**ANIMAL NUTRITION**

Animal nutrition refers to the processes by which the animals can obtain the food materials they require for body nourishment.

**Reasons for feeding animals**

To enable the animal grow

To increase disease resistance in farm animals

To enable animals give high quantity of products

To improve breeding efficiency in animals

To obtain nutrients needed to repair worn out cells and tissues.

**Terms used in livestock nutrition.**

Concentrates, these are feedstuffs that are rich in nutrients particularly proteins, carbohydrates, fat or minerals and have a low moisture and fibre content.

Crude protein, this is the amount of protein contained in a feedstuff.

Biological value, this refers to the proportion of nitrogen that is absorbed from food and used in the manufacture of body protein.

Digestibility, this refers to the proportion of a feedstuff that is retained by the body of an animal after the rest of that feed has been lost through faeces, urine and gasses.

Digestible crude protein, this is the proportion of the protein in a feedstuff that can be digested.

Total digestible nutrient, this refers to the sum of all the nutrients contained in a feedstuff that can be digested.

Ration, a ration is a mixture of feedstuffs that make up the daily diet which meets the nutritional requirement of a particular group of livestock.

Types of rations.

Maintenance ration, refers to the amount of feed that is required by an animal to stay alive without gaining or losing weight.

Production ration, is the amount of feed required by a productive animal in order to maintain itself as well as produce products such as meat, milk, wool and eggs.

Palatability, this is the relative attractiveness of a feed and its pleasantness to the taste.

Roughages, roughages are feeds that contain high fibre content and their digestibility is low. They include crop residues, grasses and hay.

Succulent feeds, this is a feedstuff with high moisture content (about 80% moisture). They are highly digestible.

Starch equivalent, this is the amount of pure starch which has the same energy as a 100kg of a particular feed.

**COMPOSITION OF FEEDS**

Feedstuffs contain the following nutrients

Water

Proteins

Carbohydrates

Lipids

Minerals

Vitamins

**WATER**

**Importance of water**

It acts as a solvent in which many substances found in the body are dissolved.

It acts as a medium in which chemical reactions take place

It softens and lubricates the food in the digestive tract.

It transports digested food to different parts of the body to be utilized

It helps in the removal of waste products from the body

It lubricates the joints and cushions the body organs

It plays an important role in the control/regulation of body temperature of an animal

**Sources of water in animal body**

From food eaten by the animal

Water taken in directly

Water produced during respiration.

**Factors that influence the water requirement/water intake by an animal**

Kind of feed eaten, feeds that are salty and those that are rich in proteins increase water intake of the animal.

Climatic conditions, during dry weather, animals need a lot of water in order to digest dry feeds and to replace lost water from the body due to high air temperatures.

Production level, lactating cows need more water than dry cows because they lose a lot of water from their bodies inform of milk

Age of the animal, water intake increases as the animal grows older.

Quality of water, animals will drink more fresh water than stinking/dirty water

Health of animals, sick animals usually take less water.

Salinity of the water, animals take in more saline water.

Type/size of the animal, cattle/large sized animals take in more water than small sized animals like goats.

**CARBOHYDRATES**

These are food substances made of carbon, hydrogen and oxygen in the ratio of 1:2:1. They provide the animals with energy.

**Importance of carbohydrates**

They provide energy to the animal

They are used to manufacture vitamin c in all animals except man.

They have a sparing effect on the proteins since in their prsesence proteins are not broken down to form energy

They prevent ketosis in lactating animals, which is due to accumulation of toxic substances called ketones in the bodies of animals

They are used to form animal structures e.g. cell walls.

They help in absorption of mineral salts e.g. potassium, calcium. Which combine with fructose sugar before they are absorbed.

Excess supply of carbohydrates are converted into fats and stored in the body for future use.

Source of carbohydrates

Grains e.g. maize wheat

Root crops e.g cassava

Grass pastures

Molasses

**LIPIDS**

They are also made up of carbon, hydrogen and oxygen as the case with carbohydrates except that they contain very little oxygen. Lipids consist of fats and oils and their building blocks are fatty acids and glycerol. Fats are of animal origin and are solid at room temperature, while oils are of plant origin and are liquid at room temperature.

