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History of animal nutrition.

defi. of Animal nutrition:- The series of process by which an organism takes in and assimilaties food for promoting growth and replacing worn and injured tissues.

- Therefore nutrition involves various chemical reactions and physiological process, which transforms foods into body tissues and activities.
- So, animal nutrition is the science of nourishment of animals. It involves in the injestion, digestion, Absorption of the various nutritions, there transport to all body cells and the removal of unuseable elements and waste products of metabolism.

→ The factors responsible for efficient animal production are-
1) Genetic potential of animal.
2) nutritional status of animal
3) Managemental factor.

Scientist	Contribution
Antoine laurent Lavoisier (1743-1794) (french chemist)	• Founder of the science of nutrition/ Father of nutrition/ • father of modern chemistry • He introduced the balanced and thermometer into nutrition studies.
G. J. Mulder	• chemical basis of nutrition established • gave the name proteins.

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Scientists	Contribution
3) Stephan M. babcock.	• He conceived the idea of trying out rations made up entirely from a single plant. • He carried out feeding experiments with cows heifer, calves on rations made entirely from corn wheat and oat plants.
4) Nathan Zuntz. (1847-1920)	• He was pioneer in the field of basal metabolism and in respiration studies with farm animals. • He developed the first portable respiration apparatus.
5) ~~Oscar~~ Osacar Kellner (1851-1911)	• found practical apparatus in feeding standard. • He gave starch equivalent system of energy evaluation.
6) Max Rubner (1854-1932)	• He shows that Carbohydrate & fat were interchangable in metabolism on the basis of energy equibalance.
7) Henery Prentiss Armsby (1851-1921).	• He constracted respiration Calorymeter for farm animals and study heat production in cattle.

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(7). He developed the net energy system of evalvating feeds.

8) Thomas B. Osborne & B. Mendal
- They had discovered particularly in the fields of protein & vitamins.

9) Peter J. Vansoest
- Work on developing procedure to estimates fibres & feeds stuff and discovered the Maillard reaction & provided a simple assay for protein availability.

10) Dr. K. C. Sen
- Published "Nutritive value of Indian cattle feeds & feeding farm animal."

11) Dr. S.K. Talapatra.
- He conducted lot of work on assessing grasses for their nutritive value.
- He developed the method of estimate mineral feeds and fodder.

12) Casimir funk.
- He gave the term vitamins.

- ICAR (1985) Indian Council of Agriculture Research. → feeding standard for various categories of livestock.
- NRC (1942) → National Research Council, USA
- ARC → Agricultural Research Concil, U.K.

→ Nutrients requirement for livestock

13) Hunsate (1966)
- Contributed in the field of rumen microbiology.

Role of Nutrition in health and production:-

- Proper nutrition is essential to the health and well being of all the domestic animal.
- Nutrition is important because animals must maintained a high level of production.
- The genetic advancement has lead to increased productivity and production systems have become more intensified, hence there is increased pressure an animal husbandary to ensure that nutrition does not limit animal well being health or production.

- **Role of Nutrition in health:-**

→ Proper nutrition is also central to the prevention and control of many infectious and noninfectious diseases.
→ Nutrition place a role in influencing the animals susceptibility to disease (ex:- feline lower urinary tract disease) as well as in managing certain diseases (ex:- Diabetes, hyperlipidimia, Ketosis).

→ Ration must be formulated to provide for the basic physiologic needs (ex:- energy, protein, fats, carbohydrates, vitamins and minerals) of the animal and to ensure optimal growth and productivity.

→ Nutritionally related diseases include diseases associated with a nutritional excess (ex:- Direct toxic effect, digestive upset), nutritional deficiency (either a primary or secondary deficiency)

Ketosis → Just after parturation → Milk production less
→ Metabolic disorders
→ happen when before parturation diet inbalanced.

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OR nutritional imbalance.

→ feed preparation and deleivary are often as important in ensuring animal health as the actual nutritional value of the ration itself.

→ In inadequacis in nutritionally deliver can directly cause diseases (ex:- ruminal acidosis, laminitis) OR increase susceptiability to disease (ex:- type - D clostridium perfringens anterotoximia).

→ feeds and feeding management can also influence animal health if feeding results in exposure to food born physical hazards (eg - sharp object), chemical (eg- micotoxins, toxic plants), Allergens (ex - Dust mites, mold spores) OR microbs (Salmonella spec.)

• Role of Nutrition in production:-

→ The term production refers to the ability of an animal to grow, reproduce and produce outputs such as milk, wool, draught and transport. for performing these function essential nutrients in the form of energy, protein, minerals, vitamins & water over & above that needed for the maintenance, must be provided.

→ The feed intake and its digestibility determine the amount of nutrients that is actually absorbed by an animal and therefore the avability of nutrient for various production purpose.

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→ Animal production via animal nutrition may be improved by adopting the following methods-
1) Crop improvement
2) Changes in livestock Management
3) Pasture improvement
4) feed suplimentation.

→ Poor nutrition delay pueberty, reduces conception rates. and increases pregnancy loses in heifers.
• Underfeeding cows during pregnancy leads to poor plan of nutrition. post-partum and delay cyclic process & conception after calving.

→ In poultry poor nutrition delays growth, has adverse effect of feed efficiency and egg production.

Composition and Camparision of plant & animal body

- The chemical composition of plant and animal represents all the physical and chemical basis of protoplasm of the living processes which occur in it.
- The animal body derives all the nutrients for its physiological functions from the digestion of plant and plant products with limited amount of animal origin feeds such as fish meal & milk. A brief consideration of the chemical composition of the animal in relation to the composition of its food is useful to get the a general picture of the nutritional processes.

Chemical composition of plant and animal.

- plants and animal tissues are made of similar type of chemical substances but their relative amount are variable
- plants are analysied by proximate method of analysis given by "Hennebelg & Stohmann". Where as animal body was first given by "Lawes & gilbert" by slaughter experiments.

- Most of the nutrients present in plants and animals are arranged into six groups which are water, protein, carbohydrates, fat, minerals and vitamins.
- Plants and their byproducts show much larger differences in the chemical composition then the animals

→ Plant synthesised complex materials from simple substances such as CO_2, water, nitrates and other mineral salts from the soil and energy traped from the sun by the process of photosynthesis.

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→ The greater part of the energy traped as chemical energy within the plant itself and the animal use this energy. Thus, plants store and animal dissipate the energy

Comparision of plant & animal body:-

- In animals the major structural material is protein and minerals in the ratio of "moisture and fat free" bases which remain almost constant.
- Whereas plants are made up of carbohydrates like cellulose, hemicellulose, pectin, lignin. other differences are tabulated as

S.No.	Parameters	Animals	Plants.
1.	Major Constituents	Water	water
2.	Major organic Constituent	Protein	Carbohydrates.
3.	Structural Component	Protein & Mineral	Carbohydrates (Cellulose, hemicellulose etc)
4.	Reserved Material	Fat	Carbohydrate (Starch)
5.	Carbohydrate amount	less	More.
6.	Minerals amount	Generally Constant to species (Ca, P)	wide variation (K, Si etc)
7.	Variation In Composition	less	More. (wide variation)

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Assignment Composition of Animal body:-

Species.	As Such or fresh matter basis.				Water and fat free basis	
	Water	Protein	Fat	Ash	Protein	Ash
1) Calf (newborn)	74	19	3	4.1	82.2	17.8
2) Steer, thin	64	19	12	5.1	79.1	20.9
3) Steer, fat	43	13	41	3.3	79.5	20.5
4) Sheep (thin)	74	16	5	4.4	78.2	21.8
5) Sheep (fat	40	11	46	2.8	79.3	20.7
6) Pig (8kg)	73	17	6	3.4	83.3	16.7
7) Pig (30kg)	60	13	24	2.5	84.3	15.7
8) Pig (100kg)	49	12	36	2.6	82.4	17.6
9) Hen	56	21	19	3.2	86.8	13.2
10) Horse	61	17	17	4.5	79.2	20.8
11) Man	59	18	18	4.3	80.7	19.3

factors affecting chemical composition of plants:-

(i) Plant factor:-
There is a marked difference in the chemical composition between the different varieties of same species of forage because of different genetic material.

(ii) Agroclimatic conditions:- (temp + humi)
temprature and humidity affect the chemical composition of plant

(iii) Cultivation practise:-
Seed rate, seed treatment, ~~seed~~ time of sowing, method of sowing, manure and fertilizer, irrigation, weeds and disease control measures.

Notes

(iv) Stage of growth:-

→ There is a relationship between the stage of growth of the plants & its chemical compositions.

→ The content of crude protein, soluble ash, phosphorus and potash is higher just before flowering and goes down at bloom and seed formation stage.

→ whereas crude fibres and dry matter content increases as the plant mature

→ Ether extract (fat) goes down with the progressive maturity of the plant

(v) processing and preservation practises.

Different processing methods may change particle size, particle shape, nutrient contents and composition of plants may change.

Nutritional Definations and terms :- Awdesh

→ **Additive** :- An ingredient or a combination of ingredients added to the basic feed mixture for specific purpose like to increase feed ingestion or to alter metabollsm.
eg :- enzymes.

→ **Ad-libitum** :- Free choice acess to feed.
इच्छानुसार

→ **Alkaloids** :- Alkaloid constitudes a large number of the active principles of plant and all posses a powerful physiological action.

→ **Animal Nutrition** :- The series of process by which an organism takes in and assimilates food for promoting growth and replacing worn and injured tissues.

Animal protein :- protein derived from meatpacking or (changes to waste non edible food, edible) rendering plant, Surplus (excess) milk and milk product and marine sources. it include protein from meat, milk, egg and poultry and fish products.

Appetite :- Immediate desire to eat when feed is present.
अभिलाषा

Bagasse :- it is the fibrous material left over in the sugar factories after extraction of all the juice from sugarcane.

Ration → 24 घंटे में देनी चाहिए, कितना → खायेगा → वही Diet.

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Balanced Ration:- The ration which provide an animal with the proper amount proportion (अनुपात) and variety of all the required nutrients to keep the animal in its form to perform best in respect of production OR health.

Basal Metabolic Rate (BMR):- The heat produced by an animal during complete rest (but not sleeping) following fasting when using just enough energy to maintain vital cellular activity, respiration and circulation the measured value of which is called Basal metabolic Rate OR BMR.

Bran (चोकर):- The pericarp OR seed coat of grain remove during processing.

Cereals:- A plant in the family geraminae, the seeds of which are used for human and animal for food. ex:- Maize, gram, rice, wheat, barley

Diet:- A regulated selection of a feed ingredient OR mixture of ingredients including water which is consumed by animal on a prescribed schedule.

Decortication:- The removal of the bark, hull, husk OR shell from a plant

Dry matter:- That part of a feed which is not water.

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Feed Conversion effeciency :- The gain in weight in kg and pond, produced by 1 kg ~~of~~ OR 1 pound (lb) of feed. It is reciprocal to the feed conversion Ratio.

Dry matter basis :- A method of expressing the level of nutrient contain in a feed on the basis that the material contain no moisture.

Efficiency of feed conversion OR feed converson efficiency :-> This is expressed as unit of feed per unit of product meal, milk or egg.

Emaciated :- An excessively thin condition of the body.

Feed OR feed stuff :- food of animals comprising any naturally occuring ingredient OR material ~~fed~~ fed to animals for the purpose of sustaining growth and development

feed conversion Ratio (FCR) :- The amount of feed in kg or pond necessary to produce one kg OR one pond of weight gain.

fodder :- Aerial parts with ears, husk or head.

Gluten :- When flour is washed to remove the starch, a tough viscid nitrogenous substance remains.

Hull :- outer covering of beans, peas and cotton seeds.

Husk :- Dry outer covering of grains.
ex:- Rice husk, gram husk.

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In-vitro :- Biological experiments performed in test tubes or other laboratory vessel.

In-vivo :- With in the living organism

Meal :- Feed ingredients of which the partical size is larger then flour.

Metabolic body weight :- $W^{0.75}$
Bodyweight to the power of zero point seven five.

Nutrient :- The chemical substances found in the feed materials are necessary for the maintenence production and health of animals. These includes carbohydrates, protein, fat, minerals, vitamins and water.

Palatability :- The result of the following factors sensed by an animals in locating and consuming feed, appearance, odour, taste, texture, temprature.

Palatable feed :- feeds that are well liked and eaten with relish (चाव)

Parts per million :- It is equals to miligrams per kilogram or microliter per liter

Ration :- A fixed amount of feed for one animal, fed for a definate period usually for a 24 hour period.

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Shell :- Hard outer covering of nuts.
eg:- groundnut shell.

Straw :- By product of any cereals, millet OR legume crop left over after harvesting, threshing and removal of the grains and pulses.
(कुटी)

Stover :- Thick solid stem and aerial parts without ears, husk OR head.

Zein :- A protein of low biological value present in the maize, deficient in lysine and tryptophen.

Stage में cut करके ~~[illegible]~~ animal को serve करें

Soilage :- Cut the crop from farm in green condn. and it gives the animal ~~[illegible]~~ this condn.

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Nutritional aspects of Carbohydrate, protein and fats :-

Carbohydrate:-

→ Carbohydrate May be define as polyhydroxy, aldehyde, ketone or acids and their derivatives or compounds that yield these derivatives on hydrolysis

Functions of Carbohydrate:-

1) Carbohydrate serve as ~~measure~~ major source of energy in animal body
2) They are essential componants of production, temprature control and proper functioning of the different parts of animal body.
3) They are essential componants of milk as Lactose.
4) They are stored as glycogen, excess of carbohydrates in the diet is converted into fat and stored in the fat depot.
→ These are reserve energy material of the body in liver and muscles of animals and starch in plants.
5) Carbohydrates are helpful in absorption of calcium and phosphorus in younger animals.
6) They help the secretion of digestive juices in GI tract.
7) They provide suitable environment for the growth of Ruman bacteria and protozoa.
8) They help in peristaltic movement of food.
9) They maintain the glucose level of plasma.
10) They are also component of several important biochemical compounds such as nucleic acid, coenzyme and blood group substances.

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11) They play a key role in the metabolism of amino acids and fatty acids.

Proteins:-

→ Proteins are complex organic nitrogenous compounds made up of amino acids. All proteins contain carbon, hydrogen, oxygen, nitrogen and generally sulphur, many contain phosphorus.

- elements such as iodine, iron, copper and zinc are occasionally present.

Amino Acids:- Amino acids are organic acids containing an amino group and a carboxyl group attached to the α-carbon atom. Amino acids are the monomers which are used in the synthesis of proteins which is a polymer.

- Amino acids are produced when proteins are hydrolysed by enzymes, acids or alkalis.

Although over 200 Amino acids have been isolated from biological materials, only 20 of these are commonly found as components of proteins.

Functions of Protein:-

1) Protein form muscles and tissues of the body, hence it is essential for the *growth* and development of the body

2) They help in maintaining the loss of body tissues and muscles.

3) They help in formation of enzymes, harmones, antigen, antibody, digestive juices of the body and regulate body osmotic pressure and acid-base balance.

4) They help in the repair of body cells as well as for the production of new cells.

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5) They also supply energy to the body.
6) They are essential for the formation of egg, milk protein, wool and hair of the animals.

7) They provides the basic cellular matrix within which the bone, mineral matter is deposited.

8) Endorphines (peptide are found in brain and are involved in the suppression of the pain.

essential and non essential amino acids
(indispensable) → (dispensable)
↓ → Synthesized in Body.
Cannot Synthesized in body

Methionin
Arginine } Semiessential amino acids
Threonine
Tryptophan
Valine
Isoleucin
Leucin
phenyl alanine
histidine
lysine

Glycine
Alanine
Serine
tyrocene.
Cystene.
Glutamic acid
Aspartic acid
Asparagine
Glutamine
Proleme.

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fat :-

- Plant and animal contain a group of substances, insoluble in water but soluble in ether, chloroform and benzene which are referred to as lipids.
- fat contains 77, 12 and 11 % C, H, O respectively.

Functions of fat :-

1) The main function of fats is to supply energy to the animal body. 1gm of fat after complete oxidation produces 9.3 KCal heat.

2) After hydrolysis, fats are converted into fatty acids and glyceral, so they provide essential fatty acids. (lenolic, lenolenic and arechidonic) to the body

3) It is essential componant of milk.

4) It helps in the absorption of calcium and phosphorus in the body.

5) Certain fat soluble vitamins such as A, D, E, K are absorbed in the blood in presence of fats.

6) Phospholipids are the essential constituent of cell wall and play an important role in cell nutrition.

7) It helps in temprature regulation and insulation for the vital organ, protecting them from shock.

8) It is required for the lubrication of joints.

9) fats are important nutrient of nervous metabolism.

