture content.

Ensiling is the term for all physical and chemical changes that occur when forage with sufficient moisture content is stored anaerobically for silage preservation.

An airtight to a semi-airtight structure designed to preserve and store high moisture feeds as hay is known as a **silo**.

The ideal characteristics of the material for silage preservation are: Dry matter content should be 25-35% and an adequate level of the fermentable substrate 8-10% Dry Matter in the form of water-soluble carbohydrate.

Steps of Silage Formation:

- ∇ Harvest forage at the proper stage of maturity.
- ∇ Chop to the proper length.
- ∇ Control of moisture content in raw materials.
- ∇ Control of water-soluble carbohydrates
- ∇ Filling, Packing and Sealing
- ∇ Additives
- ∇ Feed to cattle

Types of silos:

a) Tower silo
b) Cellar silo
c) Trench silo
d) Stack silo
e) Plastic silo

Losses during silage making:

The objective of the conservation of forage is to preserve as much of the crop nutrients as possible. However, during ensilage, loss of nutrients occurs.

There are five sources of loss:

a. Field losses
b. Oxidation losses
c. Fermentation losses
d. Effluent losses
e. Aerobic deterioration

Evaluation of Silage quality:

High-quality silage is a stable feed made from high-quality pasture, preserved in the absence of oxygen by a high-quality fermentation to minimize any loss of feeding value. It is impossible to produce high-quality silage from low-quality pasture, no matter how good the fermentation is.

- Quality of the ensiled pasture.
- Quality of the fermentation
- Colour of silage
- Smell of silage
- Moulds and Yeast

Summary of silage quality

Parameters	Very Good	Good	Fair	Poor
pH	3.5-4.2	4.2-4.5	4.5-4.8	<4.8
Butyric Acid	No	Trace	Little	High
Ammonical Nitrogen (% of N)	<10	10-15	15-20	<20
Colour	Yellow Green	Green or Brown	Tobacco brown to dark brown	Black
Fleig's Value	44-50	30-36	20-29	<19

Hay:

Hay refers to forage harvested, dried, and stored as 85-90% dry matter. Hay is a dry leafy fodder, green in colour and free from moulds. It should contain less than 15% moisture.

Principles of Haymaking:

Haymaking aims to reduce the moisture level of the green crop to a level low enough so that it can be safely stored in mass without undergoing fermentation or becoming mouldy. Drying of forage inhibits the action of plant and microbial enzymes. The process of drying the green crop without significant changes in aroma, flavour and nutritional quality of forage is called "curing". This involves reducing the moisture content of green forages so they can be stored without spoilage or further nutrient loss. Green forage with 80-85% dry matter preserves most nutrients.

Suitable crops for making Hay:

Crops with thin stems and more leaves are better suited for haymaking as they dry faster than those with thick stems and small leaves.

Examples: Oats, Lucerne, Maize, Sorghum, Napier grass, Cowpea etc.

Steps for making Hay:

- ∇ Forage is cut before it fully matures to maximize its nutritional value.
- ∇ Leaves are more nutritious than the stems, so when cutting forage, it is essential to cut with as much leaf and as little stem as possible.
- ∇ Dry the forage at 15 per cent moisture content.
- ∇ Chopping forage into small pieces after drying.
- ∇ Store on a well-drained site.

Hay Quality:

- It should have a typical aroma of the fodder from which it has been prepared.
- It should be free from foreign materials.
- It should maintain the leafiness of original fodder.
- This should possess reasonable green colour.
- This should be palatable to animals.

Factors affecting hay quality:

- **Stage of maturity**
- **Leafiness**
- **Colour**
- **Foreign materials**
- **Smell**

Characteristics of Good Quality Hay:

- Hay should be nutritious.
- Good Hay should be leafy.
- Hay should be green in colour.
- Hay should be soft and pliable.
- Hay should be free from weeds and stubbles.
- The moisture content in Hay shouldn't exceed 15%.

Benefits of Hay:

- It can be kept for a more extended period.
- Availability of nutritious feed to the animal during the scarcity of fodder

Storage of Hay:

- Hay must be stored in a dry environment.
- Hay can be baled and stored under cover or can also be stored by creating hay stacks.