**Functions of lipids in the body**

They provide energy to the animals. When oxidized, a gramme of lipids produces more than twice as much energy as that of carbohydrates.

They are used to manufacture cell membranes

When oxidized, they release metabolic water.

They serve as purgatives to cure stomach upsets

Fats stored beneath the skin act as insulator to prevent heat loss from the body

Sources of lipids

Oil feeds e.g. groundnuts, cotton seeds and sunflower seeds

Milk and milk products

Fish meal

**PROTEINS**

Proteins are food materials that are made up of carbon, hydrogen and oxygen and sometimes nitrogen, phosphorous, sulphur and iron.

**Importance of proteins.**

They are important for growth and development of the animal body (building of muscles).

They repair torn and worn out body tissue.

Proteins are needed in the manufacture of enzymes, hormones and antibodies all of which play important roles in the body.

In the absence of carbohydrates and fats in the body, proteins can be used to produce energy for maintaining the physiological processes going on in the body.

Proteins provide ingredients needed in the formation of products such as eggs, milk, meat and wool.

**MINERALS**

Theseoccur in small amounts. They include

Macro/major nutrients, these are needed by animals in large amounts. They include, calcium, magnesium, phosphorous, potassium, sulphur, chlorine and sodium.

Micro/minor/trace nutrients, these are needed by the animals in small amounts. They include, iron, copper, cobalt, iodine, zinc, selenium and manganese.

**General functions of minerals in animal bodies.**

They are constituents of tissues such as blood, bones and teeth.

They speed up chemical reactions within the body by acting as co-enzymes.

They regulate osmotic properties of body fluids such as blood.

They serve as components of enzymes and hormones.

They are components of animal products.

**Importance, sources and deficiency symptoms of MACRO elements**

|  |  |  |  |
| --- | --- | --- | --- |
| Element/nutrient | Source of element | Importance (use) | Deficiency symptoms |
| calcium | Fish meal, bone meal, legumes, crushed egg shells, milk and its products, nuts, cereal grains, vegetables. | * Formation of bones and teeth * Needed in the clotting of blood * Enable nerves and muscles to function properly * Formation of egg shells in poultry. | * Rickets in young animals (osteomalacia). * Milk fever in lactating cows. * Laying of soft shelled eggs and shell less eggs in poultry. * Absorption of part of bone to increase calcium levels in blood (osteoporosis). |
| phosphorous | Vegetables, milk and its products. | * Formation of bones and teeth * Making of cell membrane and substances in the protoplasm | * Loss of appetite * Deprived appetite (pica). Animal develops appetite for non-edible materials * Rickets in young animals. |
| Magnesium | Potatoes, fruits, cereal grains. | Formation of bones  Activates enzymes | Grass tetany (malfunctioning of the neural muscular junction). |
| sulphur | Mineral lick, protein foods | Manufacture of sulphur containing amino acids e.g. methionine. | Deficiency rarely occurs. |
| Sodium, potassium, chlorine | Mineral lick, table salt, fruits, vegetable crops. | * Maintains ph of body fluids * Potassium is needed in enzyme reactions * Sodium is needed in the absorption of glucose. | * Lack of potassium leads to retarded growth * Unsteady gait * General muscle weakness * Lack of sodium and chlorine lead to retarded growth rate and weight loss. |

**Importance, sources and deficiency symptoms of MICRO elements**.

|  |  |  |  |
| --- | --- | --- | --- |
| Element | Source of element | Importance (uses) | Deficiency symptoms |
| iron | Cereal grains, green herbage, legumes | * Manufacture of haemoglobin in red blood cells * Manufacture of some enzymes e.g, catalase | Reduced haemoglobin content in the red blood cells. (Anaemia). |
| Cobalt | Mineral licks, green herbage | Manufacture of vitamin B12 | * Loss in body weight (emaciation) * Anaemia * Loss of appetite. |
| Copper | Grains, green herbage, copper sulphate. | * Manufacture of haemoglobin in red blood cells * Influences the absorption of iron from the digestive system. * Formation of bones * Needed for normal hair and wool pigmentation. * Manufacture of some enzymes e.g. thyrosinase. | * Anaemia * Poor nervous coordination due to poor developed nerve fibres * Abnormal bone formation * Slow growth of hair and wool and abnormal pigmentation. |
| Iodine | Sea water, sea weeds, iodized salt, milk | Manufacture of thyroxine hormone. | * Goitre (swelling of thyroid gland). * Reduced growth and body metabolic rates (cretinism in young animals). |
| Manganese | Cereals, legumes, mineral lick. | * Formation of bones * Manufacture of some enzymes e.g. pyruvate carboxylase. | * Poor nervous coordination * Slipped tendon |
| zinc | Mineral lick | * Needed in protein synthesis * Activates enzymes | * Reduced growth rate * Poor development of gonads |
| Selenium | Protein foods | Manufacture of some enzymes | * Degeneration of muscle fibres mainly in lambs and pigs * Exudative diathesis (oozing of blood from capillaries in chicken). |