Water ⇒ animal body ⇒ 50 – 95% water
Embryo ⇒ 95%
Birth ⇒ 75–80%
5 month ⇒ 68 – 72%
mature ⇒ 50–60%

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Water :-

- Water, which is composed of hydrogen and oxygen in the ratio of 2:1 is not only the largest single constituent of nearly all living plants or animal tissues but it also performs exceedingly important function.
- The animal body may contain 50 to 95 percent water.
- In case of cattle water content is approximately 95% for the embryo, 75 to 80% at birth, 68 to 72% at 5 month and 50 to 60% in the mature animals.
- Whereas blood contains 90–92%, muscle contains 72–78% bones contain about 45% and enamel of teeth which is hardest tissue of body contains 5 percent water.

functions of water :-

1) Water is an essential constituent of the animal body.
2) It is an essential part of foodstuff. It makes the food soft and palatable.
3) It helps in regulating body temperature.
4) It helps in absorption and transportation of nutrients to different parts of the body.
5) It is an essential constituent of almost all the juices and secretion of the body.
6) It helps in the excretion of waste product in the form of urine, faeces and perspiration from the animal body.
7) It acts as a solvent of many constituents of body nutrients. All the biochemical and physiological reactions take place in liquid medium.
8) It provides shape to the body cells and essential for cell nutrition. The metabolic water produced inside the body help in transportation of nutrients inside the body cells.

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9) During the period of hibernation, metabolic water keeps the animal alive.
10) It helps in maintaining the acid-base balance of the body.
11) It helps in hearing by the ears and visions by the eye.
12) It acts as a cushion for tissue cells and nervous system and protects the various vital organs against shocks and injuries.

Sources of Water :-

1) Drinking water :- It is consumed by the animals from the outside source

2) feed :- Moisture content of all the feeds supplies the water requirement of the animal.

3) Metabolic/oxidation water :- It is the water, which is produced due to metabolism of nutrients.

- It meets 100% of water requirement in hibernating animals and embryo, 5-10% in domestic animals and 16-26% in desert animals.
- A 100g of each fat (107), carbohydrate (60) and protein (40) metabolism produce 107, 60 and 40g metabolic water, respectively.

metabolic water	
fat	→ 107
carbohydrate	→ 60
protein	→ 40

4) Bound water :- The water, which is combined with the constituents of protoplasm by either physical or chemical means.

- It can not be seprated easily from protoplasm by freezing at low temperature or by evaporation at high temperature or under dry conditions.
- Bound water is of special intrest in connection with the ability of plants and animals to resist at low temprature and drought condition.

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Water requirement:

- Water requirements for any class or species of animals depends on dietary and environmental factors.
- Water consumption is related to
  - Heat production
  - Energy consumption
  - Body surface area in non-stressing situations.

- All environmental temprature that do not result in heat stress, there is a good linear relationship between dry matter consumption and water consumption.

- Non-heat stressed non-lactating cattle may drink 5-6% body weight per day.

- Water consumption may increase by 12% or more of body weight per day during heat stress.

Animal	Litres/day
Dairy cattle	30-40
Milking cattle	30-40 + 1.8 l per kg of milk
Beef cattle	22-66
Buffalo	40-50
Sheep and goat	4-5
Horses	30-45
Swine	11-19
Chickens	0.2-0.4
Turkey	0.4-0.6

* Total water required → 80-100 litre/day. total work.

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- Animals will consume 2 to 5 kg of water for every 1 kg of dry feed consumed when they are not heat stressed.
- Birds require less than mammalian species.
- Young animals generally require more water than adult per unit of body weight.

Factors modifying water requirement:

- Physiological status of animal.
  - → Young calves consume more water
  - → Pregnant and lactating animals consume more water.

- Ambient temperature, Relative humidity, wind velocity, Rain fall.
- Dry matter intake.
- Composition of feed:
  - → Feed with high level of salt increases the water intake.
  - → feed with high protein leads to higher production of uric acid/urea which in turn increases water requirement.
  - → High fibrous feed also leads to increase in water requirement.

- Variation of species
- frequency of watering the animal.
- Diurnal and seasonal variation.

⇒ Animals can tolerate higher salinity than humans.
⇒ Low quality water leads to reduction in water intake and feed consumption and decreased production.

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Effect of water restriction:

- Moderate water restriction decreases
  - → feed intake
  - → Productivity
  - → urine and faecal water excretion.

- Severe water restriction leads to
  - → Rapid weight loss, increase in blood concentration.
  - → Increased renal excretion of Na, K and N.
  - → Increased pulse rate and rectal temperature especially at hot temprature because animal has no longer enough water to evaporate.
  - → Nausea, difficulty in muscular movements and death.

Toxic elements in water:

→ Universal solvent property of water sometime creates problems.
→ Water can dissolve unwanted material.
→ Such water should not be used for drinking purpose.
→ Amount of total dissolved solids (TDS) is a measure of the usefulness of water for animals.

A level of less than 3,000 mg/litre TDS can be tolerated by the animals but higher amount is harmful to animals.

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Nature of Nitrogenous End Product :-

Mammals :-

→ Urea is the principal end product of protein catabolism.
→ It is soluble in water and toxic to the tissues in concentrated solution.
→ Much water is required to dilute it to a harmless concentration, remove it from the tissues and excrete it.
→ Urea excretion in mammals requires 20-40 times more water than is required to excrete a similar amount of uric acid in birds.

Birds :-

→ Uric acid is the principal nitrogenous end product
→ It is excreted in nearly solid form with minimum loss of water.
→ further the breakdown of protein to uric acid provides more metabolic water than does its catabolism to urea.
→ That is why, birds have lower requirements of water than mammals.

-: Minerals :- Awdesh

- Minerals comprise the ash obtain after complete oxidation of organic substences or biological material.
- The bulk of total ash from the animal body represents skeleton mineral.
- Minerals make up to 3 to 4 % of animals body.

Classification of Minerals :-

- The mineral recognised for performing essential functions and present in fairly large amounts (more then 70 milligm per kg live weight) (>70 mg/kg) are called essential or macro nutrients which include Calcium, phosphorus, potassium, Na, Cl, Mg & S.
  P K, S Ca Mg
- These are required at concentration of >100 mg/day.

- The principle minerals present in microquantities (less then <70 mg/kg live weight but are physiologically equally important called trace elements or micro minerals which include Fe, Cu, Co, Mn, Zn, I, Mo
- These mineral are required in trace amount (PPm)

General functions of Mineral elements :-

1) Protective function :-

Ca and P together with F form the hard enamal thus protect the teeth from rapid wear.

- Ca has a protective function in helping blood clot formation.

organic → inorganic.

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2) Structural function :-
→ As constituent of Bone and teeth they give rigidity and strength to the skeletal structures eg :- Ca, P, Mg, F, Si
→ Minerals are constituents of organic compounds such as protein and lipids, which make up the muscles, organs, blood cells and other soft tissues of the body eg :- P, S, Zn.

3) Regulatory function :-
→ Minerals occur in body fluid and tissues as electrolytes concerned with the maintanence of the osmotic pressure, acid base balance, membrane permeability & tissue irritability.
→ Na, Cl maintain osmotic pressure of body fluids.
→ Na, k, Ca, Mg, Cl regulate the acid base ballance in the body.
→ Na, k, Ca regulate heart beat.
→ I regulate/ controls general metabolic rate.

4) General Metabolic functions :-
→ Minerals exert characteristics effect on irritiability of muscles and nerves.
→ Important in activation of many enzymes.
→ Na, Cl required for digestive processes.
→ P is essential for carbohydrate, fat and protein digestion.
→ Fe in the form of haemoglobin transport oxygen.
→ Cu is required for haemoglobin formation.
→ Co is necessary for vit. B_{12} synthesis.

Dietary Source of minerals :-
• Concentrate feed and forage that they consumed is major dietry source of mineral.
• Mineral suppliments such as bone meal, mineral mixture, common salt calcite, shell grit etc.
• drinking water is minor source.

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Calcium (Ca):-

→ Ca and P serve as the major structural element of skeletal tissue, with more than 99% of the total body calcium ~~beign~~ being found in the bone and teeth.

→ The normal level of blood calcium in animals ranges from 9-11 mg/100 ml of serum.

Factors affecting the blood Calcium level.

1) The absolute level of Ca and P And the Ca, P ratio of food-
→ a low intake of either element over long period of time leads to decreased blood calcium level.
→ a Ca, P ratio of 1:1 to 2:1 is usually recombedate.

2) fat content in the diet:-
- Impaired digestion and absorption causes inpaired absorption of Calcium because calcium form soaps which are insoluble.

3) Phytic acid and oxalate:-
- oxalates in certain foods precipitate calcium in the intestine as the insoluble Ca oxalate formed insoluble salt with calcium and makes it insoluble.

4) Acidity relation:-
acidic medium in intestine favour calcium absorption.

5) Protein in the diet
Protein ↑↑ Ca absorption ↑

6) Vitamin D in the diet
- Vit-D provide acidic medium in the intestine causing more Ca absorption

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7) Perathyroid hormone:-
- Regulate ca level in plasma.

8) Kidney threshold:-
- In a normal adult any extra ca absorb. from the kidney is readly excreted in the urin.

Regulation of Calcium:- (S.N)

- Low levels of ca stimulate pTH (parathormone) secretion, which promote the release of ca and P from bone.
- The calcium ~~needs of~~ is utilized to meet the calcium needs of the animal and phosphorus is excreted.

→ Another hormone that control blood calcium is calcitonin [from thyroid], which decreases the rate of calcium mobilization from bone and therefore, decreases serum calcium level.

Parathormone ↑ → Ca ↑ (Blood) Calcitonin ↑ → Ca level in blood

Functions of Calcium:-

1) Ca is essential for skeletal formation (a), normal blood clotting (b), rhythmic heart action (c), neuromuscular excitability (d), enzyme activation (e) and permeability of membrans (f), acid base balance of body fluid (g), also in curdling of milk.

Absorption of Calcium:-

- The main site of ca absorption is the "small intestine" specially the proximal portion of the Duodenum.
- The percentage of absorption of ca decreases with age, high dietary

level of Inorganic phosphorus, phytin phosphorus, magnisium. intake and high Ca intake. or low vitamin D intake.
→ The major route of excretion of Ca is through faeces.

Deficiency of Ca :-

1) Rickets :- This symptoms accurs in young growing animals
↳ The symptoms of rickets are (a) missshappen of bone, (b) enlargement of joint, lameness, stiffness. This condition is called rickettic rosary.
↳ Calcification of normal bone does not take place.
↳ In young animals, ca deficiency causes reduced growth rate.

2) Oesteomalacia :- In the adult animals ca deficiency results in oesteomalacia in which ca of the bone is withdrawn and not replaced.
↳ In oesteomalacia the bone become (a) weak, (b) porous, (c) soft. continuous mobilization of Ca from the bones for the higher demand with a low intake is responsible for this condition.
↳ Most acute cases of oesteomalacia occur during gastation and lactation in mammals and during egg laying in birds.

3) Oesteoporosis :- This is characterised by a decreased bone mass it is due to bone resorption being greater than bone formation.
↳ It is prominant in aging.
↳ In oesteoporosis the mineral content of bone is normal but the absolute amount of bone has decreased

Just after parturition → Ketosis and Milk fever.
Major disease.

Notes

parturient paresis

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4) Milk fever or parturient paresis or Ca tetany :-
- Shortly after parturition high yielding cows may suffer from milk fever. The serum Ca goes down with the result that there are muscular spasms and in extreme cases paralysis.
- There may be breeding difficulties in pregnant animals and the calves born may be dead or very weak.

5) Birds have a tremendous (बहुत ज्यादा) meat for Ca imidiately after commencing egg production. And bone reserves are mobilised to meet this demand for Ca to make egg shells.
↳ In laying hens deficiency of Ca results in improper development of the egg shell which is either not fully form or easily breakable.
↳ The deficiency causes soft bone and weak, curved legs and low egg production.

Sources of Ca :-
- milk and green leafy crops (specially legumes) are good source of Ca.
- cereals (अनाज) and Roots are poor sources.
- Animal by product containing bone, fish meal, meat cum bone meal are rich source of Ca.
- Dicalcium phosphate, $CaCO_3$ and Ca Phosphate are also good source of Calcium.

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Requirement :-

Dairy Cattle → 0.34% to 0.6% of dry matter
Pig → 0.9% of dry matter
Broiler → 1% of dry matter
layer → 3.5% of dry matter

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Phosphorus:

↳ Major portion of phosphorus in the animal body is distributed in the bones.

↳ The contain of Inorganic phosphorus in the blood is 4-9 mg/100ml depending upon species and age

Function of phosphorus:-

1) Phosphorus plays an important role in the formation of bones and teeth along with Ca.

↳ The amount of P present in these structures is about 80% of the total.

2) It maintain the normal level of blood Ca and its proper activity.

3) It plays active role for the formation of phospholipid in the cells, nucleic acid, coenzyme and phosphoprotein

4) It plays a vital role in energy metabolism in the formation of sugar phosphate like ADP and ATP

Deficiency symptoms:-

1) Rickets
2) Osteomalacia

Allotriphagia
Osteophagia → craving for bone
Sarcophagia → craving for flesh

Pica (Depraved appetite):- P deficiency causes a specific symptoms in cattle called Pica. The affected animals have abnormal appetite and chew woods, bone, rags and other forein material.

- The animals become very weaks if not pretened, they may die due to weakness or due to secondary infection which occur from heating, decaying bones and other materials.
- The depraved appetite (Pica) may be known as either "allotriphagia" (a generalised form) or as "osteophagia". (Craving for bones)

and as sarcophagia (craving for flesh).

4) Reproduction :-

low dietry intake of P has also being associated with poor fertility, disfunction of ovaries causing inhibition, dipression and irregularity of estrus.

Requirement of P (% of dry matter in feed) :-

Dairy cows - 0.31 to 0.40
Sheep/Goat - 0.16 to 0.37
poultry - 0.32 to 0.50

Sources of P :-

- Animal products like fish meal, meat meal, bone meal are good sources of P.
- Cereal grains, wheat bran, rice bran, rice polish, cake etc are fairly good sources of P. though poor sources of Ca.
- Leguminous fodder like berseem and lucerne are poor source of P.
- Most of the P present in the cereals and their by products is in the form of phytates, which are the salt of phytic acid.
- Ruminants can utilized the phytate P due to rumen microbial activity.

Nutritional secondary hyperparathyroidism :-

When animals are fed diets containing low or marginal levels of Ca but excessive amount of P, a condition called nutritional secondary hyperparathyroidism (NSH) may develop.

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1.) Excess P depresses Ca absorption the resulting hypocalcemia triggers the parathyroid to release parathormone which mobilizers Ca from bone to replenish the blood level.

2.) A high level of dietary P also causes a greater turn over rate in the bone. In horses and monkey the fibrous connective tissue invaders the area and enlarged facial bones result. Hence the disease is also called "osteodystrophia fibrosa" and "big head disease". Miler disease.

→ field cases of NSH have been reported in horses and rabbits fed high grain intake, birds fed all-grain diet, primates fed only fruit and nuts and carnivores (dogs, cats, lions and tigers) fed all meat diets.

→ NSH causes periodontal disease (loss of bone around the teeth) in the dog & humans.

Note:-

Calcium rich feeds	Phosphorus rich feeds.
Legume seeds, legume roughages Animal byproducts (Bone meat, tankage, meat scrap, fish meal) milk and milk products plants leaf meals.	vegetable protein supplement cereal grains and their by products (brans) Animal protein supplements

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Ca : Mg
50 : 1

Magnesium :-

- about 70 % of total Mg is found in the skeleton, the reminder been distributed in soft tissue & fluids.
- Blood serum contain 2-3 mg Magnesium/100ml.
- Bones contains about 1.5 % Mg

Functions of Mg :-

1) Mg plays important role in activating various enzymes such as phosphate transferase, Decarboxylase, Acyl transferase.
2) Mg is an activator of phosphates and takes an active part in the carbohydrate metabolism.
3) It also plays an important role in Ca and phosphorus metabolism for the formation of bone and teeth
4) Mg also plays an important role for the neuromuscular activity of the body.
5) It is essential contitute of bone ~~of~~ and teeth.

Absorption of Mg :-

- The rumen and reticulum is major site for mg absorption in ruminents. It is also absorbed from large intestine.
- P apprently depressed the absorption of Mg from the rumen.
- Mg is excreted by faeces, urin and milk.

Requirment of Mg. (% dry matter of feed)

Dairy Cows	0.2.0
Sheep and goat	0.04 - 0.08

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Deficiency symptoms:-

1) Magnesium tetany in adults animals (Grass staggers / Grass tetany)
→ It is also refered as wheat pasture poising of wheat staggers.
→ This is observed in cows fat on lush green pasture. There are other factors also which are responsible for grass staggers like harmonal disturbances and [faulty inter relationship of Ca, P and Mg.]
→ clinical signs of tetany include reduced apetite, increased exitability, profuse salivation, convulsion and death.
→ The affected cattles are nervous, with their heads held high, ears pricked and eyes staring.
→ The animal moves in a stiff manner and stagger when walking.

2) Hypomagnesimia in young calves -
When calves reared on milk diet without any other suppliment for a prolonged period.

3) Lactation tetany (hypomagnesimic tetany) :-
→ It is a disease in lactation cows and is characterised by hypomagnesia less than 1 mg / 100ml. usually accomponded with hypocalcimia, musular spasms and convulsion and death due to respiratory failure.
→ Temprature, pulse and respiration rate are high.
→ tetany can be produced by feeding excess potassium.

Sources of Mg:- Most of the commonly fed roughage and concentrates contain 0.1% Mg
→ Bran, oil cake and leguminas fodder are rich source of Mg while milk and animal products are much poorer sources

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Sodium (Na):-

→ It is an alkaline salt which form 93% alkali of blood serum.
→ It is found in body fluids and muscles of the body.
→ The total amount of Na in the body is about 0.2% out of which upto 0.05% is deposited in bones.
→ It is a major Cation.