Objectives of making Hay and Silage:

The objective behind making the Hay and silage is to preserve forage resources for the dry seasons or winter to ensure continuous regular feed for livestock, either to sustain growth, fattening or milk production, or to continue production under challenging periods when market prices are highest.

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Nutrient requirement for the calf, milking phase, transition phase, pregnancy phase of Cattle & Buffalo.

Introduction:

The high-producing dairy cow requires a diet that supplies the nutrients for high milk production. Carbohydrates, amino acids, fatty acids, minerals, vitamins, and water are all nutrients required by the lactating dairy cow to meet the demand of the mammary gland to produce milk and milk components. However, developing a cow that will produce a high yield begins with the nutrition of the calf and heifer.

Nutrient requirement for calf:

Proper management of young calves is a prerequisite to any dairy farm's success. An optimal level of nutrition in early life favours faster growth and maturity. Calves should be reared carefully to obtain optimum gain in body weight to attain about 70-75 per cent of mature body weight at puberty. Poor feeding of young calves leads to higher age at first calving and overall loss of productivity in the life span.

Essential aspects of calf feeding:

- Colostrum feeding within half an hour of birth.
- Feeding whole milk/milk replacer to calves.
- Introduction of calf starter/good quality grain from 2nd week onwards.
- Good quality hay should also be given to calves
- Deworming and vaccination

Requirement of nutrients for maintenance and production

Different Phases	DCP	TDN
Maintenance	2.84g / Kg $W^{0.75}$	34g / Kg $W^{0.75}$
Heifers		
Milking Phase	45g/litre of FCM	315g/litre of FCM
Transition Phase		
Pregnancy Phase (Last 2 Months)	0.14Kg/day	0.70Kg/day

** FCM = Fat Corrected Milk

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COMPOUND CATTLE FEEDS

(AS PER BUREAU OF INDIAN STANDARD (BIS) SPECIFICATIONS)

Nutrients (%)	Type-I	Type-II	Calf Starter	Calf Grower
Moisture (Max)	11	11	10	10
Crude Protein (Min)	22	20	23-26	22-25
Ether Extract (Min)	3.0	2.5	4.0	4.0
Crude Fiber (Max)	07	12	07	10
Acid Insoluble Ash (Max)	3.0	4.0	2.5	3.5
Salt as NaCl (Max)	2.0	2.0	---	
Calcium (Min)	0.5	0.5	---	
Available Phosphorus	0.5	0.5	---	
Vit A (IU/kg)	5000	5000	---	

CALF STARTER

Calf starter is a balanced concentrate mixture, which is fed to the calves from 10th day of age to supplement the nutrients, when they are raised on limited milk intake.

Ingredients	Parts (kg/100 kg)
Maize/ wheat shorts/ barley/ oats	50
Groundnut cake/ soybean meal	30
Skimmed milk powder	07
Wheat bran/ rice bran	10
Mineral mixture	02
Common salt	01
Vitamin A and D supplement (g/q)	10
Available Phosphorus	0.5

CONCENTRATE MIXTURE

It is a mixture of different concentrate feed ingredients like cereal grains (maize, rice kani etc), cereal grain byproducts (rice polish, brewers' dried grains etc), oil cakes (soybean meal, groundnut cake, cotton seed cake etc), mineral mixture and common salt in different ratios as per the requirement.

Feed Ingredients	Parts by Weight (kg)				
	Ex-1	Ex-2	Ex-3	Ex-4	Ex-5
Maize grain (ground)	35	35	35	35	35
Soybean meal	15	20	---	10	10
Groundnut cake	15	---	24	---	15
Cotton seed cake	---	12	24	27	14
Rice polish	32	30	14	---	23
Brewers' dried grains	---	---	---	25	---
Mineral mixture	02	02	02	02	02
Common salt	01	01	01	01	01

FEEDING SCHEDULE

a.Feeding schedule for calves (per day)

Age	Whole milk (liters)	Calf starter (kg)	Legume (Cow pea) green fodder (kg)
1-3 days	3.0 (colostrums)	---	---
4-15 days	3.0	---	---
16-30 days	3.5	Ad lib.	Ad lib.
1-2 months	2.5	0.25	Ad lib.
2-3 months	2.0	0.50	2-3
3-4 months	1.0	0.75	5-7

b.For heifers (per day)