**VITAMINS**

Vitamins are organic compounds that are essential for normal growth and prevention of diseases in animals. They are required in very small quantities.

Vitamin C and D can be synthesised in the body hence may not be supplied in the diet. Vitamins are divided into two groups namely:

Fat soluble vitamins, these are able to dissolve in fats and other organic substances e.g. ether but not in water. They include A, D, E and K

Water soluble vitamins, they are soluble in water i.e. B and C

General functions of vitamins

They take part in regulating chemical reactions that occur in the body by acting as co-enzymes

They help in the uptake and utilization of some nutrients and mineral salts.

They maintain good health of animals by protecting them from certain diseases

Helps in the process of reproduction especially vitamin E

**Importance, source and deficiency symptoms of vitamins.**

|  |  |  |  |
| --- | --- | --- | --- |
| Vitamins | Sources | Importance/uses | Deficiency |
| Vitamin A (retinol) exists in plants as carotenoids | Carrots, milk products, dark green leafy vegetables, dried grass | * Maintains health of eyes, skins, bones and teeth. * Keeps the lining of respiratory and digestive tracts resistant to diseases | * Night blindness * Dryness and irritation of the cornea * Bulging eyes in cattle * Impaired growth * Lining of respiratory and digestive tracts breaks down leading to infections. |
| Vitamin B1 (thiamine). | Pork products, legumes, cereals, nuts | * Helps in energy production from carbohydrates * Normal appetite and digestion * Proper functioning of nervous system. | * Decreased appetite (anorexia). * Twisted necks in chicks * Slow heart beat * Beriberi (inflamed nerves, muscle weakness * Retarded growth. |
| Vitamin B2 (riboflavin). | Grain products, dried beans, cereals. | * Helps nerve cells function properly * Gives good appetite * Helps in energy release from protein, fats, and carbohydrates. | * Skin sores on nose and mouth * Curled toe paralysis * Crooked, stiff legs in pigs, poor growth. |
| Vitamin B3 (niacin) | Yeast, fish, cereals, greens. | * Maintains normal metabolism, nerve function, digestion, and energy release. | * Pellagra (sores on tongue and lips) * Diarrhea * Irritability and depression. |
| Vitamin B12 | Meat, milk and its products. | Needed for formation of red blood cells. | * Pernicious anaemia * Stunted growth * Poor feathering in chicks * Poor functioning of thyroid gland * Rough hair coat in pigs. |
| Vitamin D (calciferol). | Fish  Liver oils  Concentrated milk  Animal fat | * Promotes normal body growth * Helps in absorption of calcium and phosphorous from digestive system. | * Rickets * Retarded growth of bones and teeth. |
| Vitamin E (tocopherol) | Cereal grains  Vegetables  Animal fat  Cotton seed oil  Legumes  Nuts | * Prevents formation of peroxides in the body * Maintains health of cell membranes * Prevents destruction of red blood cells. | * Sterility mostly in birds * Poor functioning of cell membranes * Red blood cells burst causing anemia |
| Vitamin K | Greens, oils, potatoes. | Helps in blood clotting | * Slow blood clotting * Haemorrhage |

**FEEDS AND FEEDSTUFFS**

Animal feeds include the following

Roughages

Concentrates

Feed additives

Mineral and vitamin supplements

**ROUGHAGES**

These are feeds of plant origin.

Characteristics of roughages.

Have a high fibre content

Have a low energy and protein content

They give bulk to food

They are highly succulent

Types of roughages, these include

Dry roughages, these contain little moisture e.g. hay, maize bran, wheat bran. They contain less water and high crude fibre.