Functions of Na:-

1) Na salt is useful in the Metabolism of water, protein, fat and carbohydrate.
2) It controls body fluids concentration, contraction of nerve and muscle fibre, body fluid PH, osmotic pressure and help in maintaining nutriality among body tissues.

absorption of Na:-

→ Takes place in rumen and upper small intestine. it is mainly excreted through urine with small amount is also excreted through faeces and perspiration.
→ The hormone aldosterone, secreted from adrenal cortex, regulates the reabsorption of Na from kidney tubules.
→ In the absence of this hormone Na is excreted in the urine

Deficiency symptoms:-

→ excessive loss of Na may occur from vomiting, Diarrhea or profuse sweating.
→ The deficiency of Na in the body of animals result in loss of apetite, general debelity, stopage of growth and development, fall of body temprature, neuromuscular disturbances, softening of bones, ceratinization of corneal epithelium, impotency in vein, delayed sexual maturity and impaired estrus rythm.

Notes

P/10

5.1. Common Salt → Is added in mineral mixture always.

1.1. mineral mixture

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→ And reproductive process in female and loss of milk production in lactating animals.

→ In laying hens, a deficiency results in lowered production, loss of weight and cannabalism.

Sources of Na :-

- The main source of Na is NaCl or common salt.
- Most of the feed and forage are poor source of Na except the herbage which grown on alkaline soil.

Awdesh

Potassium (K):

- Most of the K is found in cells. excess of this salt in the body interfares with the absorption and metabolism of (Mg)*

Functions:

1) K is essential part along with Na, Cl and bicorbonate ion, in the osmotic pressure regulation of the body fluids and in the acid base balance in the animals.
2) K plays an important role in nerves and muscles exitability and activates certain enzymes

Absorption of K:

- K is absorbed mainly from the small intestine and to some extent in the large intestine.
- The majority of K excretion is in the urine and also via sweat and milk.

Deficiency symptoms:

- Decreased use of hay and increased use of grains may result in defeciency of K.

1) K deficiency result in slow growth, reduced feed and water intake, lowered feed efficiency, musular weakness, nervous disorders, stiffness, emaciation, Intracellular acidosis and degeneration (कमजोरी weakness) of vital organs.

Sources of K:

- outside the body K is available in pasture grasses.
- Milk also contains K. Inside the body it is found in the ~~food~~ plasma muscle and blood cells.

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Chlorine (Cl)

- Cl ion is the major anion of extra cellular fluid. It is found in skin, subcutaneous tissues and gastric juices.
- Out of the total amount present in the body 80-85% chloride is found in inorganic form while the rest 15-20% in organic form.

Functions :-

1) This mineral is required for the formation of HCl of the gastric juice.
2) In the form of NaCl it assist in the digestion of food.
3) Chlorine is associated with Na and K in acid base relationship and osmotic regulation. It plays a key role in regulating the pH of body fluids. The movement of chloride from body fluid to erythrocytes is known as "Chloride shift" is a primary mechanism in regulating pH and osmolarity of tissue fluids.

4) It also helps in cell nutrition, growth and reproduction among animals.

absorption of Cl :-

Cl is absorbed in Combination with Na. It is Mainly absorb from the upper small intestine

- It is excreted through urine with small amount in feaces.

Deficiency symptoms :-

1) A dietary deficiency of Cl may leads to an abnormal increase of the alkali reserves of the blood. ("Alkalosis") caused by excess of Bicarbonate, since inadequate levels of Cl in the body are partly compensated by increase in bicarbonate.

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भूख ना लगना।

2) deficiency of salt in diet leads to decreased apetite. which results in poor growth rate and milk production

3) deficiency of salt in poultry leads to feather picking and cannabalism.

Sources of Cl:

↳ with the exceptions of fish and meat meal, the Cl content of most foods is comparatively low.
↳ The main source of this element for most animals is common salt

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Sulphur:-

Most of the S in animal body occurs in proteins containing the amino acids cystene (सिस्टीन), cystine (सिस्टाइन) and methionine.

two vitamins biotin and thiamine and hormone insuline also contain sulphur

Functions:-

1) S is an essential element for protein and vitamin synthesis. wool is rich in cystene and contains about 4% of S.
2) It combine with Fe and used for the formation of Hb in RBCs.
3) It is also useful in blood clotting and endocrine function.
4) It is also maintain intra and extracellular fluid and acid-base balance

absorption of S

- S is absorbed in the rumen and small intestine

Deficiency symptoms:-

- Deficiency of S in the body results in poor growth and development of the body, loss of weight, weakness, lacrimation and metabolic activities of the body are also disturbed.
- ★ Microbial protein synthesis is reduced and the animal shows sign of protein malnutrition.

★★ In sheep its deficiency causes production of poor quality wool

⇒ All balanced rations, muscles, wings of the birds, horns, hairs nails, bile juice, saliva, RBC, nervous system and hoof of the animals contain certain amount of S.

Microelements

Iron (Fe) :- [12-16 mg/100ml of blood]

The total amount of iron found in the body is [0.004%].
half of this amount remains in combination with RBC in the form of Heam associated with red colouring matter or Haemoglobin.

- The remaining portion is found associated with myoglobin, enzyme cytochrome peroxidase, catalase and other enzymes of the body, liver, spleen and kidney.

Functions :-

1) As a part of respiratory pigment and Haemoglobin, iron helps in the ~~utilisa~~ utilization of oxygen by the blood.

2) it activates enzymes by taking part in the enzyme system and assist in proper functioning of every organ of the body

Short question

Absorption and Excretion :- [Imp.]

1) The amount of iron absorbed is related to its needs by the animal body.

2) The capacity of the body excrete the iron is very less. Therefore its absorption is controlled by the bodies requirement.
↳ There are two hypothesis for the control of iron absorption

1) Mucosal block theory :-
↳ In this case iron is absorbed by the mucosal cells of GI tract and converted into ferritin. When the cells become physiologically saturated the iron absorption is chacked (stop)

biological value → microbial protein → 72-75
egg → 92
milk → 90

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4) The second mechanism by which iron absorption is controlled is the passage of iron from the mucosal cells to the stream which is controlled by the oxygen tension in the blood.

Factor affect the Fe absorption:
1) Acidic condition in the GIT tract helps iron absorption. absorption of iron is more effecient when body stores are low.

2) Ascorbic acid (vit-C) in the diet also helps iron absorption.
3) High level of P and Phytic acid present in the diet reduces iron absorption.

⇒ Deficiency Symptoms :-
The deficiency symptoms of iron are lower weight gain, inability to withstand circulatory strain, labelled breathing after mild excercise, Reduced appetite and decreased resistance to infection.
Iron deficiency results in Hypochromic, microcytic, Anemia in pigs and chicken while in calves it is microcytic and normochromic type.

⇒ Piglet Anemia :- → deficiency of Fe in piglets
Among farms animals suckling pigs are highly susceptible for iron deficiency.
- Piglets kept in confinement to concrete stall are more susceptible due to their non-essisablity to grits or soil.
- Anemia in piglets is characterised by (a) poor appetite and growth, (b) low haemoglobin contain of blood (3-4gm/100ml blood), lack of healthy pink colour of

the visible mucous membranes, wrinkled skin and rough coat, Breathing becomes laboured and spasmodic And this condition is called * Thump.

Ques:- Why piglets are more susceptible to anemia?

1) The placental transfer of iron is so poor that the piglet is born with unusually small store of body fe, compared with newborn of other species. The ash of a newborn puppy has 6 times higher Fe content compared to that to bitch's milk. The liver of new born has 5 to 8 times as much fe as liver of mature dogs.

2) The polycythaemia of birth seen in other species is absent in the piglet, so that a source of iron from breakdown of the excess Hb is denied to it.

3) Low levels of iron in sows milk.

4) Rapid early growth rate compared with that of the lamb or calf. If adequately fed, a young pig can reach 5 times its birth weight at the end of 3 weeks and 10 times its birth weight in 5 weeks

5) Large litter size. All these features contribute to piglet anaemia.

Sources of Iron :- (A)

- Milk is poor and green forage, liver, egg yolk are rich sources of iron.

Treatment of Piglet anemia :- Piglet anemia can be prevented or cured in its early stages by drenching the suckling pigs with a saturated solution of ferous sulphate. Pesting the ferous surface salt on udder of mother and Injection of 100mg iron-dextran intramuscular or subcut. at 4th and 14th day after birth.

Toxicity of fe :- characterised by excessive deposition of storage forms of iron in tissues. [Siderosis] *

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accompanied by high plasma iron (Hypersideremia) and damage to intestinal mucosal cells.

Copper (Cu) :- functions :-

a) Cu is the integral componant of following enzymes:

1) Ceruloplasmin (ferroxidase) → Conversion of iron into transferin

2) Erythrocuprein → occurs in erythrocytes where it plages a role in oxygen metabolism.

3) Cytochrome oxidase → which is important in oxidative phosphorylation and myelin synthesis

4) Lysyl oxidase → needed for the conversion of lysine to desmosine which forms cross linked in elastin and collagen fibers

5) Tyrosinase → necessary for the conversion of amino acid tyrosine to melanine which is necessary for normal pigmentation of hair, fur or wool.

b) Cu is the integral componant of T-uracil, a pigment of feathers.

c) Cu is required for maintaince of crimp of wool.

Absorption and excretion :

- Absorption takes place from the small intestine.
- Addition of large amount of $CaCO_3$ and ferrous sulphide in the diet markedly reduce absorption of Cu by reducing the solubility of Cu.
- under the influence of high Mo and sulphate intake Cu utilization is affected.
- More than 90% of the dietary intake is excreted in faeces and in urine excretion is low.

Notes

→ Cu

✓ sway back condition
✓ Neonatal ataxia
✓ enzootic ataxia

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complete paralysis of new born Lamb
mainly Hind limb

Cu deficiency :-

1) A deficiency of cu impaired the animals ability to absorb fe leading to anemia.

2) Deficiency of cu causes → (a) poor growth, (b) Bone disorders, (c) scouring, gastrointestinal disturbances with diarrhea in cattle, (d) Infertility, (e) depigmentation of hair and wool, (c) lesions in the brain stem and spinal cord. (The lesions are associated with muscular incordination and occur specially in young lambs. → "swayback condition" (lambs of in U.K.) also known as "enzootic ataxia" or "neonatal ataxia"

↳ The signs or symptoms range from complete peralysis of new born lamb to a swaging staggering gait, which affects in particular the hind leg.

3) loss of crim in wool :- "stringy or steely wool".

→ Sudden death without any preliminary sign due to rupture of major blood vessel)

✓ falling disease :- A chronic cu deficiency cause in disease in grazing cattle in australia.

In this condition fibrosis of myocardium takes place and macrocytic hypochromic type anaemia appears.

↳ Cu deficiency also leads to reproductive problems in cattle

↳ Coast disease (neck ill, licking disease) :→ this disease is caused by the deficiency of Cu and Co in diet of cattle and sheep

Mo excess and Cu deficiency

↳ Teartness (peat scours) :→ Certain nutritional disease which are prevented or cured by Cu suppliment, the forage contains normal amount of cu. however the assimilation of cu is apparently prevent by an excess of another minerals.

• one disease is teartness, a type of severe scouring and

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unthriftiness which affects cattle pastured of certain area of england and similar condition are noticed in new zealand peat soil pasture known as peat scours.

Requirement:-
- Cattle require 50mg of cu perday
  Sheep " 5mg per day.
  Pig " 5ppm of cu per kg of diet per day.

Cu poisining:-
↳ Continuous ingestion of cu in excess of nutritional requirement leads to an accumulation of element in the body tissues specially in the liver. hence cu can be regarded as a cumulative poision.
↳ The tolerance to cu varries in species.
pigs are highly tolerant and cattle relatively low. on the other hand sheep are particularly susceptable and chronic cu poising has been encountered in house sheep on concentrate diet containing 40mg/kg of cu.

↳ chronic cu poisining result in necrosis of liver cell, jaundice, loss of appetite and death from hepatic trauma.

Imp
(Cu-Mo-S interelationship (Ctearst):-
↳ A mechanism which explain this interrelationship has recently been suggested.
↳ Sulphide is formed by ruminal microorganism from dietary sulphate or organic sulphur compound. The sulphide than reacts with Mo to form thiomolebadate which in turn combined with cu to form an insoluble copperthiomolebadate thereby limiting the absorption of dietary cu.

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↳ In addition it is considered likely that if thiomolebdate is fom in excess, it may be absorbed from the digestive tract and exert a systemic effect on Cu metabolism in animals.

Iodine (I)

⇒ functions :-
Iodine placed an important role in synthesis of two harmones triiodothyronine and tetraiodothyronine (thyroxine) produced in the thyroid gland.
↳ The thyroid harmone accelrates reactions in most organ and tissues in the body. Thus increasing the basal metabolic rate accelrating growth and increasing the O_2 consumption of the whole organism.

⇒ Absorption of Iodine :-
Absorption of I takes place throughout the GIT.

⇒ Deficiency of Iodine :-
↳ In the deficiency of I the thyroxine production is very much reduce and In order to produce more thyroxine the thyroid gland is enlerged which called Goitre.

↳ Deficiency in pregnant animal is birth to hairless pups or dead young ones, retarted growth & delay in all the developmental process. other symptoms are edoema slow pulse rate, wrinkled skin, falling of hair etc.

⇒ Sources of Iodine :-
↳ The richest source of this element are food of marine origin like sea weeds and fish meals.

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Some sources are rich in goitrogens which cause goitre.
ex- Brasica family like cabbage, rape, kale, soybeans, linseed, peas and groundnut.

Pig → 30 - 160 microgm / day
Sheep → 50 - 100 µgm/day
Cattle → 400 - 800 µg/day
poultry → 5 - 9 µg/day

Brasica family
↓
goitrogens

Cobalt (Co)

- dietary essential for ruminants because it is necessary for the synthesis of vitamin B_{12} by the gastrointestinal microbes.

functions of cobalt :-

1) Cobalt is necessary for growth and development of the body as well as for the multiplication of rumen microbes among ruminants.
2) It forms as essential part of the enzyme system and plays an important role in the synthesis of vitamin B_{12} in rumen.
   - About 3% of ingested cobalt is converted into vitamin B_{12} in the rumen.
3) As a component of vitamin B_{12}, Cobalt is involved in propionate metabolism where it acts as a cofactor.

Deficiency Symptoms :-

- Loss of appetite, emaciation, rough coat and paleness of skin normocytic anemia and normochromic anemia, retarded growth or weight loss, weakness and reproductive failure, stumping gait and finally leading to death are the main symptoms of cobalt deficiency.

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↳ In ruminants, Co is required by rumen microorganism for the synthesis of vitamin B_{12}.
- Deficiency of Co leads to insufficient production of vit B_{12} to satisfy the animal requirements.
- These symptoms can be cured by the injection of vit B_{12} in the blood but the Co injection does improve the condition.

↳ In australia and new-zealand, the deficiency of Co is called "Coast disease", ~~"Marasmus~~ OR "Enzootic marasmus" OR "Vinguish" or "Pining".

Source of Cobalt:-
↳ Normally the feed and fodder contain traces of Co. ranging 0.12 - 0.25 ppm.
↳ leguminous grasses are rich source of Co as compare to other animal feed.
↳ Co sulphate and chloride are good source of cobalt

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: Zinc (Zn) :

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functions of Zn :-

1) Zn is an important trace element for the proper growth of body and development of hairs and keratinization of epithelial tissues.
2) Being an essential part of Insulin hormone it plays important role in the metabolism of carbohydrates. It involved in the nucleic acid and vit. A metabolism and protein synthesis.
3) Zn play a key role in both cell and antibody mediated immune responses for resistant against infection and also provide protection against liver damage caused by toxins from the fungi.

Absorption of Zn :-

↳ Absorption of Zn takes place in small intestine.
↳ Absorption of Zn involves solubilisation of Zn, which is higher at high acidic pH, dissociation from the source, binding to receptors at the intestinal cell wall and transport into the cell aided by Zn binding proteins.
↳ The rate of absorption of Zn varies significantly between various forms within and between organic and inorganic sources (dietary level, amount, chemical form of Zn).

↳ High levels of Ca, phosphate, phytate, Cu and Cd in ration decreases Zn absorption.
↳ The inorganic sources have low solubility and poor dissociation and hence often pass through the gut into faeces without appreciable absorption.
↳ Zn is mainly excreted through faeces and a small proportion through urine.

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Deficiency symptoms:-

1) In Cattle → on the zn deficient diet, milk production reduced, poor fertility, loss of hair, lower feed efficiency, loss of appetite etc.

2) In calves :→ symptoms of zn deficiency in calves include inflammation of the nose and mouth, stiffness of the joints, swollen feet and parakeratosis.

3) In pigs :→ Zn deficiency in pigs is charaterized by subnormal growth, depressed appetite, poor feed conversion efficiency and "parakeratosis". ★

- The latter is a redeleing of the skin followed by eruption that develop into scab. The deficiency symptoms are more common in young one and housed pigs fed ad-libitum on a dry diet.
- High level of Ca in the diet aggravated the condition.

