

Subject : animal nutrition .

Lec 1 :

Syllabus of the yearly course in animal nut. Second year student college of vet. Med.

First semester ...

1- introduction and importance of nutrition.

2- animal and its food .

A- water and its function in farm animals.

B- energy metabolism .

C- carbohydrate metabolism .

D- protein and nucleic acid metabolism .

E- lipid metabolism.

F- trace elements , function and its deficiency.

G- vitamin function and its deficiency .

Second semester .

3- evaluation of food .

A- digestibility.

B- energy content of food .

C- system of expressing the energy value of food .

4- feeding standards for maintenance and growth .

A- ruminant.

B- rabbit.

C- poultry .

5- feeding standards reproduction and growth.

A- ruminant.

B- rabbit.

6- effect of environmental stress on nutrient used .

7- nutritional problems related to nutrition .

Lec 2 :

Introduction and definition of nutrition :

Everything should be fed if it has to work , this is true in case of everything right from the automobiles which require gasoline or fuel to the living cells which requires food . nutrition is an organic process to nourishing or being nourished , the process that allows organism to assimilate the food and use it for growth , work and maintenance in other words , nutrition is defined as a science , which narrate the relationship between the health and diet . in a same way , nutritionists or dieticians are health professionals who specialize in this area.in animals as well as in humans , nutrition clearly may affect health and welfare , emotions , physical capabilities , susceptibility to and recovery from disease , and incidence and severity of chronic metabolic diseases of aging .

The purpose of knowing nutrition :

The main purpose of studying and knowing nutrition is to explain the physiological and metabolic response of the body to the diet it takes. Molecular biology, biochemistry and genetics are the newer sciences that assist in studying the body mechanism.

The human body is made up of water, protein, nucleic acid, fatty acid and carbohydrate. These components in turn have elements like hydrogen, carbon, oxygen,

phosphorus and nitrogen. we do have minerals like calcium , zinc , iron etc. these are to be maintained in the body at any cost as any alteration in this will invite the diseased state . Foods are the sources of all the elements we want and it is important to understand how foods affect the body.

Variation in knowledge of nutrient requirements among animal species:

Nutrient needs of chickens have been defined more precisely than those of other domestic species primarily because chickens are grown under more uniform environmental conditions than other domestic animals and are less genetically diverse. In addition, the age and weight of broilers when they marketed is relatively uniform, and they are usually grown under similar conditions and fed diets of similar composition regardless of geographic location . all of these factors make it less difficult to determine the quantitative nutrient requirements of chickens compared to those of other species . unique features of the anatomy and functions of the digestive system of various species of animals (e.g., the complex stomach of ruminants compared with the simple stomach of non ruminants)are associated with differences in nutrient requirements among domestic animal species . furthermore , it is now recognized that selection for specific traits (e.g., growth rate , body composition) within a given species produce genetic changes in quantitative nutrient requirements .

Types of nutrients:

The substance that provides nourishment or nutrition is called as nutrient . there are six main classes of nutrients , which the body needs namely (proteins , carbohydrate ,

fats , vitamins , minerals and water) the protein or amino acid are required to produce a new body tissue and to replace the damaged proteins . protein help in building the body . there are many types of vitamins in the body that help in performance of bodily systems . water and salts maintain the hydration of the body , it is also an important structure that maintain blood pressure . carbohydrates and fats are the powerhouse of the body , they release energy as and when required .

Mechanisms of nutrition include :

Digestion – absorption – circulation – respiration – metabolism- excretion .

Animal body is that what u see .(cell – tissue – organ – system –animal body)

All information we having now is going to be double the next ten years . the scientists of nutrition ; (nutritionist)

1- Antoine Lavoisier 1743-1794 . the father of nutrition (introduced the balance and thermometer of nutrition and observed + that respiration is involved on O₂ intake CO₂ output amount depend upon food intake and work down .

2- Alt water , 1850 .(setup 1st experiment station in USA – human respiration calorimeter – physio chemical bases of life process) .