Succulent roughages, these contain high amount of moisture and low crude fibre.

**CONCENTRATES**

These are feeds that contain high amounts of given nutrients per unit weight. These include protein concentrates and carbohydrate concentrates.

**Characteristics of concentrates**

Contain high energy or proteins

They have a high digestibility

They have a low fibre content

They have a low moisture content.

Protein concentrates include fish meal, cotton seed cake, blood meal, sunflower seed cake, groundnut seed cake, soy bean, simsim.

Carbohydrate concentrates are also known as energy/basal feeds, they include. Cereal grains, molasses. Sweet potatoes, cassava.

|  |  |
| --- | --- |
| **Roughages** | **Concentrates** |
| High fibre content | Low fibre content |
| Feeding values are variable | Feeding values are uniform |
| Low energy and low protein content | High protein and energy content |
| Low digestibility | High digestibility |
| More bulky | Less bulky |
| Low palatability and acceptability | High palatability and acceptability |
| Derived from plants | Derived from both plants and animals |

**MINERAL AND VITAMIN SUPPLEMENTS**

These are added in varying quantities in a variety of feedstuffs to guard against possible deficiencies.

**FEED ADDITIVES**

These are substances added to feeds in order to:

Improve the look and taste of feeds

Increase resistance of animals against diseases

Stimulate growth of the animals

Examples of additives include

Flavourings, these improve food taste and palatability.

Hormones to improve feed utilization

Drugs to control diseases

Anti-oxidants to prevent auto oxidation of feeds.

Tranquilisers to reduce stress in animals

RATION FORMULATION AND FEED MIXING

**Factors to consider when formulating animal rations**

Nutrient requirement of the animal, different animals require deferent nutrients for example layers should be given feeds that are rich in proteins and calcium

Availability of feedstuffs, rations should be mixed using the feedstuffs that are readily available.

Cost of feedstuffs, farmers should use cheap ingredients for example cotton seed cake is cheaper than fish meal therefore a farmer should use cotton seedcake

Age of the animal, young animals require more proteins than old animals

Type of the animal, work type animals require more carbohydrate feeds to acquire energy for ploughing.

Palatability of the feed, a farmer should use ingredients that are liked by the animal in order to encourage intake.

Health condition of the animal, sick animals should be given well balanced feed with the required vitamins and minerals.

Physiological state of the animal, pregnant and lactating feeds require more nutritious and well balanced feeds.

Wholesomeness of the feed, feeds formulated should not cause any harm to the animal.

Digestibility of the ingredients, ingredients to use should be easily digestible by the animal. \

**Factors that affect the utilization of feed rations by animals**

Health of the animal, healthy animals have better utilization of rations than sick animals

Type of the animal, ruminants are more efficient in feed utilization than non-ruminants.

Amount of feeds given to the animal, when animals are given enough or less feeds, they utilize it better than when given a lot of feeds.

Digestibility of the feed, feeds with a high digestibility are highly utilised than those with a low digestibility.

Nutrient content of the feeds, feeds that are well balanced usually have a high digestibility than poorly balanced feeds

Addition of additives, additives such as hormones increase increase utilisation of feeds in which they are contained.

Processing of feeds, processed feeds e.g. maize bran are highly utilized.

Physiological state of the animal, pregnant and lactating animals utilize feeds more efficiently.

**Factors affecting feed intake by animals.**

Environmental temperature, high environmental temperatures reduce feed intake while low environmental temperatures stimulate feed intake.

Palatability of the feed, feeds that are highly palatable would be consumed in large quantities by the animals as compared with unpalatable feeds.

Blood components, a high quantity of glucose and volatile fatty acids in the blood of ruminants will supress feed intake.

Lignin content of the feed, high lignin content in feeds will supress feed intake since it has a low digestibility.

Shift in hormonal balance, during pregnancy, foetal displacement of the rumen and reticulum and change in hormones will affect feed intake.

Level of animal production, animals that produce a lot of milk will eat more feeds to compensate the loss in milk.

Animal health, sick animals will take less feeds as compared with the health ones.

Amount of feed provided, animals will always strive to eat all what is provided hence giving a lot of feeds increasing intake.