Age	Diet (kg)	
	Maize/ CO-3/ CO-4 Fodder	Concentrate Mixture
4-6 months	6-7	1.5
6-12 months	12-15	1.5
12-18 months	20-25	1.0
18-30 months	25-30	1.0
Pregnant (last quarter)	30-35	2.0

c.For pregnant animals 8-10 weeks before calving

Feeds	Quantity (kg/ day)
Maize/ CO-3/ CO-4 fodder	30-35
Paddy straw/ Maize stover/ Kadaba Kutti/ Dry karad grass	5
Concentrate mixture	2-3

d. For lactating animals

Rations for lactating animals (for cows producing up to 7 kg milk and buffaloes producing up to 5 kg milk per day)

Feeds	Quantity (kg/ day)
Maize/ CO-3/ CO-4 green fodder	10-20
Paddy straw/ Maize stover/ Kadaba Kutti/ Dry karad grass	7-8
Concentrate mixture	3-4

RATIONS FOR LACTATING ANIMALS

1. For Cows producing more than 7 kg milk &
   Buffaloes producing more than 5 kg milk per day

(i) If the dairy animal i.e. cows producing more than 7 kg milk and buffaloes producing more than 5 kg milk per day, then provide extra concentrate mixture @ 400g per kg increase in cow milk and 500 g per kg increase in buffalo milk.

(ii) If the dairy animal is pregnant, then besides the maintenance and production requirement, one kg concentrate mixture as pregnancy allowance should be offered extra only in the last three months of the pregnancy.

2. For high producing animals

The high yielding dairy animals need very special feeding strategies. Low quality roughages like straw or stovers should not be offered to high producing animas. The concentrate mixture of high yielders must contain energy and protein rich ingredients like soybean meal, roasted soybeans, by pass nutrients etc. Buffers like sodium bicarbonate, magnesium oxide and vitamin mixture should be added in the diet for better utilization of the feedstuffs. The composition of concentrate mixture for high yielders is presented in below Table .

Concentrate mixture for high yielding animals

Ingredients	kg
Maize	40
Mustard cake	20
Soybean meal	10
Roasted soybean	05
Rice bran	15
Wheat bran/ Deoiled rice bran	07
Mineral and vitamin mixture	02
Common salt	01

IMPORTANT TIPS ON FEEDING OF DAIRY COWS

(i) The green fodder must be chopped before feeding to the dairy cows for better utilization.

(ii) If possible, soak the concentrate mixture in water for 6-8 hours and then feed to the animals.

(iii) The required concentrate mixture, green fodder and straw may be offered either separately or mixing together as total mixed ration (TMR).

(iv) The total ration to be offered daily should be divided and offered twice (morning and afternoon) for better utilization.

(v) Do not feed calcium rich feed ingredients or mineral mixture to the dairy cows 15 days before parturition, as high calcium intake during this period increases the chances of milk fever.

(vi) Provide clean fresh water free of choice to the dairy cows. For easy accessibility, a cemented water tank should be constructed near to the cow shed and the tank should be painted with lime at frequent intervals to make the water clean.

Anatomy of Male and Female Reproductive system of Cow and Buffaloes.

Introduction

Production of dairy animals largely depends upon reproduction. For successful reproduction, the animal should attain puberty and sexual maturity at the right time, insemination or naturally matting at the proper time, conceive, carry the foetus for full gestation, calve normally, start cycling and conceive again at the right time: approximately 6-8 such cycles can happen in the life time of a cow. If there is any break in this cycle, then the reproduction efficiency of the animal and the farm goes down.

Anatomy of Male Reproductive System

The essential components of the male reproductive system are:

- Scrotum
- Spermatic Cord
- Testis
- Duct system
- Accessory sex gland
- Penis and muscle

The male reproductive system is supported by the pelvis and housed internally in the abdomen and outside the abdominal cavity in the groin region. The bull's reproductive tract consists of the testicles, secondary sex organs, and three accessory sex glands. These organs work in concert for the formation, maturation and transport of spermatozoa, which are eventually deposited in the female reproductive tract. The secondary sex organs are the **epididymis, vas deferens** and **penis**. The three accessory sex glands include the **seminal vesicles, prostate** and **bulbourethral gland** (Cowper's gland).