Ca↑ Zn↓

4) In chicks :→ Retarded growth, "frizzled" feather, parakeratosis and a bone abnormality referred to as the "swollen hock syndrome". ★

Sources of Zn :-

↳ Brans are rich source of zn.
↳ feed and fodders contain adequate amount of zn.

zn def ← [Swollen hock syndrome → poultry
parakeratosis → pig]

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Manganese (Mn)

↳ The amount of Mn present in the animal body is very small, the highest concentrations occuring in the bones, liver, kidney, pancrease and pituitary gland.

↳ Excess amount of Ca and P in the body prevents its absorption from the digestive tract.

↳ The mineral is excreted out from the body along with bile in faeces and urine.

Functions of Mn:-

1) Mn plays an important role for the bone development and vital nutrient in the synthesis of chondroitin sulphate which is the organic matrix of the bone.

2) Mn is important trace mineral for normal growth, reproduction, egg production and for the prevention of perosis among poultry.

3) Mn is important in the animal body as enzyme activators such as phosphate transferases and decarboxylases associated with the Krebs cycle.

4) This trace mineral has an active role in immune functions where it helps in detoxifying free O_2 radicals which can cause tissue damage produced by immune cells in response to killing bacteria.

Absorption of Mn:

↳ Mn is one of the poorly absorbed and retained trace element / minerals in livestock.

↳ High dietary intake of Ca, P and Fe reduces Mn absorption from the small intestine.

↳ The mineral is excreted out from the body along with bile in faeces and urine.

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Deficiency symptoms:-

1) Cattle :- Deficiency of Mn show poor growth, leg disorders, skeletal abnormalities, ataxia of the new born and reproductive failures.

2) Swine :- In swine deficiency of Mn results in poor growth of bones with shortening of leg bones, enlarged hocks, muscular weakness, increase in back fat and irregular oestrus cycle.

3) Poultry :- In young chicks a deficiency leading to perosis in young birds may be aggravated by high dietary intakes of Ca and P.

↳ Mn deficiency in breeding birds reduces hatchability and causes retraction in chicks. "Perosis"

Source of Mn:-

↳ forages are rich in Mn as compared to cereals.

↳ In feed it is available in maize, oat, wheat, green fodder and brans.

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"flourine" Awdesh

The amount of flourine in common feedstuffs is 1 to 2 part per million.
Presence of 100 ppm flourine in the ration on dry matter basis, and above 3ppm in drinking water is toxic to animals.

Functions of flourine:-
- In very small amount the mineral is essential for the growth and proper development of the bones and teeth.
- It reduces the incidence of dental caries.

Deficiency symptoms:-
Deficiency of flourine causes dental caries.

Toxicity of flourine:- (Imp)
- The major clinical signs of flourine toxicity are found in teeth and bone. It is slowly being deposited in the body and produces ill effect afterward.
- The bone become thick and soft with dirty colouration, teeth loss their normal shining appearance.
- Finally they become soft and very weak. They look quite bad and are unable to bear cold water.
- Sometime yellow and black spots are also visible on the teeth.
- It results in loss of appetite, growth and production.

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"Selenium"

- The presence of Se in roughages and concentrates is harmful to the animals.
- In soils it may be present upto 40 ppm. in soil
- Se is present in all cells of the body but concentration is normally less than 1 ppm.
- Toxic concentration in liver and kidney are normally between 5 and 10 ppm.
- Most important role of Se in livestock is prevention of liver necrosis in rat and exudative diathesis in chicks.

functions of Se :-

1) Se is essential for growth, reproduction, prevention of various diseases and protection of the integrity of tissues. The metabolic function of Se is closely related with vit E and acts as an antioxidant and required for adequate immune response.
2) It is essential for prostaglandin synthesis and essential fatty acid metabolism.
3) It has a strong tendency to complex with heavy metals and exerts a protective effect against the heavy metals.
4) Se is important part of an enzyme glutathione peroxidase. This enzyme destroys peroxides before they can damage body tissues.
5) Se is also important in s amino acid synthesis. Sulphur amino acids protect animals against several diseases associated with low intakes of Se and vit. E. This protection is due to the antioxidant activity of selenium.

vit E and Se → natural antioxidants in body.

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Deficiency symptoms:-

1) Deficiency of se in the diet causes myopathies (muscles abnormality) in sheep and cattle.
2) In hens selenium deficiency reduces hatchability and egg production.
Exudative diathesis, a haemorrhagic disease of chick and dietary liver necrosis in pigs are prevented by either se or vit. E.
3) Bilateral paleness and dystrophy of the skeletal muscle, mottling and dystrophy of myocardium (mulberry heart disease) are noticed in pigs.
Mulberry heart disease is most common when cereal based diets contain less than 0.05 ppm selenium vit E also.

Toxic effect:-

↳ Se toxicity is known as "alkali disease" and "blind staggers" which is characterized by stiffness of joints, lameness, loss of hair from mane and tail and skin lesions on the legs.

↳ In some parts of Haryana and Punjab, the animals suffer with selenosis, the disease is known as "Dognala".

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Molybdenum (Mo)

- This mineral is available in pasture grasses, liver, intestinal tissues and milk of the animals.

functions of Mo :-

1) As a component of the enzyme xanthineoxidase, especially important to poultry for uric acid formation.
2) As a constituent of nitrate reductase it also helps in the utilization of nitrate.
3) It also takes parts in purine metabolism and stimulates action of rumen microorganism.
4) Mo participates in the reaction of enzyme with cytochrome c and also facilitates the reduction of cyt. c by aldehyde oxidase.

Absorption of Mo :-

Mo is absorbed from the intestine.
It is excreted through urine with a small amount in bile and milk.

Deficiency symptoms :-

Deficiency symptoms under natural condition have not been reported.

Toxic effect :- Mo↑ Cu↓

In the Mo toxicity (Molybdenosis) in ruminants suffer from extreme diarrhoea, loss in weight and reduced milk yields. The condition is known as "Teartness".

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Chromium. (Cr)

- Cr has been found in nucleoproteins isolated from beef liver and also in RNA preparation.
- It may plays role in the maintenance of the configuration of the RNA molecule.
- Cr has also been shown to catalyze the phospho-glucomutase system activates the succinic dehydrogenase-cytochrome system.
- Cr influences metabolism of glucose, lipid and protein.
- Cr is a primary active component of glucose tolerance factor (GTF) which makes the metabolic action of hormone insulin more effective in regulating energy utilization, muscle tissue deposition, fat metabolism and serum cholestral levels.
- As an integral part of GTF, it helps in binding insulin to cell membrane receptors sites and subsequent transport of glucose and amino acids in side the cells.

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Interaction of minerals:-

- Minerals may intreact with each other and with other nutrients and non-nutrient factors.
- This interaction is of two types:-

1. Synergistic Interaction:-

- The interaction elements, which mutually enhance their absorption in the digestive tract and meet out the requirements of the body, are called synergistic interaction.
- The synergism of essential minerals is described as:-

1) Calcium is synergism with P.
2) P with Ca, S, I, Cu, Co.
3) Na, Cl and K with eachother.
4) S with Co, Mg, P.
5) Zn with Mo.
6) Mn with Cu, Mo, Co, Fe
7) Cu with Mn, I, Co, Fe, P
8) I with Cu and Mn
9) Mo with Mn and Zn
10) I with Cu, Co, P.
11) Mg with S.
12) Co with I, Cu, Mn, S and P.

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Elements	Synergism with other minerals.
Ca	P
P	Ca, S, Cu, I, Co
S	Co, Mg, P
Zn	Mo
Mn	Cu, Mo, Co, fe, P
Cu	Mn, I, Co, fe, P
I	Cu, Co, P
Mo	Mn, Zn
Co	I, Cu, Mn, S, P
fe	Cu, Mn
Mg	S

9) Antagonistic Interaction:-

- The interaction in which minerals inhibit the absorption of each other in the digestive tract and produce opposite effects on any biochemical functions is called antagonistic interaction.
- Antagonism may be one sided or two sided.

(i) one sided antagonism:-

- one-sided antagonism means one mineral is antagonize the other but other can not.
- It inhibits the absorption of zn and Mn but zn and Mn may not.

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Elements	Antagonism with other minerals
Ca	Zn, Mn, Cu, I, Mg, Fe
Na	Zn, Mn
Cl	I
S	Cu, Se
Zn	Co
Mo	I, P
K	Zn, P

One side

ii) Two sided antagonism :-

- In two sided antagonism both the mineral inhibit the function of each other.
- P and Zn inhibit the absorption of each other. Similarly Zn and Cu antagonise with each other.

Elements	Antagonism with other minerals
P	Zn, Mn, Fe, Mg
Zn	Mo, Fe, P
Mn	Mg, P
Cu	Zn, Mo
Mo	Cu, Zn
I	P
Mg	P, Mn.

Interaction of minerals with other nutrients :-

- Minerals are not only interacting with each other but also interact with other nutrients like protein, vitamins, carbohydrates, fats and feed additives like antibiotics, alkaloids, antioxidants and glucosides etc.

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- vit. D affects the absorption of Ca, P, Mg, Zn.
- vit. E is antacts with trace mineral Se.

↳ The minerals may form new bonds with organic compounds and form chelates.

↳ Such mineral organic complex chelates may stimulate or inhibits the absorption of minerals.

↳ fat affects the absorption of Mg and Ca.

↳ The protein level and their sources determine the degree of utilization of P, Mg, Zn, Cu and other minerals.

↳ excess Mo stimulates the elimination of urea nitrogen and reduces the biosynthesis of muscle protein.

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:- Vitamins :-

By Casimir funk.

vital + Amine

Defination:-
vitamins are organic substances required by animals in very small amount for maintaining health and life of animal.

- Hofmeister - define vitamins as these are substances which are indispensible or essential for the growth and maintanance of the animals and are present in only amounts in food.

- The term vitamins was introduce by Casimir funk in 1912 for an amine the active factor from rice polishing: which are necessary for existence for life.

- vitamins are chemical substances found in plant and their importance generally in the metabolism of all living organism.

- In morderm sense vitamins are the substances distinct from major components of food required in minute quantities and whose absence causes specific deficiency diseases.
- plant can synthesised all the vitamins which they required as a component of various enzyme system.

- vitamins cannot be synthesised by the animal and therefore must be obtained exclusively from the diet.
exceptions are vit D and nicotinic acid.
↳ vit C is synthesised by all animals. except human being and guinea pig.

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↳ microorganism are capable of synthesizing water soluble vitamins provitamin A and vitamin B_2. vit B_{12} cannot be synthesized by either plants and animals. But it synthesised only by certain microorganism.

↳ Ruminal vitamins synthesis was confirmed through feeding experiment conducted by A. I. Virtanen in 1963 and R. R. Altejen in 1969 in ruminants for atleast one production cycle on purified diet free of vitamin B Complex.

- There are atleast 15 vitamines which has been accepted as essential food factors.
- vitamins are classified according to their solubility in water and fat in two main groups.
  1) water soluble 2) fat soluble.

which are differentiated as

Sr. Parameters	fat soluble vitamins	water soluble vitamin
1) Solubility	fat Soluble	water Soluble
2) chemical Nature.	Consist only of C, H, O	Ring compound except pantothenic acid (straight chain), contains, C, H, O, N, S P or Co (vit B_{12}) • S containing - thiamin and biotin
3) functions	vit A, D, E, K work as in vision, Ca absorption, maintance of genital system and blood clotting respectively	as coenzymes or prosthetic groups of enzymes except vit. C.
4) Synthesis.	ont Vit K is synthesized by symbiotic microorganism. Vit D can be synthesized in the skin upon exposure to sunlight	Ruminant synthesized all vit B complex with interporation of Co in diet.

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	fat soluble	water Soluble
		Niacin (nicotinic acid) can be synthesized from Tryptophane except cat vit c except guinea Pig, human.
5) Absorption	Absorbed along with other lipids from gastro intestinal tract by passive diffusion	Absorbed from gut directly
6) Storage	Liver	Not stored except vit B_{12} (liver) and riboflavin (some extent)
7) Excretion	Excretion in faeces via bile	Excreted in urine.
8) toxicity	Excess dietary intake causes toxicity because they are stored in body	Relatively Non-toxic.

Classification of vitamins

- fat Soluble
  - vit A
  - vit D
  - vit E
  - vit K
- Water Soluble.
  - B-Complex
    - energy releasing
      - ① thiamine, ② Riboflavin B_2
      - ③ nicotinic acid B_3 ④ Pyridoxin B_6
      - ⑤ Biotin B_7 ⑥ Pentothinic acid B_5
    - Haematopoietic
      - eg:- folic acid B_9, B_{11}
      - vit B_{12}
  - Non B-Complex (vit c)
    - Ascorbic acid

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Vitamines and their synonyms:

Vitamin	Accepted Name	Alternate names
1) vitamin A	Retinal Retinal Retinoic acid.	vit A (anti infective vitamin) Aldehyde
2) vitamin D	Ergocalciferol cholecalciferol	vitamin D_2 vitamin D_3 (antirachitic vitamin)
3) vitamin E	D-alpha tocaferal	Anti sterility
4) vitamin K	Phylloquinone Menaquinone. Menadione	vitamin K, (antihaemorrhagic) vitamin K_2 vitamin K_3 (Synthetic vitamin)
5) vitamin B_1	Thiamine	vitamin F
6) vitamin B_2	Riboflavin	vitamin G
7) Nicotinic acid. (B_3)	Nicotinic acid. (Niacine) Nicotinamide	vit. B_3
8) Bitamin B_6	Pyridoxine	Adermine
9) Pantothenic acid. (B_5)	Pantothenic acid	vitamin B_5, chick. antidermatitis factor
10) Biotin (B_7)	Biotin	vitamin H
11) Folic acid. (B_9, B_{11})	pteroyl monoglutamic acid	Folacin vitamin B_{10}, B_{11}
12) vitamin B_{12}	Cyanocobalamin	
13) choline	choline	
14) vitamin C	Ascorbic acid.	

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functions of vitamins :-

1) vitamins are essential for the good health and play important role in the body growth.
2) vitamins provides resistance against diseases and increases the productivity of animals.
3) vitamins are essential constituents of certain enzyme system regulate body metabolic and clotting of blood.
4) vitamins are needed during pregnancy for development of foetus.
5) vitamin A is responsible for the proper functioning of vision and vit. c keeps the gums in healthy state.

Vitamin - A

11- Cis-Retinal

Retinoids → this is a natural and synthetic forms of vitamin-A

- There are 3 form of vitamin A

1) Retinol → Alcoholic form. it is met in animal tissue as retinyl ester with long chain fatty acid

2) Retinal (Retinaldehyde :→ aldehyde form. obtain by oxidation of Retinal.

- Retinal and Retinal are interconverting.

3) Retinoic acid :- This is acid form produced by oxidation of Retinal.

- vit-A was discovered in 1930 by McCollum.
- vit-A also called trans-Retinal. It is a group of unsaturated organic compounds that includes retinol, retinal, retinoic acid and several Co-vit-A carotinoid
- vit-A exist as a provitamin in vegetables that is β-Carotene.
- Retinal plays an important role in vision while retinoic acid plays an important role in reproductive biology, Bone remodeling and epithelium tissue Homeostasis.
- Although retinol and retinal are stored in the body while retinoic acids are not stored.
- vit-A associated with thyroid harmone action.
- vit-A is a precursor of rhodopsine. the photopigment found in rods with in the retina of our eye, that helps us to see at night.

Retina → Rods —opsin / 11-cis Retinal→ Rhodopsin → Dim light → Black & white
Retina → Cones —opsine→ Iodopsin → colour vision → light

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- vit-A is needed by the retina of the eye in the form of Retinal which combines with protein (opsin) to form Rhodopsin. The light absorbing molecule necessary for low light or dim light

- vit-A also functions in very different role retinoic acid which is an important hormone like growth factor for epithelial and other cells.

- chemical name -

chemically vit. A known as retinal is an unsaturated monohydric alcohol.

↳ vit. A does not exist as such in plants but it present as precursor or provitamin in the form of certain carotinoids which can raidly converted into vit. A by the animals.

↳ Atleast 80 provitamins are known and these included as α, β, γ - carotenes, cryptoxanthines which is present in higher plant and microxanthine which occur in Blue green algal.

↳ Provitamin β-Carotene is the most widly distributed and most active.

- vitamin - A contains one β-Ionone ring and β-Carotene contains two Ionone rings.

- Carotene is converted into vit. A in the epithelial cell of Intestine.

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Metabolism :-

- Conversion of β-Carotene to vit-A takes place in Intestinal Mucosa
- In most of animals absorption takes place in the form of vit-A.
- The main site of absorption of vit-A is proximal jejunum.
- liver is the main storage site of vit-A in the form of retinal palmitate and retinyl ester.
- Vita-A is transported via chylomicrone (large triglycerids) which lipoproteins. via chylomicrone is intstinal cell of intestine.
- from the liver they transported to target cell or tissue as retinal via retinal binding proteins.

Functions :-

vit-A plays following important functions :-

1) growth → vit-A is responsible for the normal development of various epithelial tissues in the body.

2) vision → Vit-A is helpful in the transmission of light stimuli from the eye to brain. Each vit-A molecule is combined with specific type protein for opsin to form a visible pigment.

- The rods are concern with vision in dim light while the cones are concern with bright light / colour vision.
- There are 4 pigments. 1) Rhodopsin
  2) Rodopsin
  3) Porpyropsin
  4) Cynopsin.