DIGESTIBILITY

This is a measure of the proportion of food eaten by an animal less that lost through faeces, gasses and urine.

Determining feed utilization

Percentage digestibility =

**Factors affecting feed digestibility**

**Amount of feeds eaten,** digestibility decreases with increase in amount of feeds eaten.

**Differences between species,** ruminants are more efficient in utilizing feeds than non-ruminants due to their long digestive tracts.

**Age of the animal**, very old and young animals have inefficient digestive systems hence show low digestibility of feeds.

**Amount of crude fibre/cellulose content**, feeding animals on high crude fibre like grasses lowers digestibility.

**Exercise,** a light exercise improves digestibility of a feed. A heavy exercise depresses digestibility of feeds.

**Energy to protein ratio of feeds**, feeds with high energy to protein ratio have a lower digestibility those with a lower ratio.

**Type of feeds,** proteins and carbohydrates are more digestible as compared to other types of feeds.

**Presence of anti-metabolites**, some feeds may contain anti metabolites e.g. trypsin inhibitor in raw soy beans, gossypol in cotton seedcake.

**Health of the animal**, sick animals will have a low digestibility.

**Processing of feeds,** digestibility increases with crushing of feedstuffs.

**Water intake,** when an animal is provided with adequate water to drink, its feed digestibility increases.

**Effect of concentrates,** increased intake of proteins will improve digestibility of fibre.

**Improving digestibility of feeds**

Providing feeds with high nutrients value to animals

Avoid excessive exposure of feeds to rains and sunshine in order to maintain their quality.

Provide plenty of fresh water for the animals

Add molasses to feeds to improve digestibility

Chop pasture and crush feeds to increase surface area for enzymatic action.

**METHODS OF RATION FORMULATION**

Using the pearson square

Algebraic equation method

**THE PEARSON METHOD**

**Procedure**

Draw a square

Write the percentage protein of the ingredients on the left hand corners of the square. And that of the ration in the centre of the square

Subtract diagonally across the square, disregarding the + and – signs

Values obtained at the right hand corners of the square give the proportion of the ingredients to be mixed in the ration.

Example 1 a farmer would like to make a 16% crude protein ration using maize bran 8% protein and fish meal 48% crude protein. Using the pearson square, Calculate the percentage proportions of each ingredient he would need to mix the ration.

If he is to consider a 2.5% mineral supplement, in what proportions would he mix the above ingredients?

**Leave space for the answer (about 1 page)**

**Compound pearson**

Example 2, a farmer would like to make a 16% crude protein ration using maize bran 8% crude protein, fish meal 36% crude protein, wheat bran 10% crude protein and blood meal 40% crude protein. In what proportions would he mix the above ingredients to get 1000kg of feeds?

If he is to consider a 2% vitamin supplement, in what proportions would he mix the above ingredients?

**Leave space for the answer (about 2 pages)**

**ALGEBRAIC EQUATION**

Example 1 a farmer would like to make a 16% crude protein ration using maize bran 8% protein and fish meal 48% crude protein. Using the algebraic equation method, Calculate the percentage proportions of each ingredient he would need to mix the ration.

If he is to consider a 2.5% mineral supplement, in what proportions would he mix the above ingredients?

**Leave space for the answer (half a page)**

**Process of mixing feedstuffs**

The area where to mix the ingredients from is cleaned and dried

The main ingredients of the ration are weighed and heaped on the cleaned ground

Minor ingredients such as mineral and vitamin supplements are then measured and pre mixed

The premix of the vitamin and mineral supplement is then added on to the heap

The feed ingredients are then blended using a shovel until a uniform mixture is obtained

**DIGESTION IN FARM ANIMALS**

Digestion is the mechanical and enzymatic breakdown of food into simple chemical compounds as it moves along the digestive tract.

Mechanical digestion involves chewing (mastication), grinding and mixing the food with enzymes and digestive juices.

**Digestion in non-ruminants**

Non ruminants are animals which do not chew the cud. Unlike ruminants, they have a single stomach and hence referred to as ***monogastric animals***. The pig is an example

**Digestive system of a non-ruminant (pig)**

**Process of digestion**

**In the mouth**

Digestion starts in the mouth where food is chewed and mixed with saliva from the salivary glands. Saliva contains an enzyme ptyalin (salivary amylase) which breaks down some of the carbohydrates into maltose. Food is then swallowed and moves down the oesophagus by peristalsis process.