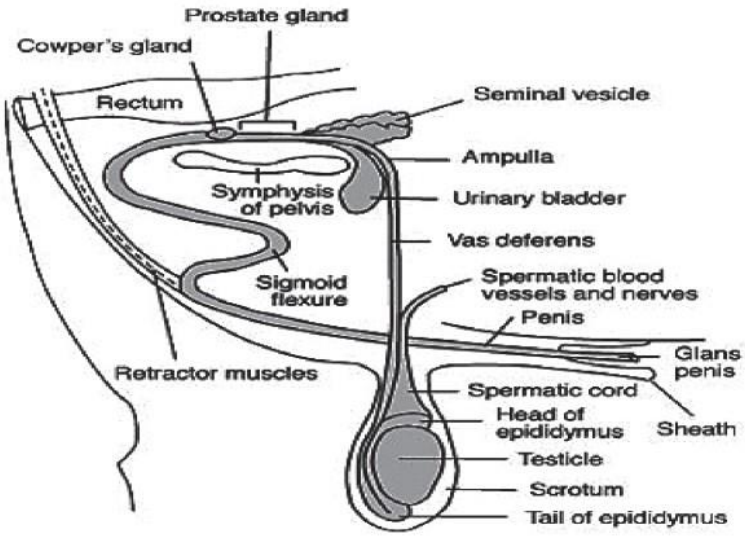
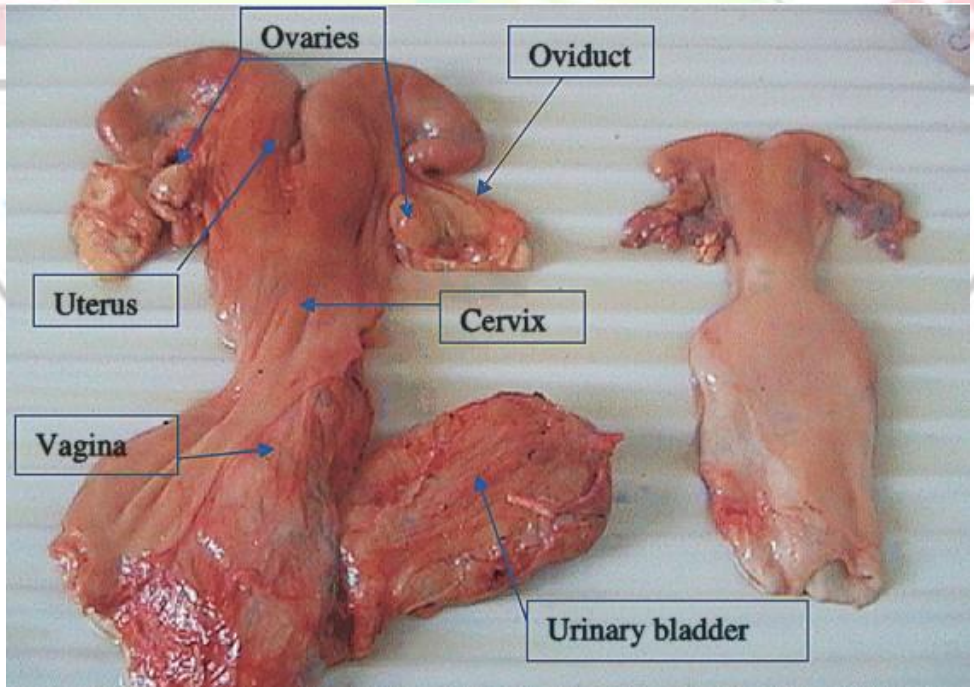


Figure 1: Parts of male reproduction system

Anatomy of Female Reproductive System

The essential components of the female reproductive system are:

- Two ovaries
- Two fallopian tubes
- Uterus
- Cervix
- Vagina
- Vulva



- The vestibule lies between the vagina & vulva. It is susceptible due to nerve innervations.

- The vagina lies within the pelvis between the cranially to the cervix & caudally to the vulva. It generally acts as the birth canal for delivery of the foetus & the act of breeding or service (for the penis of a male during copulation).
- The cervix is a unique structure within the reproductive tract. It is 4 to 5 inches long, and 1 to 2 inches in diameter and lies between the vagina and uterus. This structure is designed to restrict access to the uterus.
- The uterus consists of a body, a neck (cervix) & two horns. The uterine wall consists of a lining of mucous membrane & an outer serous layer of perimetrium and is suspended & supported by the mesometrium.
- Fallopian tubes consist of ampulla, isthmus and infundibulum.