3) Reproduction → vit-A plays an important role in male and female reproduction. Deficiency of vit-A in the diet causes atrophy of the germinal epithelium resulting in sterility.

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4) Skin:- lack of vit. A in diet causing Keratosis in skin. keratosis specially in hair follicle.

5) Urolithiasis: ⇒ condition in which urinary calliculi are present is known as urolithiasis.
deficiency of vit. A in the diet causing keratinisation of epithelial cells in genitourinary tract followed by bacterial infections and deposition of calcium phosphate precipitate on the site and ultimately calliculi is form.

6) Infection.
↳ vit. A is called as Anti-infective vitamin which help to establish and maintain a resistance to infection in the body and bone development.

7) Bone development
↳ It has a role in normal development of bone through a controlled activity of osteoclast and osteoblast of the epithelial arteries.

Requirement of vit. A.

growing cattle – 80 IU / kg
Dry cow → 76 IU / kg body weight
lactating cow → 110 IU / kg body weight
piglet → 500 – 1000 IU / per kg b. wt.
pig → 2000 – 3000 IU / kg b. wt
Broiler → 1500 IU / kg feed.
layer → 4000 IU / kg feed

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Factors influencing vitamin A requirement :-

following factors effect vitamin A requirement.

1) Genetic differences.
2) Conversion efficiency of carotene to vitamin A
3) Variation in level, type and precursor of vit. A in feed stuff.
4) Destruction of vitamin A in feed through oxidation, peroxidizing effects of rancid fats, length of storage and catalytic effects of trace minerals.
5) Presence of adequate bile in small intestine.

Source of vitamin A :-

In the form of its precursor carotene, vitamin A is found in carrot, yellow maize and green plants. Liver, kidney, buttermilk, cod liver oil and egg yolk are also rich in vitamin A.

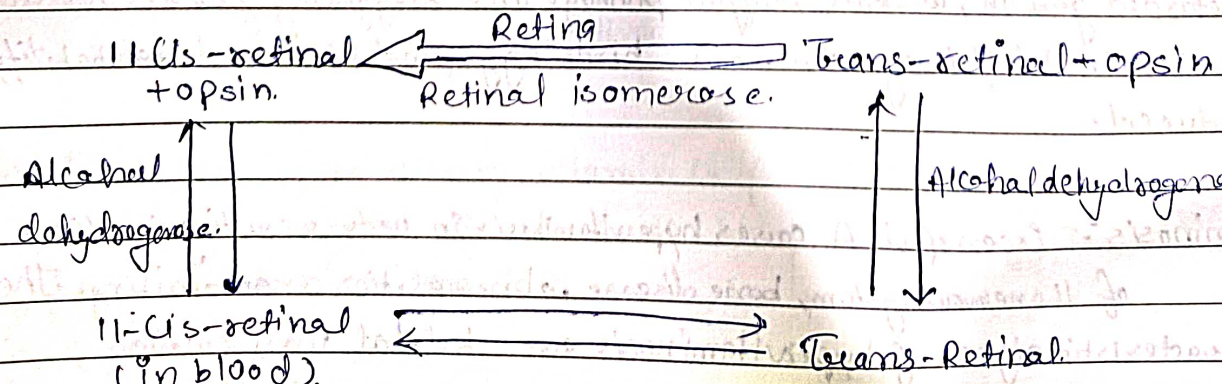
Deficiency Symptoms :-

1) Night blindness :-

- Diet deficient in vitamin A causing impaired rhodopsin formation which makes unable to see in dim light slow, dark adaptation and progress to total blindness.
- Rhodopsin. [Responsible for vision in dark.]

In dark. | In light

~~topsin~~



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2) Xeropthalmia:- Cattle with prolonged eye symptoms leading to excessive watering, softening and cloudiness of the cornea and development of xerophthalamia, characterized by a drying of the conjunctiva. Constriction of the optic nerve canal may result in blindness in calves.

3) Infertility and abortion:- In breeding animals a deficiency may lead to infertility, and in pregnant animals lead to abortion or the production of dead, weak and blind calves. In male there is failure of spermatogenesis.

4) Keratinization of epithelial cell:- vit A deficiency causes keratinization of epithelial cell, which results in cold and sinus trouble, diarrhea and formation of calculi in genitourinary tract and reproductive failure in male and female animals.

5. Disorganized bone growth and irritation of joints are two manifestations of vit A deficiencies.
- In some cases, there is a constriction of the opening through which the optic and auditary nerves pass thereby resulting in blindness and/or deafness.

Poultry:- Retarded growth, weakness, ruffled plumage and staggering gait are noticed in vitamin A deficiency. In mature birds egg production and hatchability are reduced.

Short

Hypervitaminosis:- Excess of vit A causes hypervitaminosis in body resulting in disease of the nervous system, bone disease, abnormalities and vomiting. The most characteristic signs of hypervitaminosis are skeletal malformations, spontaneous fracture, internal haemorrhage, degenerative atrophy and fatty infiltration of liver.

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Vitamin-D :

- Mc collum (1922) discovered this vit. as an antirachitic factor.
- for nutritional purposes the most important vit D are D_2 (ergocalciferol) and D_3 (chalecalciferol)
- Ergocalciferol → produced from ergosterol, which occurs in plants. (D_2)
- Chalecalciferol → derived from 7-dehydrochalestral. (D_3)
- ↳ UV light is main power, which converts provitamin into vitamin D
- ↳ 1 IU of vitamin D → the activity of 0.025 µg crystalline vit D_3.
- ↳ The sulfate derivative of vit D present in milk is a water soluble form of vit.
- ↳ vitami. D_3 is more stable than D_2. (vit D_3 > D_2)

Metabolism :-

Chalecalciferal (food) → Chalecalciferal ← 7-Dehydrochalestral (Skin)

↓ Liver

25-hydroxy chalecalciferal

↓ kidney

1,25-Dihydroxy chalecalciferal (active form of vit. D) (VVV Imp)

↓

Target tissues

- ↳ About 50% of the dietary vitamin is found in the chylomicrons leaving the digestive tract in the lymph; most of this vitamin finds its way to the liver with the remnants of the chylomicrons.

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↳ vit. D synthesized in the liver diffuses into the blood and picked up by a specific vit D bind protein which transports it to the liver, although some may remain free and be deposited in fat and muscle.

↳ Dietary vita D_2 and D_3 are absorbed through the small intestine and are transported in the blood to the liver where they are converted into 25 hydroxychalecalciferol, which is converted into active form as 1,25-dihydroxychalecalciferal in kidney and reached to target tissues by blood circulation.

↳ vit D transported by protein called transcalciferin or vit D binding protein (DBP).

↳ Excretion of absorbed vit D and its metabolites occurs primarily in faeces with the addition of bile salts.

Functions:-

1) vit D plays an important role for the absorption of Ca and P from gastrointestinal tract, which account for the antirachitic properties of vit. D.

2) It helps in the absorption of P from the kidney tubules.

3) Addition of vit D reduces oxidation of citric acid and a high citrate concentration is found in kidney, bone and blood but not in liver.

4) It increases the activity of the enzyme phytase in the intestine.

5) It also stimulates release of Ca rather than up take of Ca by kidney mitochondria.

6) It stimulates incorporation of P into phospholipids of intestinal mucosa.

7) It promotes normal development of bone, mobilization of Ca from bone to extracellular fluid compartment and biosynthesis of collagen.

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Requirements :- Animals and humans donot have a nutritional requirement for vit D.

→ factors, which influence dietary vit D requirements are:
i) Amount and ratio of dietary Ca and P.
(ii) Availability of P and Ca.
(iii) Species
(iv) Physiological factors.

- Lactating cow → 30 IU/kg body weight
- Piglet → 100-200 IU/kg feed
- Pig → 200-400 IU/kg feed
- Poultry → Broiler - 200 ICU/kg feed
  Layer - 600 ICU/kg feed

Sources of vitamin-D :-
- As vitamin D it is present in cod liver oil, kidneys, lungs, egg yolk, liver, milk, fish oil and sun dried grasses.
- The vitamin is synthesized by the action of UV rays on the skin of the animals.
- Heating destroys the rachidogenic activity.

Deficiency Symptoms :-
- Deficiency of vit D impairs the following functions:-
a) failure of Ca salt deposition in the cartilage matrix.
b) failure of cartilage cells to mature, leading to their accumulation rather than destruction
c) condensation of proliferating cartilage cells.
d) Elongation, swelling and degeneration of proliferative cartilage
e) Abnormal pattern of invasion of cartilage by capillaries.

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- In young animal vit D deficiency results in rickets and retarded growth.
- Ricket includes skeletal deformities characterized by enlarge junction between bone and cartilages, curvature of the bones, tendency to drag hind legs, beaded ribs, deformed thorax and weakening of muscular tissue and susceptibility to infection.
- In adult animals vitamin D deficiency causes osteomalacia, where there is reabsorption of bone ca already laid down.
- In Poultry a deficiency of vit D causes the bone and beak to become soft and rubbery, growth is usually retarded and the legs may become bowed (rubbery legs), ruffled feathers.
- Egg production is reduced and egg quality deteriorates.
- In swine:-

deficiency of vit D causes poor growth, stiffness, lameness and stilted gait, softness of bones, bone deformities, unthriftiness, enlargement and erosin of joints.

Vit D → poultry → Bone → soft and rubbery growth

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Vitamin - E (Tocopherol)

- In Evans and Sure (1936) discovered it as an important factor in reproduction of rats.
- After absorption from the wall of the GI tract the vitamin is mainly stored in the liver and to a certain extent in various organs and tissues of the body.
- The vitamin can pass through the placenta and mother's milk to its offsprings.
- Vitamin E is a group name, which includes a number of closely related active compounds.
- Eight naturally occuring forms of the vitamis are known and they can be divided into two groups.
  1) four saturated vitamin is → a, b, g and d tocopherals.
  2) four unsaturated vitamin is → a, b, g and d tocotrienols.

- α-tocopherol is the most biologically active and most widely distributed.
- Selenium vit. E are interrelated. Both are needed by animals and both have metabolic roles in body in addition to an antioxidant effect.

Metabolism:-

- Act as biological antioxidant with glutathione peroxidase enzyme which contains Se.
- Protects cells against oxidative damage caused by free radicals.
- free radicals are scavenged by vit E and glutathione peroxidase destroys any peroxide formed before they can damage the cell.
- vit. E is also helpful in development and function of the immune system.
- Absorption of vit. E either in free alcohol or esters is facilitated by bile and pancreatic lipase.

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↳ Most of vit. E absorbed as alcohol.
↳ Tocopherol passes through placental membranes and mammary gland.
↳ Less than 2% of dietary vit. E is transferred from feed to milk.
↳ vit E stored through out all body tissues, with highest storage in liver.
↳ In plasma, the vit. is transported in the low density lipoprotein (LDL) fraction and concentrates in the cell membrane.
↳ Highest concentrations are found in the adipose tissue, other organs and tissues which contain the vitamin include liver, heart, skeletal muscle and adrenal gland.

functions:-

1) vit E acts as an antioxidant at cellular level.
eg:- it prevent oxidation of unsaturated fatty acids mostly present in all cellwall components.
• α-tocopherol is an excellent natural antioxidant.
2) It participates in normal tissue respiration possible by the way of cytochrome reductase system and protect the lipid structure of mitochondria from oxidative destruction.
3) It aids the normal phosphorylation of creatine phosphate, ATP-which is a high phosphate energy compound in the body.
4) It also involved in the synthesis of ascorbic acid, ubiquinone (Co-enzyme) and the metabolism of nucleic acid.
5) α-tocopherol exerting a unique influence on structural component of membrane phospholipid.
6) It stimulates formation of prostaglandin E from arachidonic acid while synthetic vito E had no effect.
7) Vit. E inhibits platelet aggregation so help in blood clotting

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8) Relationship of vit E with toxic elements -
- vit E and Se provide protection against toxicity with 3 groups of heavy metals.

(i) Cd and Hg → Se is highly effective in altering toxicities, vit E has little influence

(ii) Ag and Arsenic → vit E is highly effective Se at higher doses.

(iii) Pb → vit. E is highly effective in altering toxicity produced by lead.

Requirements :-
- vit. E requirement of normal animals and humans ≃ 30 ppm of diet
- Requirement of vit E is dependent on dietary levels of polyunsaturated fatty acids (PUFA), antioxidants, and sulphur containing amino acids and Se.
  - Lactating Cow → 2.5 IU/kg body weight
    Piglet → 5-10 IU/kg feed
    Pig → 20-30 IU/kg feed
    Poultry (Broiler) → 5-10 IU/kg feed
    (Layer) → 5 IU/kg feed.

Sources :- vit E widely distributed in foods.
- green fodder is good source of α-tocopherol.
- Cereal grains also good sources.
- Animal products are relatively poor sources of vitamin.

⇒ **1 IU vit. E** :- the specific activity of 1 mg synthetic α-tocopherol acetate.

Notes

vit-E → non toxic at higher doses

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Deficiency symptoms :-

- In farm animals are muscle degeneration (myopathy).

1) Nutritional Myopathy (Muscular dystrophy) :-

- In cattle affects the skeletal muscles, which is manifested by difficulty in standing, trembling and staggering gait.
- The animals are unable to rise and weakness of the neck muscles prevents them from raising their heads, also known as "white muscle disease".

Nutritional myopathy in lambs is called "stiff lamb disease".

In pigs vit E deficiency diseases are myopathy and cardiac disease known as "mulberry heart disease"
↓
haemorrhagic lesions within the heart that gives characteristic "mulberry appearance"

OR

"hepatosis dietetica (toxic liver dystrophy)"

In poultry → vit E deficiency causes following diseases.

exudative diathesis.
↓
characterised by edema, blackening of affected parts, apathy and inappetence.

2) Nutritional encephalomalacia. (Crazy chick disease) :-
↓
characterised by ataxia, head retraction and cycling with legs.

3) Muscular dystrophy.

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Vitamin-K

- Identified in 1935 by Henrik Dam → to be an essential factor in the prevention of haemorrhagic symptoms produced in chicks.
- fat soluble vit was disignated as vit k → Danish word Koagulation

↳ vit K is synthesized in the body of ruminants by the action of rumen microbes.
↳ Bile juice assists in the absorption of this vitamin from the intestine.
↳ In dogs there is microbial synthesis in intestine.

vit K_1 (Phy Hoquinone) ⎫ → Natural
vit K_2 (Premyl menaqueinone) ⎭
vit K_3 (Menadione) → Synthetic → 3.3 times as potent, biologically, as vit K_2.

Metabolism:-
↳ Like all fat soluble vitamins, vit K is absorbed in association with dietary fats and requires the presence of bile salts and pancreatic juice for adequate uptake from the alimentary canal vit K is stored in liver.
↳ Most of the ingested vitamin appears in the chylomicrons entering the lymph.
↳ Synthetic form is absorbed directly in the hepatic portal vein and carried to the liver, where it is activated and then released along with the naturally occuring forms of vit. K.
↳ These are carried in the LDL to target tissues.

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Functions:-

- vit k is necessary for the formation of prothrombin, which is important intermediate of the blood clotting.
- Prothrombin must bind to Ca^{+2} before it can be activated as thrombin.
- If the supply of vit k is inadequate, the prothrombin molecule is deficient in a carboxyglutamic acid, a specific amino acid responsible for Ca binding.
- Thrombin converts the protein fibrinogen in blood plasma into fibrin, which holds blood clots together.
- There are four blood clotting proteins, which are dependent on vitamin k for their synthesis.

Blood platelets → Thromboplastin
↓
Prothrombin —Thrombokinase→ Thrombin

fibrinogen —Thrombin→ fibrin.

The important biochemical function has been found to be involved in electron transport and in bacteria, oxidative phosphorelation.

Requirement:- daily requirement for most species varies in a range of 2-200 µg vitamin k/kg body weight.

- This requirement can be altered by age, sex, strain, antivitamin k factor, disease condition.

Animal	Requirement (mg/kg)
Beef Cattle, Dairy Cattle, Horse, Goat, sheep	→ Microbial synthesis
Swine	→ 0.5
fish	→ 0.5-1
chicken	→ 0.5-1

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Sources of vitamin k :-
green and leafy fodder, Lucerne, Cabbage, soyabean, liver, fish meal and egg yolks are good source of vitamin k.

Deficiency symptoms :-
Ruminants and pigs
- under normal conditions vit k deficiency have not been reported, but deficiency symptoms, occur when spoiled sweet clover forage is fed.
- when sweet clover hay undergoes spoilage with certain molds, the coumarin is converted to dicumarol, (dicumarol passes through the placenta in pregnant animals and new born animals may become affected immediately after birth) an anti vitamin k and lowers the prothrombin content of the blood and at the same time a bleeding syndrome develops throughout the animal body. This disease is called "sweet clover poisning" or "bleeding diseases" or "haemorrhagic sweet clover diseases".

↳ Prolongation the prothrombin time in absence of liver disease indicates vitamins k deficiency
↳ Initial signs may be stiffness and lameness from bleeding into muscles and articulations.
↳ Haematomas, epistaxis or gastrointestinal bleeding may be observed.

Poultry : vit k deficiency in chicks is delayed clotting time of the blood, birds are easily injured and may bleed to death.
↳ chicks show anaemia, which in part may be due to loss of blood or to the development of a hypoplastic bone marrow.