**In the stomach**

Food is stored for some time, digestion of proteins starts here and is facilitated by pepsin enzyme secreted by gastric glands

HCL provides suitable ph for proper functioning of pepsin enzyme and also kills some germs taken in with food.

Pepsin breaks down proteins to polypeptides and peptides. Renin is responsible for clotting of milk suckled by the young calf. From the stomach food continues to the duodenum

**In the duodenum**

Digestion is facilitated by bile juice from the gall bladder and enzymes contained in the pancreatic juices from the pancreas

Pancreatic juice contains three enzymes namely:

Pancreatic amylase which breaks down starch to maltose

Trypsin which breaks down proteins to polypeptides

Lipase which breaks down fat droplets to fatty acids and glycerol

Pancreatic juice also contains sodium bicarbonate which neutralizes HCL in the food and changes the medium to alkaline.

Bile contains salts which emulsify fats into droplets so as to increase the surface area for the action of lipase enzyme. Bile salts also help to reduce the acidity in the food. From the duodenum food continues to the ileum

**In the small intestines (ileum)**

In the ileum, intestinal juice is secreted into the food by glands located in the part of the small intestines called the jejunum. The juice contains four enzymes namely:

Maltase, this breaks down maltose to glucose

Sucrose (invertase), this breaks down sucrose to fructose and glucose

Lactase, this breaks down lactose to glucose and galactose

Peptidase (erepsin), this converts peptides and polypeptides into amino acids.

At this stage digestion is completed and their after the simple food substances are absorbed through the villi into the blood stream. From the ileum the undigested food continues to the large intestine (colon).

**In the colon**

No further digestion occurs in this part. Water is absorbed from the undigested material, leaving behind residues called faeces.

**Rectum**

Faeces are stored here for some time before they are expelled from the body through the anus.

**Digestion in ruminants**

Ruminant animals include cattle, sheep and goats. Their digestive system contains a special stomach which is divided into four compartments or chambers. These are: the rumen (pouch) which is the biggest, reticulum (honey comb), omasum and abomasum (true stomach). Its due to possession of this kind of stomach that they are called ***polygastric animals***.

**Digestive system of a ruminant**

**In the mouth**

During feeding, ruminants swallow their food when its not well chewed, but later when they are resting they return (regurgitate) the food back to the mouth to be chewed. This is known as rumination or chewing the cud. There is no enzymatic digestion that occurs in the mouth because ruminants lack ptyalin enzyme in their saliva. The food is partly chewed, mixed with saliva and then swallowed. From the mouth, food moves to the rumen through the oesophagus by peristalsis.

**Functions of saliva in ruminants**

Aids in mastication and swallowing

It has anti frothing properties which is important in controlling bloat

**In the rumen (pouch).**

In the rumen, food is churned and mixed with rumen fluids. The churning action breaks up coarse food particles in to smaller ones.

The rumen also acts as a temporary storage organ for food

The rumen also provides a place for fermentation of food

The rumen also absorbs volatile fatty acids

The rumen also has microorganisms which ferment food. The microorganisms in the rumen include bacteria, protozoa and yeast.

Rumen microorganisms ferment cellulose by producing cellulose enzyme which breaks down cellulose to volatile fatty acids e.g. butyric acid, propionic acid and acetic acid which are absorbed by the rumen wall to provide energy.

Acetic acid is the major source of energy in ruminants.

The microorganisms in the rumen also synthesise vitamins like vitamin B complex, C and K

During fermentation, carbon dioxide and methane are produced. The animal gets rid of these by the reflex action of belching.

The coarse food is sent back to the mouth for rechewing and the rest continues to the reticulum.

**Write down five functions of the rumen**

**In the reticulum**

The reticulum separates finely ground food from coarse food and allows fine food to move to the omasum and coarse food is sent back for rumination via the rumen and gullet.