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Basic Concepts of Animal Reproduction

Introduction

Reproduction is one of the essential considerations determining the profitability of cattle production. The reproductive performance of a farm is reflected by the interval between two calves of a cow and how many animals are culled for reproductive reasons. These parameters are directly or indirectly influenced by specific parameters such as heat detection, conception, and breeding period. Reproduction management, in the broad sense, is manipulating all these contributory parameters to achieve a calving interval of 12-13 months, with reproductive reasons contributing less than 8% to the total culling of animals.

Puberty

The term puberty is defined as the achievement of the ability to reproduce. For the female, although the onset of sexual activity (in domestic animals) or first menstrual bleeding is often used as the onset of puberty when a male or female animal can release gametes that can fertilize and characterized by showing the sign of estrus in females and by the presence of sperm in the ejaculates in males has said to reached puberty.

- Age of Puberty

  The age of puberty is different in different animals. The following table shows the age of puberty in different animals in different conditions:

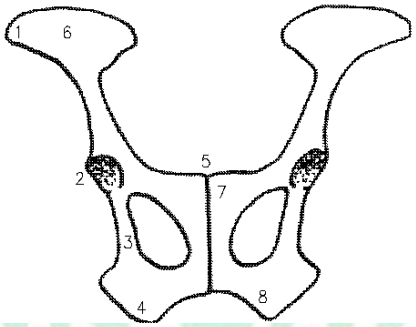
Animal species	Age of puberty (months)
Exotic Cattle	12 - 18
Zebu Cattle	18 - 24
Buffalo	24 - 30
Sheep	04 - 08
Goat	04 - 08
Mare (female horse)	12 - 24
Sow	06 - 10

The age of puberty is affected by many factors. Some important are mentioned below: -

- Hormonal
- Genetic background
- Nutrition
- Environmental factors

Pelvic Bone and Biometry

Pelvic bones include the hip bone, sacrum and coccyx. It forms the base of the spine as well as the socket of the hip joint.



Pelvic bone comprises three bones:

- Ilium
- Pubis
- Ischium

Oestrous Cycle

The Estrus cycle can also be defined as the rhythmic changes that occur in the reproductive system of a female animal, starting from one estrus phase to another. The typical duration of the estrus cycle is 21 days in the cow.

Species	Length of estrous cycle	Proestrus	Estrus	Metestrus	Diestrus	Average length of estrus	Time of ovulation
Cow	21 days (Poly estrus)	3 - 4 days	12 - 24h	3 - 5 days	10- 14 days	18h	10 - 12h after the end of estrus
Buffalo	21 days (Poly estrus)	2 - 3 days	5-27h	3 - 5 days	10- 14 days	20h	33-40h after onset of estrus
Doe	21 days (Poly estrus)	2 - 3 days	24 - 48h	3 - 5 days	10- 14 days	30h	Near end of estrus

➢ <u>The oestrous cycle has four stages</u>

1. Proestrus 3-4 days
2. Estrus 12-24 hrs
3. Metestrus 3-5 days
4. Diestrus 10-14 days

Luteal Phase: 14-18 days

Follicular phase: 4-6 days

- **Proestrus** is an ill-defined period characterized by the growth of graffian follicles and increased estrogen production. This is the period during which the animal prepares himself for mating.
- **The Estrus cycle** is well defined and assumes greater significance as proper detection of estrus is essential for successful AI. This period is characterized by sexual desire and begins with the first acceptance and ends with the last acceptance of the male. The average duration of the oestrous cycle is 21 days.
- **Metestrus** is the transitional period between ovulation and full development of the corpus luteum and lasts for 3-5 days. In cows, capillary bleeding occurs in the uterus and is exerted along with the mucus. This phenomenon is called as post estrual or metestrual bleeding.
- **Diestrus** is the most prolonged period of the oestrous cycle characterized by the maturation of the corpus luteum. Under the influence of progesterone, endometrial gland hypertrophy and increased endometrium thickening occur to nourish the embryo. The cervix is closed, vaginal mucus is scanty and vaginal mucus membrane is pale. Females in diestrus do not display sexual receptivity.
- **Gametogenesis**

  The first phase in the sexual reproduction of an organism is gametogenesis. The process of formation of gametes from the germ cells in the testes and ovaries is known as gametogenesis. This process is termed spermatogenesis in males and oogenesis in females.