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3) Human :- It is uncommon in humans because wide distribution of vitamin k in plant and animal tissue and microflora of gut synthesize the menaquinones.

↳ Newborn infants may suffer because :

(i) Placenta is a relatively poor organ for maternal - foetal transmission of lipids.

(ii) Sterile gastrointestinal tract.

(iii) Breast and cow's milk are poor source of vit. K.

factors which causes vit. k deficiency :-

1) Increase control feeding with less pasture and alfalfa meal.

2) feeding of solvent extracted soyabean meal and other seed meal and better quality fishmeal.

3) Haemorragic gastric ulcers which occurs frequently.

4) Mycotoxins and molds present in the feed.

5) Any antimetabites (antivitamin k) in the feed.

6) Use of sulfa drugs and different type of antibodies.

7) Use of slatted floors which reduce the opportunity for Coprophagy.

vitamin k toxicity :-

↳ Toxic effects mainly related with haematological and circulatory distributions.

↳ Natural vit k phylloquinone and menaquinone are non-toxic at very high dose level.

↳ synthetic menadione shows toxic effects at high level.

eg :- anaemia, haemoglobinuria and urobilinuria.

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Water Soluble vitamins :-

- The vitamins of the B Complex and vitamin C comprise the water soluble group.
- vit. C is the only member of the water soluble groups that is not a member of the B family and its functions and characteristics are different from the B Complex vitamins.

vitamin B Complex :-

- The vitamins included under this group are water soluble and most of them a component of coenzymes.
- Ruminants are able to synthesis all the vit. of B group in the rumen through rumen microorganism.
- In preruminant calves and mono gastric animals B-Complex vitamin should be supplied in the daily ration.

Thiamin (vitamin B_1) :-

- Thiamin is considered to be the oldest vitamin.
- Deficiency of this causes beri-beri in man which is earliest documented deficiency disorder.
- In 1890 Eijkman, a Dutch investigator

Notes

Energy

Awdesh

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↳ Energy is define as the capacity to do work.

Calory (Cal) :-

The amount of energy as heat required to raise the temprature of 1gm of water to 1°c (precisely from 14.5°C to 15.5°C).

1 Cal = 4.184 J

1 J = 0.24 Cal.

- The simplest method for measuring the value of any feed is to determine the amount of digestible nutrients that is supplied to the animal.
- for the expressing the energy value from feed & requirement of animals & following system are :-

i) Total Digestible Nutrient (TDN)
ii) Starch equivalent (SE)
iii) Gross Energy (GE)
iv) Digestible Energy (DE)
v) Metabolisable Energy (ME)
vi) Net Energy (NE)
vii) Scandinavian feed Unit

$$\text{Substance} \xrightarrow{\text{Energy}} CO_2 + H_2O + gas$$

Gross Energy :-

gross energy is the amount of heat energy given off when a substance is completely burned / oxidised (to its ultimate oxidation products CO_2, H_2O and other gases) in a "bomb calorimeter" containing 25-30 atm of O_2.

↳ GE is the total heat of combustion of a material

as determine with a bomb calorimeter and expressed as mega joule per kg dry matter.

Gross energy Losses from the Animal body :-

Gross Energy
- Faecal energy → feed origin / metabolic origin.

Digestible energy → GE − FE
- gaseous product of digestion (GPD)
- urinary energy → feed origin / endogenous origin.

Metabolisable energy
- DE − UE (Non ruminants)
- DE − UE − GPD (Ruminants)
- Heat → HF (heat formentation) / HNM (Heat of nutrient metabolism)

Net energy
- N Em
  1) Basal metabolism (BM)
  2) Energy for voluntary activity (VAE)
  3) Heat to keep body warm or cool
- NEp or NEg
  1) Growth & fattening
  2) foetus growth
  3) Milk, egg, wool, work etc.

Feacal energy :-

- It is the gross energy of faeces.
- It consists of energy content of the undigested feed and of metabolic fraction (Digestive fluids & abrated mucosa) of the faeces.
- Faecal energy reflects undigested feed, microbial cell residues and metabolic energy from endogenous sources (FEm).

GE ingested - GE in feces

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True

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Digestible energy (DE):-

- This is that portion of gross energy of a feed which does not appear in the faeces. It includes metabolisable energy as well as the energy of urine and methane.
- The apparent digestible energy of the food is the gross energy of the feed less the energy content in faeces.
- The value is labled apprent because the faecal energy includes energy of undigestible feeds, microbial cell residue and metabolic products such as spent digestible fruits and apprented intestinal mucosa.
- The term true D.E is used to denote the value arrived by substracting the faecal energy of feed origin only from the gross energy.

Loss due to faecal energy:-

1) Ruminants → In case of Roughage → 40-45% of gross energy

In case of concentrates → 20-30% of G.E.

2) Horses → 35-40% of G.E

3) Pigs → 20% of G.E.

Gaseous products of digestion (GPD):-

- It includes the combustible gases produced in the digestive tract by the fermentation of the ration. These include H_2, CO_2, CO, H_2S, acetone, ethane and methane. Methane makes up the largest portion of the combustible gases produced and these reach significant proportions only in ruminants.

Urinary energy:- It is the gross energy of urine. It includes the energy contain of the nonoxidised portions of the absorbed Nitrogenous products, primarily urea in mammals and uric acid in birds. And the energy contain in the endogenous fraction of the urine. It is off the order of 2-3% of GE in pigs and 4-5% of G.E in cattle.

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ME = DE × 0.82 ↳ 18%

1 kg Methane → 13-34 K Cal of (E)

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Metabolisable energy :-

↳ It is that portion of Gross energy Not appearing in faeces urine and gases of fermentation (principally Methane).

↳ It is digestible energy – the energy of urine and Methane.

↳ It is the portion of total energy ingested which is actually capable of transformation in the body.

ME (for nonruminants) → DE – UE (G.E – F.E – U.E.)

ME (for ruminants) → DE – UE – GPD
(G.E – F.E – U.E – GPD)

factors affecting the metabolisable energy value of foods :-

① Species of animal :-

↳ In ruminants about 8–10 % losses of energy are in methane production while in nonruminants → No gas production. So ME value are high in nonruminants

ME ruminant < Nonruminant.

② Composition of feed :-

↳ chemical composition of the feed also affect the ME values of food. If the crude protein present in the feed is unbalanced than the majority of amino acids will be deaminated and greater proportion of Nitrogen will be excreted as urea.

1 g urea → 23 K J

③ Processing of food :-

↳ It also affect the ME values since it affects the loses of nutrients in faeces and methane production.

④ level of feeding :-

↳ At high level of feed intake ME values are reduced.

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Nitrogen corrected M.E :-

- The M.E value of a feed will vary according to wheather amino acids it supplies are retain or are deaminated and their nitrogen excreted in the urine. for this reason M.E values may be corrected to zero Nitrogen balance by deducting for each one gram of Nitrogen retain or by adding for each one gram of nitrogen catabolised.

Net Energy :

This is that portion of ME which may be used by the animal for growth, fattening, foetal development, milk production and heat production.

↳ It differs from ME that net energy does not include the heat of fermentation and nutrient metabolism or the heat increment :-

Heat Increment :- It is the increase in heat production following consumption of food when the animal is in thermo-neutral environment.

HI is due to [fermentation (H.f.) and heat of neutrient metabolism (H.N.M.)]

↳ Hf is the heat produced in the digestive tract as a result of microbial action.

↳ HNM is the heat produced in intermediary metabolism of absorbed nutrients.

↳ The HI is also k/as [specific dynamic effect of food.]

↳ cold weather में करना चाहिए

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Total digestible nutrients: (TDN)

- TDN is simply a figure which indicates the relative energy value of a feed to an animal. It is ordinarily expressed in kg or in % (pound or kg of TDN per 100 pound or kg of feed)
- It is arrived at by adding together the following.

TDN ⇒ % digestible crude protein (DCP) + % Digestible Crude fibre (DCF) + % digestible nitrogen free extract + % Digestible ether extract × 2.25.

$$\% TDN = \% DCP + \% DCF + \% DNFE + \% DEE \times 2.25$$

Fat on oxidation provides 2.25 time more energy as compared to carbohydrates, hence the figure is multiple by 2.25. The protein in this equation has been included because of the fact that excess of protein eaten by the animals serve as a source of energy to the body.

Limitation of the TDN system:-

1) It over estimates the value of roughages because more energy spent in chewing of such feeds remains unaccounted.
2) Only the loss in faeces is accounted.
3) If feeds are high in fat content will some time exceed 100 in percentage of TDN.

Factors affecting the TDN value of a feed :-

i) The % age of dry matter moisture ↑ TDN ↓

(ii) The digestibility of the dry matter :->

- unless the dry matter of a feed is digestible, it can have no TDN value. Only digestible dry matter can contribute TDN.
- Lignine has a high energy value but it can not be digested by the animals. So has no digestible energy or TDN values.

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iii) The amount of mineral matter in the digestible dry matter →

- Mineral contribute no energy to the animal though mineral compounds are digestible but have no TDN value. The mineral (more) matter a feed contains, other things being equals, the lower will be its TDN.

iv) The amount of fat in the digestible dry matter :-

- fat contribute 2.25 times as much as energy per unit of weight as ~~much as~~ carbohydrates and proteins.
- The feed high in digestible fat sometime TDN value exceed 100%.

Starch equivalent :

- Oscar kellner measured the values of feed for productive purpose in terms of starch values instead of ~~heat~~ net energy values.
- SE is defined as the no. of kg of starch that produces the same amount of fat as 100kg of the respective feed this value is also called as starch value of the feed stuff.

→ $SE \Rightarrow \frac{\text{weight of fat stored per unit of food}}{\text{weight of fat stored per unit weight of starch}} \times 100.$

→ Suppose the starch equivalent of wheat bran is 45kg it means that 100kg of wheat bran can produce as much amount of fat as 45kg of pure starch.

1Kg Digatible protein → 235 gm
1Kg Starch/Cellulose → 248 gm
1Kg fat → 477-598 gm

Chapped - 0.29
Dry - 0.58

Oscar Kellener expressed the energy value of feed stuff by its fat producing ability related to that of pure starch.

Methods for measuring the heat production & energy retention:-

There are two ways by which heat production can be measured for determining the net energy ~~ener~~ value of feed stuff.

1) **Direct Calorimetry:-**

In which heat production is measured directly, this combined the feature of both respiration chamber and *Calorimeter.*

2) **Indirect Calorimetry:-**

In this method Net energy is determined by indirect Calorimetry where only exchange of gases is recorded. that means only respiration chamber is needed.

1) **Direct calorimetry:-**

- This apparatus was used by "Atwater" in 1892 for the human beings. After that "Armsby" built an apperatus for energy metabolism studies for the farm animals.
- In this apparatus there is a provision for recording the intake of feed, water and oxygen and the outgo of faeces, urine, gaseous excretion and heat loss from the body.
- The heat is lost from the body through conduction, radiation convection and evoparation of water from skin and expired gases through lungs.

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→ The animal calorimeter is basically an air tight and insulated chamber. Evaporative losses of heat are measured by recording the volume of air drawn through the chamber and its moisture content on entry and exit are used for calculation of heat loss.

↳ The heat loss through conduction, radiation, convection of the animal is measured by the rise in temprature of coldwater flowing in various pipes suspended in the chamber from ceiling. The rate of flow of water and differences in the temprature at the entry and exit are used for calculation of heat loss.

↳ There are two kinds of calorimeter.
1) Adiabatic Calorimeter. 2) Gradient Calorimeter

i) Adiabatic Calorimeter:
→ In this type an animal is confined in a chamber in such a way that heat loss through the walls of the chamber is reduced to near zero.
→ This is attained by a box with in a box. when the outer box or wall is electrically heated to the same temprature as the inner wall, heat loss from the inner wall to the outer wall is impossible. Water circulating in a coil in such chamber absorbs the heat collected by the inner wall, the volume and change in temprature of the water can be used to calculate sensible heat loss from animal body.
→ The construction and operation are complicated and very expensive

2) Gradient Calorimeter :-

→ Calorimeter of this type allow the loss of heat through the walls of animal chamber. The outer surface of the wall of calorimeter is maintained at a constant temprature with a water jacket. The temprature gradient is measured with thermocouples which line the inner and outer surface of the wall.

→ By the use of appropriate techniques it is possible to measure separately the radiation Componant of the sensible heat loss. The amount of water vapour added to the air is measured by assessing the rate of air flow and change in humidity.

→ Advantage → Accurate
Disadvantage → Expensive and complicated.

Determination of Heat in Creament (HI)

The HI of Heat is determined by feeding two levels of feed intake. The difference in the two level would give heat production due to increase in feed intake. In this case assumption is made that heat production due to basal metabolism would remain the same at both the levels.

→ The increase in heat production at higher intake is due to the additional feed given to the animals.

2) Indirect Calorimetry :-

Measurement of heat production by direct Calorimetry is costly So, most of the measurement for heat production are done by indirect method.

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i) open circuit system:-

- Devices allow the animal to breath atmospheric air of determined composition, the exhaust air from a chamber or expired air from a mask or cannula, is either collected or else metered and sampled and then analysed for O_2 and CO_2 content.
- Analysis of gases has been accomplished with chemical and volumetric or manometric techniques.

ii) Closed circuit system:-

- Devices require the animal to rebreathe the same air.
- CO_2 is removed with a suitable absorbent which may be weighed before and after use to determine its rate of production.
- The use of O_2 by the animal body decreases the volume of the respiratory gas mixture, and this change in volume is used as a measure of the rate of O_2 consumption.
- O_2 used by the animal is then replaced by a metered supply of the pure gas.
- Both O_2 consumption and CO_2 production must be corrected for any difference in the amounts presents in the circuit air at the begining and end of the experiment.
- CH_4 is allowed to accumulate in the circuit air and the amount present is determined at the end of the experiment.

↳ The heat loss in indirect calorimetry is measured by carbon-nitrogen balance or through gaseous exchange method.

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i) Carbon-nitrogen balance method:-

↳ C and N enter the body only in the food.

↳ C leaves the body through faeces, urine, methane and CO_2
N leaves the body through faeces and urine only.

↳ Therefore, the balance trial must be carried out in a respiration chamber. The procedure for calculating energy retention and heat loss from carbon nitrogen balance data is illustrated by considering an animal in which storage of both fat and protein is taking place.

↳ In such an animal intakes of C and N will be greater than the quantity excreted and the animal is said to be a positive balance with respect of these elements.

↳ The quantity of protein stored is calculated by multiplying the ~~wt~~ N balance by factor → 6.25.

- Protein also contains 51.2 % Carbon.
- The amount of carbon stored as Protein can therefore, be computed.
- The remaining carbon is stored as fat, which contains 74.6 %.

↳ fat storage is therefore, calculated by dividing the carbon balance, less that stored as protein by 0.746.

- The energy present in the protein and fat stored is then calculated by using average calorific values for body tissues.
- These values for cattle and sheep are 3.93 MJ/100g fat 2.36 MJ/100g of Protein.

↳ Calculation of energy retention and heat production of a sheep from carbon nitrogen balance is given below as.

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Nutrient	Carbon (g)	Nitrogen (g)	Energy (MJ)
Intake	684.5	41.67	28.41
Excretion in faeces	279.3	13.96	11.47
Excretion in urine	33.6	25.41	1.50
Excretion as methane	20.3	-	1.49
Excretion as CO_2	278.6	-	-
Balance	73.3	2.30	-
Intake of Metabolizable energy	-	-	X 13.95
Protein and fat storage.			
Protein stored.	X		X 14.375
Carbon stored as Protein	X		X 7.4
Carbon stored as fat	X		X 65.9
fat stored.	X		X 88.33
Energy retention and heat Production.			
Energy stored as protein	X		X 0.34
Energy stored as fat	X		X 3.47
Total energy retention.	X		X 3.81
Heat Production.	X		X 10.14

Protein stored ⇒ Nitrogen Balance × 6.25

⇒ 2.30 × 6.25

⇒ 14.375 g

Carbon stored as Protein = $14.375 \times \frac{51.9}{100}$

⇒ 7.36 ≃ 7.4 g.

Carbon stored as fat → Carbon Balance − Carbon stored as Protein

⇒ 73.3 − 7.4

≃ 65.9 g.

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Fat stored:- 74.6g C present in → 100g fat

1g → $\frac{100}{74.6}$

65.9g → $\frac{100}{74.6} \times 65.9$

≃ 88.33g.

Energy stored as Protein.

100g Protein → 2.36 MJ energy

1 → $\frac{2.36 MJ}{100}$

14.4g → $\frac{2.36}{100} \times 14.4 \Rightarrow 0.339 MJ$

≃ 0.34 MJ

Energy stored as fat.

100g fat need → 3.93 MJ energy

1 → $\frac{3.93}{100}$

88.33g → $\frac{3.93 \times 88.33}{100}$

≃ 3.47 MJ

Total energy retention ≃ energy stored as Protein + energy stored as fat

≃ 0.34 + 3.47

≃ 3.81 MJ

Heat Production ⇒

⇒ total energy in body − total energy retention

⇒ 13.95 − 3.81

≃ 10.14 MJ.

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(ii) Respiratory exchange of gases method :-

These methods take into account the oxygen consumption, CO_2 production and urinary nitrogen to calculate the non-protein RQ.