Enzymes : organic catalysts which alter the speed of chemical reaction without becoming involved in the reaction .

Types of enzymes :

1- exogenous (digestive systems – outside) .

2- endogenous (inside the cell itself) .in 1926 J.B.summer crystallized first enzyme , he found it to be a protein in nature .

Properties of enzymes :

1-specific (amylolytic act on carbohydrate – proteolytic act on protein) .

2- can be used over and over again .

3-they require specific condition for optimum activity (pepsine , hydrolyze protein from digestive tract optimum ph range 1.8 -2 .

For a newborn animal ph ranged = 5 therefore it's not going to be very effected for protein hydrolyzes the reason behind because of outside the limit .

Definition of terms :

A nutrient is any chemical element or compound in the diet that is required for normal reproduction , growth , lactation , maintenance of life processes . it is difficult to give a completely accurate short definition of a nutrient , for example , some compounds such as starch are readily utilized by most species as a source of energy (and thus provide nourishment) ,yet starch is not specifically required by an animal as a source of energy or for any other function .

Nutrients required by plants and animals :

Plants :

In contrast to animals , the nutrient requirements of plant are simple . in general plants take up nitrogen (N) in the form of nitrate or ammonia , and they synthesize complex proteins by incorporating these forms of (N) into amino acids and other intermediate products .

Animals :

Depending on animal age and species , animals require a source of N in the form of essential amino acids , fat in the form of essential fatty acids ,essential mineral elements , fat-soluble and water-soluble vitamins , and a source of energy that may vary from primarily fat and protein for carnivorous animals to coarse fibrous plant tissue for some herbivorous animals . the amounts and proportions of nutrients required are influenced by the type of gastrointestinal tract , the age of the animal , its level and type of productivity (maintenance of body tissues , work ,growth , milk , eggs and pregnancy).

A simplified list of elements and compounds that may present in food .

Organic compounds

Nitrogenous

Proteins

Amino acids

Nonprotein (partial list)

Peptides

Amines and amides

Nucleic acids

Nitrates

Urea

Lipids

Fatty acids

Phospholipids (lecithin , sphingomyelin)

Triacylglycerol (triglycerides)

Sterols (hormones , cholesterol , vitamin D)

Terpenoids (carotene , xanthophyll)

Waxes (cutin)

Carbohydrate

Monosaccharides (glucose , xylose)

Disaccharides (sucrose , lactose)

Oligosaccharides

Polysaccharides , fibrous (hemicellulose , cellulose , xylans)

Polysaccharides , nonfibrous (starches , dextrin , pectin)

Vitamins

Fat soluble

Water soluble

Other

Polyphenol (lignin)

Organic acid

Compounds contributing to color , flavor , odor , toxins , inhibitors

Glossary terms and its definition to aid your introduction to nutrition

Ruminant : any of a group of hoofed mammals that have a four – compartment stomach and that ruminant or chew a cud such as cattle , buffalo , camel , sheep, goat and deer .

Non- ruminant ; a simple stomached animal that does not ruminant such as duck , horses , dogs , swine , poultry , turkey , geese , rabbit and also human.

Rumen : also called the fore stomach or paunch , it is the first compartment of four compartment of a ruminant animals stomach . the rumen serves as the primary site of food fermentation in the entire digestive tract . non-structural carbohydrate (including starch , sugar and pectin) and structural carbohydrates (including cellulose and hemi cellulose) are fermented and digested by ruminal microbes for the duration of their time in the rumen .

Microflora: the gross overall bacterial population present , it sometimes used to include the protozoa as well as the bacteria .

Hay : the aerial part of finer stemmed forage crops stored in the dry form for animal feeding . such as alfalfa hay , barley plant hay , yellow corn plant hay , clover hay wheat hay .

Silage : the feed resulting from the storage and fermentation of green or wet crops under anaerobic conditions . for example are green fodder , alfalfa silage , barely plant silage , yellow corn plant silage , grasses silage .

Straw : the part of manure plant remaining after removal of seed by threshing or combining ,for example are wheat straw , barley straw , rice straw .