Oestrus sign in cows and Buffaloes

S.No.	Heat Signs	Cows	Buffaloes
1	Excitements	Very Clear	Little Excitements
2	Bellowing/crying	Very Pertinent Signs	Little
3	Mounting to Other animals	Increased	Not present
4	Stand to be mounted by other animals	Very common	Not clear
5	Licking of other animals	Increased	Not clear
6	Swelling of Vulvae	Present	Present
7	Transparent mucus discharges from the vagina	Very common	Lesser than cows
8	Redness/pinkish of Vaginal Mucosa	Very common	Lesser than cows
9	Milk production	Decreased	Decreased
10	Frequent urination	Very common	Very common with the presence of a white mark
11	Moving of tail	Very common	Lesser
12	Off fed	Common	Common

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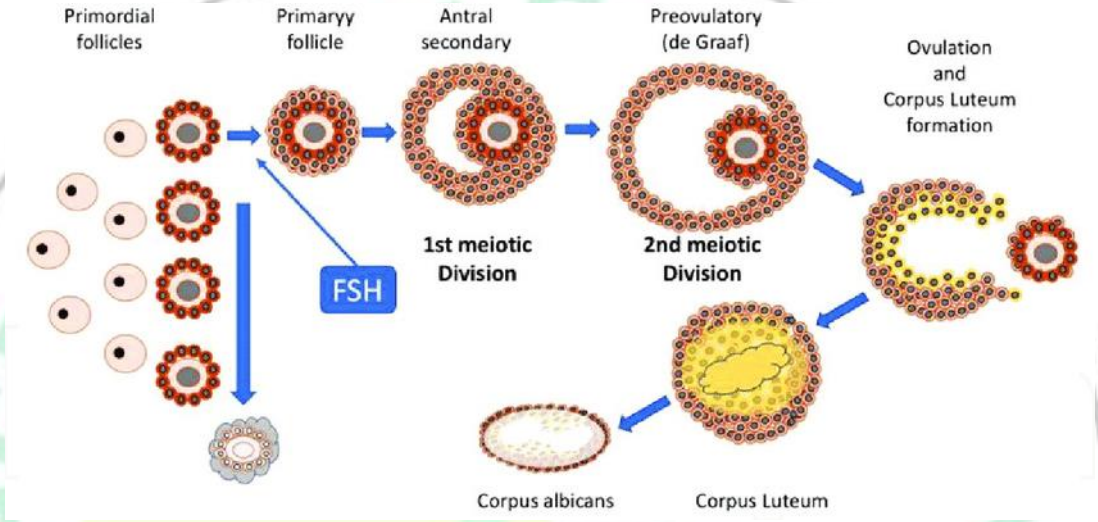
Pregnancy and its Diagnosis

Folliculogenesis

Folliculogenesis is the term which means the maturation of the ovarian follicle. It describes the progression of the number of small follicles into large preovulatory follicles that occur in part during the reproductive cycle.



Fertilization

Fertilization occurs when a sperm fuses with the female act during intercourse and further forms an egg implanted in the female's uterus.

Gestation

The period from fertilization to parturition is known as the gestation period. Or the condition of females when developing young is present in the uterus. This is usually 279- 287 days for cows and 281-334 days for buffalo.

Parturition

It is the physiologic process by which the pregnant uterus delivers the fully grown fetus and placenta from the maternal organism on the completion of the standard pregnancy period.

- Stages of Parturition
  - Preliminary stage
  - Dilation of the birth canal (2-6 hrs)
  - Expulsion of foetus (0.5 – 1hrs)
  - Expulsion of membranes (6 – 12 hrs)

Pregnancy Diagnosis

- It helps in the identification of non-pregnant animals which can be treated or rebred at the earliest
- It is required for certifying the animals for sale purposes.
- It helps in sound and economic management
- It reduces economic loss in breeding Programme using expensive hormonal techniques.
- It helps to prevent the lapse of one season for breeding in seasonal breeders.