↳ The respiratory quotient (RQ) is the ratio between the volume of CO_2 produced and the volume of O_2 used by the animals.

$$RQ = \frac{\text{Volume of } CO_2 \text{ produced}}{\text{Volume of } O_2 \text{ used}}$$

- When carbohydrates are being oxidised in body for energy purposes the R.Q. is 1 and

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + 2.62\,MJ$$

- When fats (tripalmitin) are being oxidised in the body for energy purposes the RQ is 0.7

$$C_3H_5(C_{15}H_{31}COO)_3 + 72.5\,O_2 \longrightarrow 51\,CO_2 + 49\,H_2O + 32.04\,MJ$$

- The heat of combustion of protein varies according to the amino acid proportion but averages 22.2 KJ/g proteins.
- The quantity of protein catabolized can be estimated from the output of N_2 in the urine, 0.16g of urinary nitrogen being excreted for each gram of protein.
- For each gram of protein oxidised, 0.77 litre of CO_2 is produced and 0.96 litre of O_2 used, giving an RQ of 0.8.

↳ For measuring the respiratory exchange in the farm animals two types of respiration chamber have been used.

1. Open circuit respiration chamber.
2. Close circuit respiration chamber.

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- In Both the cases the chamber is air tight where there is an arrangement for feeding, watering and milk of animals.
- There is arrangement for collection of faeces and urine also.

⇒ **Brouwer equation :-**

This equation is used for calculation of heat Production (H.P.) in kilojoule.

$H.P. = 16.18 VO_2 + 5.16 VCO_2 - 5.90 N - 2.42 CH_4$

where VO_2 → oxygen consumed (litres)

VCO_2 → CO_2 produced (litres)

N = urinary nitrogen excreted (gm)

CH_4 = Methane Production (litres.

for Poultry, the N- Coefficient is 1.20 (Instead of 5.90) as poultry excrete nitrogen in the more oxidized form of uric acid rather than as urea.

Physiological fuel values of Atwater :-

- In human nutrition, Atwater calculated the calorific values of the nutrients which were available for transformation in the body. The following digestibility figures were taken for the nutrients.

Carbohydrates - 98%.

Fats - 95%.

Proteins - 92%.

- The calorific values of the nutrients were then multipled by these coefficients to get the physiological fuel values.
- In the case of protein 5.23 MJ is substrated per g of protein in order to account for the energy lost in the urine as urea.

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The physiological fuel values were calculated as follows.

1gm of carbohydrates = 17.46 x 0.98 = 16.27 MJ ✓

1gm of fat = 39.33 x 0.95 = 37.36 MJ

1gm of Protein = 23.64 - 5.25 x 0.92 = 16 MJ

- The factor 5.22 MJ is too low to estimate the urine loss in case of herbivore because of excretion of large amount of hippuric acid instead of urea.
- Physiological fuel values are not applicable in case of ruminants because the digestibility of nutrient is low in ruminant than non-ruminants.
- Physiological fuel values are similar to metabolizable energy.

16.18 VO2
+
5.16 VCO2
-
5.90 N
2.42 CH4

C - 98
F - 95
P - 92

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Mukesh

Evaluation of Protein value of feed in Animal Nutrition:-

1) Crude Protein (CP) :- (N × 6.25)

- Crude protein in the feed stuffs is estimated by determining the nitrogen content of feed and multiplying it by a factor 6.25.
- Two assumptions are made in calculating the protein content from the nitrogen:-
  - i) that all the Nitrogen of the food is present as protein
  - ii) that all food protein contains 16 g N/100g.

- The Nitrogen content of food is then expressed in term of crude protein (CP) calculated as follows.

$$CP\ (g/100g) = \frac{g\ Nitrogen}{100g} \times \frac{100}{16}$$ OR more commonly

$$CP\ (g/100g) = \frac{g\ nitrogen}{100\ g} \times 6.25$$

↳ Both above assumptions are unsound. Different food proteins have different nitrogen contents, and therefore different factors should be used in the conversion of nitrogen for individual food.

↳ The nitrogen content of a number of common proteins together with appropriate nitrogen conversion factor is shown as:

Food protein	Conversion factor
Cotton seed	5.30
Soyabean	5.71
Barley	5.83
Oat	5.83
Wheat	5.83
Maize	6.25
Egg	6.25
Meat	6.25
Milk.	6.38

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True protein (TP) :-

- The term true protein is used to denote the protein only. It can be separated from non-protein nitrogen by precipitation with cupric hydroxide (Stutzer's reagent) or by heat coagulation.
- The protein is determined by multiplied the factor 6.25.
- The protein is then filtered and residue subjected to Nitrogen estimation by kjeldahl method.

Digestible Crude Protein (DCP) :-

- When the crude protein content of the feed stuffs is multiplied by its digestibility coefficient, it gives the digestible crude protein.
- It is the most common way of expressing the protein values and requirement of the ruminants on most of the countries.
- In India, DCP is taken as the measure for expressing the protein values of feeds for ruminants.
- DCP figures are not entirely satisfactory assessments of protein, because the efficiency with which the absorbed protein is used differs considerably from one source to another.

Protein Equivalent (PE) :-

- In some of the European countries protein equivalent is used instead of DCP.
- In protein equivalent non-protein nitrogen fraction is given half the nutritive of the true protein and is calculated as follow :-

$$PE = \frac{\%DCP + \%DTP}{2}$$

So PE is the arithmetic mean of the % of DCP and DTP.

Protein Quality (PQ) :-

- In ruminants protein quality is not given much of the importance since all the essential amino acids are synthesized in the rumen by synthesis of microbial proteins.

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Methods

Weight gain Methods.

① PER = Protein effeciency Ratio.
⇒ gain in body weight (g) / protein consumed (g)

② NPR = Net Protein Retention
⇒ wt gain of test protein fed − wt loss of non protein fed / wt of protein consumed.

③ GPV = gross protein value.
⇒ g increased wt gain/g test protein / g increased wt gain/g casein

Nitrogen balance experiment

V.V.V.Imp
① BV ⇒ Biological value.
⇒ N intake − (faecal N + Urine N) / N intake − faecal N × 100
⇒ NI − fN − UN / NI − fN × 100

B.V ↑ · Protein Quality ↑

② NPU ⇒ ~~Nitrogen U~~ Net protein Utilization.
⇒ Body N with test protein − Body N with N-free diet / N intake.
⇒ Retained Nitrogen / Nitrogen intake × 100
⇒ B.V × digestibility

digestibility ↑ · Retained in body ↑

③ NPV = Net Protein values.
⇒ NPU × % C.P.

④ PRV = Protein replacement value.
= A − B / N intake.

A → Standard protein nitrogen balance.
B → test protein nitrogen balance

C.P = True protein + NPN

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However, digestible crude protein value for non ruminants animals is not adequate to express the protein value.

- It is the important to know how much of the absorbed protein is used by the animal body.
- This utilization will be different with the various protein sources as it is dependent upon the amino acid composition of protein.

Evaluation of protein value of feed in non ruminants:-

Weight Gain methods.

1) Protein Efficiency Ratio (PER):-

- The protein efficiency ratio normally uses growth rate as a measure of nutritive value of dietary protein.
- It is defined as the wt. gain per unit wt. of protein eaten.

$$PER = \frac{\text{Gain in body weight (g)}}{\text{Protein consumed (g)}}$$

Limitations:-

1) It is tedious method. This method cannot assess the digestibility of protein.
2) It cannot measure how much of the protein fed is used for maintenance and how much for tissue formation.
3) The weight gain may be due to bone or fat formation and so the protein content of the gain may be variable.

→ The PER values will vary with different protein sources as the composition of protein varies with regard to essential amino acids.

→ For the optimum rate of growth, various level of protein would be required depending upon the quality.

Notes

defaunation → Removal of Protozoa from Rumen

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↳ On this basis comparison between different sources of protein can be made.
↳ It is simplest method for evaluating protein quality.

2) Net Protein Retention (NPR) :-

- A modification of PER method, where the weight gain of the experimental group is compared with a group on a protein free diet, give the net protein retention which calculated as

$$NPR = \frac{\text{Wt gain of test protein group fed} - \text{wt loss of non protein group fed}}{\text{wt of protein consumed.}}$$

- NPR method is claim to give more accurate results than the PER method.

3) Gross Protein Value (GPV) :-

- The body wt. gain of chicks receiving a basal diet containing 8g CP/100g are compared with those of chicks receiving the basal diet plus 8g/100g of test protein, and of others receiving the basal diet plus 3g/100g of Casein.
- The extra live wt. gain per unit of supplementary test protein, stated as a proportion of the extra live wt. gain per unit of supplementary casein, is the gross protein value of the test protein.

$$GPV = \frac{\text{g increased wt gain / g test protein}}{\text{g increased wt gain / g Casein.}}$$

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Nitrogen Balance Experiments ⇒ SN

V.V.V.Imp.

SN

1) Biological value (BV) of Proteins:-

- Karl thomas has first used the term BV.
- It is defined as the proportion of nitrogen absorbed which is retained by the animals for maintainance and/or growth or proportion of digested protein that is not excreted in urine.
- A balance trial is conducted in which N intake and urinary and faecal excretions of N are measured, and the results are used to calculate the biological value as follows.

$$BV = \frac{N\,intake - (faecal\,N + Urinary\,N) \times 100}{N\,intake - faecal\,N}$$

(3) BV ↑ ⇒ protein quality ↑

→ This is called apparent BV part of the nitrogen in faeces, the metabolic faecal nitrogen, is not derived directly from the feed.

→ urinary Nitrogen also contains a proportion of Nitrogen, known as the endogenous urinary nitrogen, which is not directly derived from feed.

→ The existence of nitrogen fractions in both faeces and urine, whose excretion is independent of feed nitrogen is most conveniently demonstrated by the fact that some Nitrogen is excreted when the animal is given a nitrogen free diet.

→ It is obvious that their exclusion from the faecal and urinary fractions in the formula given above will give more precise estimate of B.V by thomas-Mitchell formula

apparent

$$BV = \frac{N\,intake - (faecal\,N - MFN) - (urinary\,N - EUN)}{N\,intake - (faecal\,N - MFN)}$$

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Where MFN = Metabolic faecal nitrogen → consists of spent digestive enzymes, abraded mucosa and bacterial N.

EUN = endogenous urinary nitrogen → refers to the N resulting from normal catabolism of N constituents in body that are regularly voided in urine.

The Biological values of some of the proteins source have been given.

food	BV
Milk	95
whole egg	94
fish meal	74-89
wheat	67
Maize	49-61
Soybean meal	63-76
Cotton seed meal	63
Linseed meal	61
Barley	57-71
Peas	62-65
Microbial protein	75-78

B.V. ↑ Protein quality ↑

↳ B.V. are dependent on the amino acid composition, If all the essential amino acid present in right amount and proportion than BV will be higher since the protein will be utilized for body tissues rather than being diverted for energy supply.

↳ In the latter case the amino acid will be deaminated and there will be more excretion of urea.

↳ Animal proteins have higher BV since the essential amino acid ~~will be determined~~ present in them are very near to the

proportion in which they are needed by the body.

- Deficiency or excess of anyone of the amino acids lowers the biological value.
- Biological value of individual protein has a limited scope in practical feeding since no single protein is fed.
- Mixture of protein will have different biological value as it would not be a simple mean because one protein deficient in one amino acid may be supplemented by the addition of other.
- The B.V. are also dependent on the level at which protein is being fed. It is maximum at maintenance level.
- For determining the B.V. the protein under test must be fed adequately as per requirement.
- Excess protein will reduce the BV. Adequate amount of energy must also be present in the diet otherwise protein would be used for energy purpose which would reduce the BV of test protein.

Nitrogen Balance index :-

It is same as biological value.

NBI = Nitrogen balance (B) - Nitrogen balance when N-intake is zero (B₀) / Nitrogen absorbed.

2) Net Protein utilization (NPU) :-

The usefulness of a protein to an animal will depend upon its digestibility as well as its biological value.

- The product of these two values is the proportion of the nitrogen intake which is retained and is termed as the net protein utilization.
- It is based on comparison of body Nitrogen content resulting from a test protein with that resulting over the same period on a nitrogen free diet.

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$$NPU = \frac{\text{Body N content with test protein} - \text{Body N content with N free diet}}{\text{N-intake}}$$

$$NPU = \frac{\text{Retained nitrogen} \times 100}{\text{Nitrogen intake}}$$

$$NPU = B.V \times \text{digestibility}$$

digestibility ↑ → Retained in body ↑.

3) Net protein values (NPV)

The product of the NPU and the % crude protein is the net protein value (NPV) of the food, and is a measure of the protein actually available for metabolism by the animals.

$$NPV = NPU + \%CP$$

4) Protein Replacement value (PRV)

→ It is based on the nitrogen balance. This value measures the level at which the protein under test gives the same balance as an equal amount of standard protein.

→ To evaluate the protein replacement value, two nitrogen balance studies are conducted.

1) for standard protein (egg and milk)
2) for the protein under test

$$PRV = \frac{A - B}{N \text{ intake}}$$

A = Nitrogen balance for standard protein in mg per Basal K Cal.

B = N Balance for protein under test in mg per basal K Cal.

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The PRV measures the efficiency of utilization of the protein given to the animal. Other methods measure the utilization of digested and absorbed protein.

Estimation of Protein Quality from Amino acid composition :-

Chemical score :-

- given by Block & Mitchell (1946).
- There are methods in which protein quality is estimated without conducting the animal experimentation.
- The protein quality is dependent upon the amount of and proportion of essential amino acids present in the protein.
- The value would be lower if one or more amino acids are present in right amount and proportion.
- In the chemical score method the content of each essential amino acids of a protein is determined and expressed as the % of standard and the lowest % is taken as the score. test protein and → compare
- The amino acid present in the ~~geat~~ greatest deficit is the is considered as the limiting amino acid.

ex :- in wheat protein lysine is the first limiting amino acid. The content of it is 7.2 and 2.7% in egg and wheat protein respectively

Amino acids.	Egg %	Wheat Protein. (%)	
Lysine	7.2	2.7	4.5 → limiting amino acid
Isoleucine	8.0	3.6	4.4
Methionine	4.1	2.5	1.6

The chemical score for wheat protein is. $\frac{2.7}{7.2} \times 100$

$= 37.0\%$

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These values compare with the biological values for protein in rat, pig and human being but not in poultry. It is because there are other amino acids which are deficient in protein and are taken into account.

The Essential Amino Acids Index (EAAI):

- given by B.L. Oser (1951)
- All 10 essential amino acids are considered.
- Define as the geometric mean of the egg ratio's of these acids to the food amino acids and calculated as follows.

$$EAAI = \sqrt[n]{\frac{a}{a_e} \times \frac{b}{b_e} \times \frac{c}{c_e} \times \frac{d}{d_e} \times \cdots \frac{j}{j_e}}$$

where a, b ..... J = concentrations g/100gm of essential amino acids in the food protein. (test protein)

a_e, b_e ---- J_e = Concentration of same amino acid in egg protein,

n = number of amino acids.

It has the advantage that all the essential amino acids are considered but proteins having different amino acids composition may have the same index.

↳ Both the chemical score and the essential amino acid index are based upon gross amino acid composition. A more logical approach would be to use figure for the amino acids available to the animal.

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Measures of Protein Quality in Practical feeding of Pig and Poultry:-

- The difficulties in assessing the value of proteins in the diet will now be apparent from the variety of methods that have been proposed, all of which have considerable limitations.
- A crude protein figure is useful, because the degradability of the proteins in foods commonly given to pig and poultry is fairly constant.
- More recently, DCP has been used.

→ In practice pigs and poultry diets are based largely on cereals and assessment of the protein value of feeds for such animals is then a question of measuring their ability to supplement the amino acid deficiencies of the cereals.

→ The gross protein value is propably the most commonly used biological method fo evaluating proteins.

Crude Protein, DCP and MP and RDP and UDP.

Protein quality for Ruminants :-

- The significance of protein quality in ruminants is very limited since all the essential amino acids are synthesized by the micro-organism.
- The poor quality protein are improved in BV whereas, high quality proteins are degraded.
- The BV of microbial protein is about 70 but the overall BV of the food protein is very much less because of the production of NH_3 in the rumen. Therefore, BV in the ruminants has little application.

↳ For higher production, protein quality in ruminant is also getting importance. It has now being established that the microbial protein synthesized in the rumen are deficient in S-containing Amino acid for higher production and specially for wool production in sheep in which cystine is present to the extent of 11% in the protein.

↳ Good quality protein should be protected from rumen degradation so that better amino acid mixture is available in the blood pool of the animals.