All the foreign indigestible materials such as stones, metals are stored in the reticulum and for this reason it’s known as the hardware stomach. From the reticulum, food continues to the omasum

**In the omasum**

The internal structure of this compartment consists of paper like rough surfaced muscles whose function is to grind food further. Water is squeezed out of the food and absorbed. From the omasum food continues to the abomasum

**In the abomasum**

This is the true digestive stomach and its walls secrete gastric juice containing HCL, pepsin and renin in young ruminants. Protein digestion starts from here, and its acted on by pepsin which breaks it down to polypeptides. Germs in the food are killed by hydrochloric acid (HCL) produced by the gastric glands. In young ruminants, milk protein (casein) is broken down by renin to amino acids. From the abomasum, food moves to the duodenum

**In the duodenum**

Digestion is facilitated by bile juice from the gall bladder and enzymes contained in the pancreatic juices from the pancreas

Pancreatic juice contains three enzymes namely:

Pancreatic amylase which breaks down starch to maltose

Trypsin which breaks down proteins to polypeptides

Lipase which breaks down fat droplets to fatty acids and glycerol

Pancreatic juice also contains sodium bicarbonate which neutralizes HCL in the food and changes the medium to alkaline.

Bile contains salts which emulsify fats into droplets so as to increase the surface area for the action of lipase enzyme. Bile salts also help to reduce the acidity in the food. From the duodenum food continues to the ileum

**In the small intestines (ileum)**

In the ileum, intestinal juice is secreted into the food by glands located in the part of the small intestines called the jejunum. The juice contains four enzymes namely:

Maltase, this breaks down maltose to glucose

Sucrose (invertase), this breaks down sucrose to fructose and glucose

Lactase, this breaks down lactose to glucose and galactose

Peptidase (erepsin), this converts peptides and polypeptides into amino acids.

At this stage digestion is completed and their after the simple food substances are absorbed through the villi into the blood stream. From the ileum the undigested food continues to the large intestine (colon).

**In the colon**

No further digestion occurs in this part. Water is absorbed from the undigested material, leaving behind residues called faeces.

**Rectum**

Faeces are stored here for some time before they are expelled from the body through the anus.

DIGESTION IN A YOUNG RUMINANT

In a young ruminant, the rumen is not yet fully developed and digestion is similar to that of simple stomached animal. The calf only has a fully functioning abomasum.

When the calf takes in milk, it passes through the oesophageal groove. The oesophageal groove closes the entrance of the undeveloped compartments there by preventing milk from going or entering them.

As the rumen develops, the calf can start to utilize food other than milk and by the 12th week , the rumen is fully developed and its microorganisms established.

**The stomach of a calf**

**Digestion of carbohydrates in ruminants**

Ruminants do not have salivary amylase and therefore chemical (enzymatic) digestion of carbohydrates starts in the rumen.

In the rumen, microorganisms produce microbial amylase and cellulose which ferment the food.

Microbial amylase breaks down starch and microbial cellulose breaks down cellulose into volatile fatty acids such as acetic acid, propionic acid and butyric acid

Carbondioxide and methane are given off during microbial fermentation. These gasses escape through the oesophagus by a reflex action of belching. If the reflex fails, bloat occurs.

Acetic acid is the major source of energy in ruminants and the amount of acetic acid produced depends on the amount of fibre and starch in the diet. A diet with a high fibre results into production of more acetic acid while consumption of high amounts of starch results into production of more propionic acid and butyric acid.

The volatile acids are absorbed and utilised for energy

**Digestion of proteins in ruminants**

Proteins ingested in the diet are rapidly broken down by the enzymes produced by the bacteria in the rumen.

Proteins are changed to peptides and amino acids. Some amino acids are absorbed through the rumen wall while others are broken down to ammonia.

When the rate of production of ammonia exceeds the available energy, it accumulates and becomes toxic, so it’s important to ensure that there is adequate energy in the feeds.

The remaining proteins and some bacteria are passed on to the abomasum where they are digested to release the protein content in them.

**Nitrogen conserving mechanism in ruminants**

Digestion of roughages depends on the activity of microorganisms in the rumen. These require a supply of energy and nitrogen for their growth and multiplication therefore it must be considered. Ruminants have a mechanism for conservation of nitrogen that would otherwise be lost.

**Mechanism**

Ammonia absorbed from the rumen plus that arising from tissue metabolism is converted into urea by the liver. In non-ruminants this urea would otherwise be lost through excretion e.g. urine.