➢ Indication of pregnancy

- ☞ Presence of non-echogenic area in transverse as well as in longitudinal image.
- ☞ Embryonic heartbeat
- ☞ Placental membranes containing embryo and fluid
- ☞ Placentomes in later stages

➢ Methods of Pregnancy Diagnosis

- ☞ Ultrasonography
- ☞ Abdominal ballottement
- ☞ Chemical Test with $BaCl_2$
- ☞ EPF

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Artificial Insemination

Artificial Insemination

Artificial insemination is the process of collecting sperm cells from a male animal and manually depositing them into the reproductive tract of a female.

'or'

Artificial insemination is the process by which semen is deposited inside the female's reproductive tract by means of instruments.

AI is the first great biotechnology applied to improve the reproduction and genetics of farm animals. AI is the primary tool for animal breeders to propagate superior germplasm more quickly and efficiently. AI technology is the prime factor behind the dairy industry's success and India's top position in milk production.

History and Development

Artificial insemination is a technique in which semen with living sperm is collected from the male and introduced into the female reproductive tract properly with the help of instruments.

- The first scientific research in A. I of domestic animals was performed on dogs in 1780 by the Italian Scientist Lozano.
- In 1936, Brownell was inseminating cows in the Cornell herd.
- In 1938, A. I Cooperative was established in New Jersey, modelled after Danish System.

Advantages

- Increase the usefulness of a superior sire to an extraordinary degree.
- Services of superior sire are greatly extended.
- It helps in better record keeping.
- Old, heavy and injured sires can be used.
- There is no need to maintain a breeding bull for a herd; hence the cost of maintenance of a breeding bull is saved.
- Increases the rate of conception.

Disadvantages

- Requires well-trained operations and unique types of equipment.
- Requires more time than natural services.
- Lack of understanding of A.I.
- Markets for bulls will be reduced.
- Necessities the knowledge of the structure and function of reproduction.

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Infertility in Dairy Cattle

- **Infertility**
  Reproductive disorders and associated infertility are when dairy cattle do not become pregnant. It is a temporary disturbance in reproductive function.
- **Common reproductive problems in dairy animals**
  Reproductive problems can be divided into major categories: functional disorder, infectious disorder, genetic disorder and other miscellaneous disorders.
- **Causes of Infertility**
  The causes of infertility in dairy animals are many and can be complex. Infertility causes in farm animals due to various factors such as:
  - Nutrition
  - Physiological disturbance
  - Infections
  - The disease of genital organs
  - Anatomical cause
  - Faulty AI technique.
- **Treatment of Infertility**
  - Inseminate at the appropriate time of heat.
  - Provide proper nutrition right from the birth of the animal.
  - Provide adequate quantities of the mineral mixture.
  - Animals with anatomical conditions may not conceive.
  - Consult a veterinarian if a regularly cycling animal has not conceived even after three inseminations to identify the problem.

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Semen Evaluation

Semen

Semen is a complex substance created by the male reproductive organs. The fluid is made mainly of water, plasma, and mucus. It also contains 5 to 25 calories and comprises small amounts of essential nutrients.

Semen Collection

Semen from a bull can be collected approximately 2-4 times a week. Various methods of collection of semen have been devised from time to time. The new modern techniques have gradually replaced the older unsatisfactory methods.

From bulls' semen is collected by three methods, namely;

- Use of artificial vagina
- By electro-stimulation method
- By massaging the ampullae of the ductus difference

The ideal method of semen collection is the use of an artificial vagina which is safe for the sire and the collector.

Artificial Vagina

AV consists of a hard spongy rubber cylinder or hose, latex liner, neoprine liner or other suitable material that is non-toxic, non-irritant sterilizable, director cone, collection tube and tube cover.

- Parts of Artificial Vagina
  - Heavy rigid rubber 2-inch is loose, open at both ends with nostle for air and water in and outlet.
  - Semen receiving cone or rubber cone.
  - Semen collection tube made of glass or plastic graduate in cc.
- Semen Collection Method

  The cow or dummy is secured in service creation. The artificial vagina assembled is held at a 45º angle from the direction of the penis, and the thrust is at that angle. The artificial vagina is held with the left hand by a right-handed person. When the bull mounts the cow, the sheath of the bull will be graphed by the operator, directing the gland penis into the artificial vagina, and then the bull gives a thrust to ejaculate.