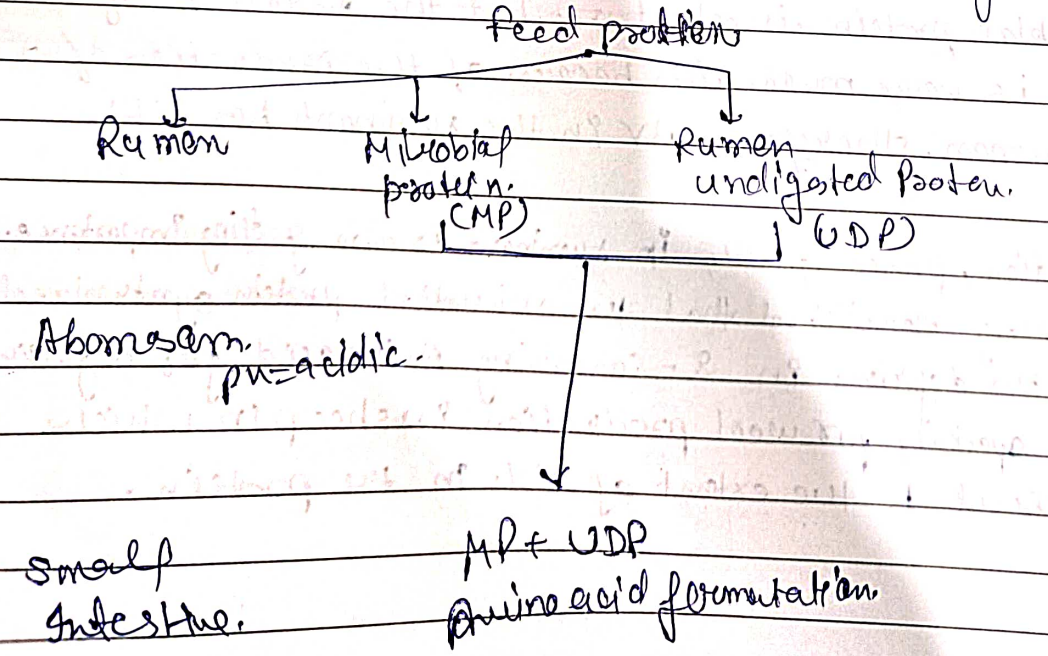
↳ The protection of protein is being done by physical means (heat treatment) or by chemical means of treating the protein with formaldehyde and tannic acid.

↳ Several alternative systems for evaluating the protein values in ruminants have been proposed.

1) Metabolisable protein :-

- Metabolisable protein is that part of the dietary protein which absorbed by the host animal and is available for use at tissue level.
- It consists partly of dietary true protein which has escaped degradation in the rumen but has been broken down to amino acids which are subsequently absorbed from the small intestine.
- Microbial protein synthesized in rumen, similarly contributes to metabolisable protein.
- This system is used in the United state of America.

Calculation of metabolisable protein schematically is given as:-



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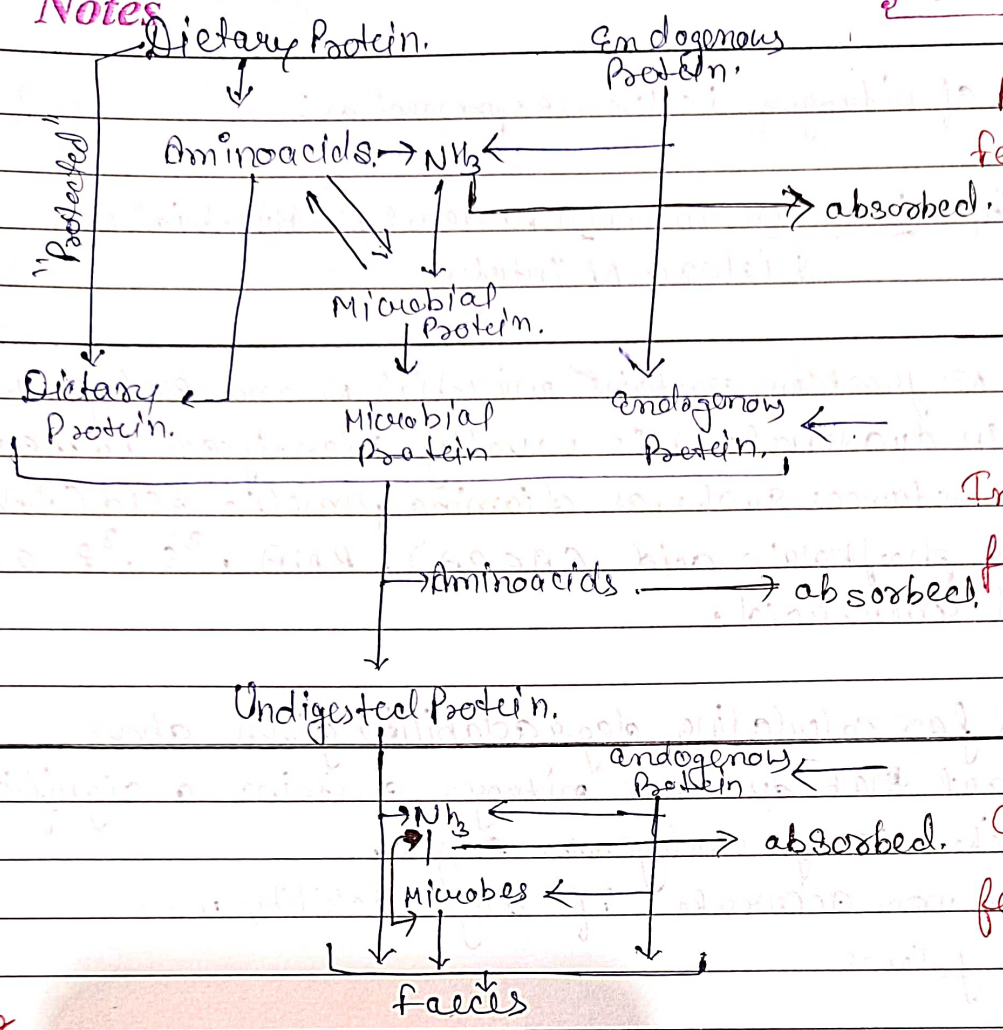

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2) Rumen degradable and undegradable protein:-

- In this system of protein allowances, proposed by the Agriculture Research Council (ARC) for the United kingdom and based on rumen degradable protein i.e. that available to the microorganism and undegradable protein which escapes degradation in the rumen but which undergoes digestion and absorption in the lower gut, and utilisation at tissue level.
- The proportion of protein escaping breakdown in the rumen may be estimated in vivo by measuring dietary nitrogen intake and non ammonia nitrogen and microbial nitrogen passing the duodenum.

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Degradability of nitrogen is then expressed as:

$$\text{Degradability} = 1 - \frac{\text{Non-ammonia duodenal N} - \text{Microbial N}}{\text{Dietary N intake}}$$

- The duodenal N fraction contains microbial N and endogenous N. microbial-N in duodenal-N is usually identified by means of marker substances such as diamino pimelic acid (DAPA) Amino ethyl phosphoric acid (AEPA), RNA, ^{35}S, ^{32}P and ^{15}N levelled amino acid.

- The formula for calculating degradability given above ignores the fact that duodenal nitrogen contains a significant fraction which is of endogenous origin.
- It would be more accurate if degradability was calculated as follows.

$$\text{Degradability} = 1 - \frac{\text{Non-ammonia duodenal N} - (\text{Microbial N} - \text{Endogenous})}{\text{Dietary N intake}}$$

- The Endogenous N fractions constitute about 50 to 200 g/kg of duodenal nitrogen but are difficult to quantify.

- A method of estimating protein degradation in the rumen by incubation of the food in synthetic fibre bag suspended in the rumen has been proposed.

- The degradability figure is calculated as the difference between the nitrogen initially present in the bag and that present after incubation, stated as a proportion of the initial nitrogen.

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$$\text{Degradability} = \frac{\text{nitrogen} - \text{Nitrogen after incubation}}{\text{Initial nitrogen}}$$

The technique is subject to several source of error like sample size, bag size and porosity of the bag materials which must be controlled if reproducible results are to be obtained.

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Processing Methods of Animal feed Stuffs.

Animal feed technology :-

↳ It deals with processing of feeds, fodders and preparation of formula feeds for which the knowledge of nutritional requirements of various livestock and poultry, quality control of feed ingredients, feed plant management and storage of feed ingredients and feeds are essential.

→ OR

// Also defined as the application of physical, chemical, biochemical, biological, physiochemical and engineering methods to increase the nutrient utilization of feeds and fodders in animal system for the development of livestock and poultry and feed industry.

Objective of feed processing :

1. To make the feed more palatable.
2. To detoxify or remove undesirable ingredients.
3. To make the storage easy and safe.
4. To increase nutrient content and nutrient availability.
5. To change the particle size or density of feed.
6. To make the animal production more economical.
7. To make more profit.
8. To improve keeping qualities.
9. To lessen moulds, salmonella, and other harmful substances.

Roughage Processing methods :-

All these methods are broadly divided into 2 groups i.e. - Dry processing method and wet processing method based on the addition or deduction of water content of roughages.

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These methods are further classified based on thermal treatment.

1) Cold processing method:-

It includes cracking/dry rolling, grinding crimping, crumbling, extrusion, water soaking, reconstitution and decortication.

2) Hot processing method:-

It includes steam rolling, steam flaking, pressure cooking, exploding, gelatinization, popping, pelleting, roasting and microwaving.

1) Dry Processing methods:-

- In these methods water content is reduced to a desired level.
- It includes baling, field chopped, grinding, pelleting, cubing and dehydration.

a) Baling:-

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

b) chopping:- energy Conserve ↑ digestibility ↑:

- It is also known as Chaffing. The forages are chopped into small pieces as fine or coarse particles. Chopping avoids the selective feeding thus wastage of plant material is reduced. The machine used for the intended purpose is called chaff cutter.
- chopping facilitates easy handling due to increased bulk density and also improves digestion due to exposure of relatively large surface area of roughages for microbial digestion.

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3) Grinding

It is a process of particle size reduction. grinding of roughages improve the feed consumption and growth rate but reduces the digestibility of crude fibre due to faster rate of feed particles in G I Tract due to smaller particle size. But due to large cost, grinding of roughages is not economical.
(digestibility ↓ होती है)

4) Pelleting :-

The ground roughages are pelleted and feed to animals. It improves the consumption of poor quality roughages. A complete feed is made by pelleting poor quality roughage with 30% concentrates.

- The size of pellets is 12/64" to 48/64" and has a density of 40 lb/cft whereas long hay roughages have density equal to 5 lb/cft.

5) Dehydration :

It is process of reduction of moisture content in a dehydrator using a temp. 600-1000°f for a short time period of 3-5 minutes. The dehydrated forage retains a lot of dry matter and protein and there is no loss of leaves, but carotene content is reduced due to dehydration (hay formation)

6) Cubbing :-

It is process of cube making. It increases the density of roughages upto 30 lb/cft. The good quality hay is sprayed with water to increase the moisture content upto 14% and broken down rather than to ground the roughage so that there is minimum of fine particles in the cube.

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2) Wet processing method:-

It includes soaking and green chopping. Soaking is a process of mixing or spraying water on roughages so that become soft and mixing of concentrates with roughage is uniform which improves the feed intake and digestibility of roughes. When green roughages are chaffed, there is no need of soaking and fed as such or mixed with dry roughage or concentrate mixture.

:- Processing of grains :- Concentrate.

Processing methods for grain are broadly divided into two group as:-

Wet Processing Methods	Dry processing Methods
(Soaking, steam rolling, flaking, pressure cooking, exploding, pelleting and reconstitution, extrusion, gelatinization.)	(grinding, dry rolling, popping, micronizing, extruding and roasting decorticating / dehulling, crimping and crumbling.

1) Wet Processing Methods:-

1) Soaking:-

Grains are soaked in water for 6 to 12 hours. The soaking softens the grains, which swells during the process and thus a palatable product is made. Soaked grains are easily mixed with roughages and wastage is reduced. Some time when soaked cakes of mustard and neem seed are filtered, help to remove the toxic factors present in cakes.

2) Reconstitution:- → कुछ time तक ऐसे ही रखते हैं। जबकि soaking में लम्बे समय तक

It is similar to soaking water is added to mature dry grain to raise the moisture content to 25 to 30% and stored the wet grain in an oxygen limiting silo for 14-21 days prior to feeding. It also increase the solubility of the grain protein.

atm → 100°C dup → 16-20% moisture → 8-20 min
20-60 psi 121-150°C → 18-25% → 1-2 min.

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3) Steam Rolling :- (wet + heat)

- The grain is subjected to live steam for different periods of time depending upon the pressure used prior to rolling. At atmospheric pressure, 100°C temp. and 16-20% moisture containing grain is steamed for 8 to 20 minutes whereas at a pressure of 20-60 psi preconditioning, grain having a temp. 121 to 150°C and 18-25% moisture is steamed for a period of 1-2 minutes only.
- This only soften the grains without any significant change in starch granules. The only advantage of steam rolling over dry rolling is the production of large particles with little fines.

4) steam flaking :- → Starch granules में change होता है। with steam Rolling में

- Steam treatment is given for 15-30 min. due to which moisture content in the grains rises to 18-20%. After rolling of such grains, flakes are produced. This process ruptures the starch granules and improves physical texture, nutrient utilization and performance of the animals in most of the cases.

5) Pressure cooking and flaking :-

- In this process the grains are first cooked under steam pressure, cooled to room temprature and then rolled. The product is more or less similar to steam flaked grains but the processing is much expensive. grains are cooked with live steam at 50 psi for 1.5 min in air tight pressure chambers, which achieved a temprature at 300°F. When flakes are made, this temprature is reduced to 200°F and moisture content upto 20% by passing them through cooling and drying tower.

50 psi → 1.5 min. → air tight chamber → temp 300°F → After roll of flake → 200°F → moist - 20%..
Pressure

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6) Extrusion :-

A process of cooking in which feeds are also expanded by the application of adequate pressure is known as extrusion. The main purpose of extrusion is the gelatinization of starch in grains or complete feeds.

- It is also used for the incorporation of urea in starchy feeds and for the control of pathogenic microorganisms in the feeds of animal source.

7) Exploding :-

- The process of swelling of steam treated grains under high pressure and sudden expose to atmospheric pressure or the grains are treated with high pressure steam (250 psi) for 20 sec. followed by sudden decrease to atmospheric pressure is known as exploding.
- It is done in steel vessel fitted with valve for injecting steam to raise pressure inside the grain containing vessel to 250 psi for about 20 sec.
- After that outlet is opened through which treated grains escape in the shape of expanded grains with the husk removed.
- This happens due to entry of large amount of moisture in the kernels due to high pressure.

8) Pelleting

- The process of densification of a ground grain or composite feed with or without the application of steam or moisture is known as pelleting. The ground feed material is forced to pass through the holes of specific size by mechanical process.
- The machine used for the purpose is called pelleting machine.
- The purpose of pelleting is to change dusty and unpalatable feed material into more palatable, easy to handle large

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particles by application of optimum amount of heat, moisture and pressure.

The normal size of pellets is 3.9mm to 19mm with cylindrical shape.

Advantages of pelleting :-

1. Increase the palatability of feed and thereby improves the feed intake.
2. Improves the feeding value of different feeds especially with roughages as compared to concentrates.
3. Increases the density of feed and thereby reduce the storage space required.
4. No segregation and selective feeding.
5. Reduces the wastage of feed by the animal.
6. Pelleted feed is in a free flowing form and can be handled mechanically thereby saving labour cost.
7. Heat labile inhibitors are destroyed, gelatinization of starch occurs.
8. feeding pelleted feeds enhance the growth rate and milk production and reduce cost of the end product, meat/milk.

Q) Gelatinization:-

- The complete disintegration of starch granules of a grain brought about by the combined application of moisture, heat and pressure is known as gelatinization.
- It improves the digestion of feed by increasing water absorption ability and rate of action of amylase on soluble carbohydrates (starches).

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2) Dry Processing Methods

1) Cracking or dry rolling:-

- It is the disintegration of kernels into particles with the application of pressure by moving rollers. It is done by a combination of breaking and crushing of the grains.
- The physical properties of dry rolled or cracked grain would be very similar to that of grains coarsely grained in a hammer mill.

2) Crimping:-

- The process of rolling of feed ingredients with the use of corrugated rollers is called crimping.
- The process may include conditioning and cooling of the processed feed.

3) Crumbles:-

The feed of granular particle size produced from the grinding of pelleted feeds is called crumbles.

4) Popping/puffing:-

- It is produced by the action of dry heat (370-425°C) for 15-30 sec. Causing a sudden expansion of the grain which rupture the endosperm and this results in rupture of starch granules and makes the starch more available to the animals.
- About 3% moisture of grain is lost during heat treatment
- Popping reduces the density of grains and increase palatability and digestibility of starch.
- Popped grains are also a good carrier for molasses.

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5) Micronizing :-
The popping of grains with the application of infrared heat energy having wavelength of 3×10^8 to 3×10^{11} cycles/sec. is called micronizing.

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6) Roasting OR Extruding
- The treatment of grains with direct flame is called roasting.
- It causes expansion in volume due to heating and generally increases digestibility.
- Roasting of whole soyabeans inactivates enzymes or inhibitory factors which improves the nutritive value for poultry.

(Crumbling used.)

7) Grinding :-
The process of reduction of feeds into particles with the application of pressure and shearing. It is prerequisite for mixing, pelleting or extrusion. It is simplest and least expensive method which is accomplished with the help of hand stone mill, hammer mill and roller mills.
- The size distribution of grains depends on the shape, size and hardness of the kernel.

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Advantages of grinding :-

1) It is prerequisite for mixing, pelleting or extrusion.
2) It increases the surface area of grains which is reflected as improve feed utilization, digestibility and performance of animals.
3) It avoids selective feeding of grains and reduces the scope of sorting out less palatable feeds by the animals from the compounded mash.

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4) grinding increases compactness and reduces space requirement for storage.

5) energy loss due to mastication will be decreased.

7) Palatability of ingredients will be improved.