In ruminants its recycled back to the rumen through absorption into saliva and some of it is absorbed across the rumen wall. The saliva is then swallowed together with the urea contained into it to the rumen.

The recycled urea is utilised by the microbes in the same way they utilise nitrogen in the diet.

The proportion of urea-nitrogen recycled depends on the quantity of nitrogen in the diet

Low dietary nitrogen causes more nitrogen from the liver being returned to the rumen to build proteins

The cycle ensures continuous source of nitrogen from rumen digestion.

**Conditions that favour rumen microbes (benefits rumen microbes obtain from the ruminants)**

Favourable ph within the rumen ranging between 6.2-6.7, this is maintained by saliva and continuous removal of volatile fatty acids

Low levels of oxygen in the rumen since most of the microbes are anaerobes

Favourable temperature of about 39 in the rumen.

Enough moisture from water drunk, animal feeds and saliva.

Supply of food i.e. energy, nitrogen and macro and micro mineral elements.

**Benefits the ruminant animal derives from the microbes**

They enable ruminants to utilize fibrous food material by breaking down cellulose to simple carbohydrates and volatile fatty acids.

They build proteins from nitrogen in the diet, when they die, they are digested and proteins utilized by the ruminant.

They synthesize vitamin K, C and B complex which are later utilized by the animal

They build up complete protein from non-protein nitrogen compounds in the diet e.g. urea.

Similarities between ruminants and non-ruminants

In both final absorption of food is in the ileum

In both water absorption occurs in the colon

Enzymatic reactions yield the same end products for the different food

**Differences between ruminants and non-ruminants**

|  |  |
| --- | --- |
| **Ruminants** | **Non ruminants** |
| They are polygastric (have four stomach chambers) | They are monogastric (have one stomach chamber) |
| Chew cud | Do not chew cud |
| Microbes digest cellulose well | Lack microbes and cannot handle cellulose effectively |
| Microbes synthesise vitamin B, C and K | No microbes to synthesise vitamins |
| Volatile fatty acids is the major source of energy | Glucose is the major source of energy |
| Small caecum | Large caecum |
| Fermentation of food in the rumen by microbes | No fermentation |
| Absorption starts in the rumen | Absorption occurs in the ileum |
| Chemical Digestion starts in the rumen | Chemical digestion starts in the mouth |
| Lack ptyalin in saliva | Ptyalin present in saliva |
| Capable of converting NPN compounds like urea into amino acids | Cannot make use of NPN compounds |
| Digestion of carbohydrates in the rumen produces organic/ volatile fatty acids. | Digestion of carbohydrates produces monosaccharide sugars as the end product. |

**DIGESTION IN POULTRY**

The major parts of the system are, the beak, crop gullet, glandular stomach, gizzard, small intestines, colon, caeca and cloaca.

**Diagram showing digestive system of a bird.**

**Process of digestion**

**Mouth/beak**

Birds don’t have teeth, therefore they do not chew the food. Food is swallowed whole and moves down the oesophagus to the crop.

**Crop**

This serves as the food storage organ before it’s passed on to the proventriculus. It’s thin walled and contains glands that produce juices that soften food.

**Proventriculus (glandular stomach)**

This is a true stomach whose walls secrete gastric juice. Pepsin in gastric juice breaks down proteins to peptides and polypeptides. HCL provides a suitable acidic medium for pepsin to work on proteins, and also kills germs in food. Food is then passed to the gizzard.

**Gizzard**

Unlike the proventriculus, the gizzard is a thick muscular organ whose inner surface is ridged, hard and horny. It contains grit which helps in the grinding of food. Grit consists of coarse small stones that are picked up and swallowed together with food. Food then continues to the duodenum.

**Duodenum**

Here the digestion process is similar to that of non-ruminants

**Ileum**

Here the digestion process is similar to that in non-ruminants and absorption takes place here.

Caeca

Poultry birds possess a pair of caeca, some digestion occurs here with the assistance of microbial enzymes as in ruminants. The caeca harbours the microorganisms which produces cellulose enzyme that breaks down cellulose into volatile fatty acids which are absorbed and yield energy. The undigested food continues to the colon

Colon

Water is absorbed and the waste material continues to the rectum

Rectum

Waste materials are temporally stored before they are expelled from the body through the cloaca