  The operator should evince care so as not to touch the exposed part of the penis. After the bull dismounts, the artificial vagina is removed from the penis, and the air vent is opened to release the pressure from a jacket.

  The water from the jacket is also drained by opening the nostle. This allows the ejaculation to flow from the cone to the semen collection tube. The semen collection tube is detached from the cone, plugged with cotton wool and taken to the laboratory for examination. The rubber cone and the semen collection tube can be protected from external contamination, heat, or higher by covering them with an insulation bag and zip.

- **Semen Evaluation**

  It is economically and biologically crucial that only semen with high fertilizing potential be used in AI programmes. Generally, in most of the semen stations in the country, the ejaculate quality is assessed to determine its suitability for preservation. These tests include the following.

  Immediately after the collection, the ejaculate is examined for colour, volume, mass activity and contamination, if any. Then the sperm motility is estimated using a microscope. We are estimating the proportion of live spermatozoa, membrane intact spermatozoa and sperm abnormality is advised.

  So, semen from the bull is evaluated for its volume, sperm cell concentration, motility, viability, morphology and ability to withstand freezing and thawing procedures. The quality of semen from a single bull can change over time. Computer-assisted semen analyzers (CASA) are commonly used to quantify different motility parameters.

- **Semen Processing**

  Bovine semen is examined in the lab and processed for further use. The expert veterinarian doctors observe the quality and motility of semen, and then it is loaded into different bags for performing the A.I

- **Semen Storage**

  The sperm quality of bovine semen is not affected by long-term storage at -196°C. Semen is stored in a liquid nitrogen refrigerator tank to maintain its fertility rate and motility of semen. The level of liquid nitrogen should be regularly checked.

- **Selection of Bulls for Semen Production**
  - A qualified veterinarian should physically examine bulls to ensure that bulls do not show any clinical symptoms of the disease.
  - The size of the testis is correlated with sperm production of offspring and the age of puberty.
  - It is essential to measure the scrotal circumference.
  - Healthy and high-yielding bulls' semen are necessary to store.
- **Management of Bulls for Semen Production**
  - Identification of bull.
  - Regular health check-ups by the labours or attendants.

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Mastitis and Its Management

Introduction

Mastitis is the inflammatory condition of the mammary gland and udder tissues. It usually occurs as an immune response to bacterial invasion of the teat canal by various bacterial sources on the farm. It can also occur due to chemical, mechanical, or thermal injury to the cow's udder. It manifests the changes in the milk colour and consistency.

- Some important points to be remembered:
  - Milk yield reduces abruptly and results in heavy economic losses.
  - High-yielding dairy cows are more commonly affected than lower yielders.
  - Exotic and cross-breed cows are more prone to mastitis than Indian Zebu Cows.

Causes of Mastitis

- Many species of microorganisms have been implicated as causes of mastitis. They are bacteria, fungus, Mycoplasma and virus.
- The most critical bacterial organism causing mastitis is *Staphylococcus aureus*, *Mycobacterium bovis; E.coli; Pseudomonas pyocyaneus.*
- The infection reaches the mammary gland through the teat canal.

Symptoms of Mastitis

- The udder is swelling as a hard mass.
- Swollen udder with hot and pain while touching it.
- The animal will not allow touching the udder and kick while touching it.
- Swollen and reddening of teats.
- Milk mixed with blood.
- Milk mixed with yellow or brown fluid with flakes or foul-smelling clots.
- Reduction in milk yields
- Increase in body temperature.

Management

Treatment

- The milk from the infected teat should be milked out daily three times and disposed of safely outside.
- NSAIDs are widely used for the treatment of mastitis.
- Aspirin-like drugs reduce the inflammation and pain associated with mastitis.
- It can be treated by intramammary or systemic antibiotics or a combination.

- **Prevention**
  - Hygienic teat management
  - Prompt identification and treatment of clinical mastitis cases
  - Dry cow management and therapy
  - Culling chronically affected cows
  - Regular testing and maintenance of the milking machine
  - Good record keeping

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