Concentrate : feeds high in energy and also high (more than about 60%) in T.D.N on air-dry basis and low in (less than 20%) in crude fiber , opposite of roughage .

Roughage : any feed high (more than about 60%) in crude fiber and low in (less than 20%) in T.D.N on air – dry basis ,opposite of concentrate .

Ration : a 24 hour allotment of feed for an animal .

Balanced ration : a combination of feeds that will provide the essential nutrients in proper proportions .

Balanced daily ration : a combination of feeds that will provide the essential nutrients in the proper amounts to nourish a given animal for 24 hour period .

Hormone: a chemical substance secreted into the body fluids by an endocrine gland that has a specific effects on other tissues .

Antibody : a substance produced in the body that acts against disease.

Antibiotic : a substance produced by one micro organism that has an inhibiting effect on the growth of another .

In vitro : refers to a feed sample that is digested in test tubes or tested outside the animal , an in vitro digestion study occurs in the laboratory , not in the animal .

In vivo : refers to a digestion study of feed that is tested inside the animals rumen or stomach .

Palatability : taste appeal the degree of acceptability of a feed to livestock .

Total mixed ration (TMR): consist of all the feed ingredients mixed together to form the ration allowance for the animal .

Supplement : a product that contains high levels of one or more nutrients and that is fed to correct or prevent deficiencies of these nutrient .

Forage : crops used as a pasture , hay , silage or green chop for feeding purposes ,

Complete ration : a single feed mixture into which has been included all dietary essentials , except water of given class of livestock .

Feed efficiency : the amount of feed required to produce one unit of product , such as pounds (KG) of feed to produce one pounds (KG) body weight gain , or one pounds (KG) of milk or one dozen eggs .

Nutrient : an element , compound or group of compounds that can be used as nourishment by an animal .

Digestion : refers to all changes that feed undergoes within the digestive tract , with the end result being that the broken down products are absorbed from the digestive tract for use by animal .

Carbohydrate : organic substances that contain carbon , hydrogen and oxygen with the hydrogen and oxygen present in the same proportions as in the same proportions as in water carbohydrate in plants can be divided into those that serves as storage and energy reserves in plants and are available for metabolism (sugars , starch , pectin and some cellulose , for example barley grain) and these that are structural (for example fibers cellulose , hemi cellulose and lignin ,for example straw) carbohydrate are a major source of energy in livestock feeds .

Starch : the main carbohydrate component of the dry matter in grain . it consists long chain of glucose

molecules ,which are easily broken down by rumen microbes .

Lipids : a broad terms for fats and fat like substances .

Oil : usually a mixture of pure fats that is liquid at room temp.

Fat : the product formed when three fatty acids combine with one glycerol . the glycerol ester of a fatty acid such as stearin , palmitin and olein .

Fatty acid : any one of several organic compounds containing carbon , hydrogen and oxygen , which combine with glycerol to form fat .

Volatile fatty acid (VFA): any one of several volatile organic acids found especially in rumen contents and silage such as acetic acid , propionic acid and butyric acid are ordinarily the most prevalent .

Saturated fatty acids : any one of several fatty acids containing no double bonds such as stearic acid , palmitic acid , arachidic acid .

Unsaturated fatty acid : any one of several fatty acids containing one or more double bonds , palmitolic acid , oleic acid , linoleic acid , linolenic acid , arachidonic acid .

Crude fat : a part of a feed that is soluble in ether . also referred to as ether extract .

Protein : complex compound containing carbon , hydrogen , oxygen , nitrogen and usually sulphur are composed of one or more chain of amino acids . protein are essential in the diet of animals for growth , lactation and reproduction . in ruminant (cattle) the rumen microbes breakdown about 80% of protein to ammonia , carbon dioxide , VFA, and other carbon compounds . the microbes then use the ammonia to synthesize their own body protein .as a feed is passed through the rumen into

the rest of the digestive tract, the microorganisms containing about 65% high quality protein are washed along too. The ruminant obtains most of its required protein by digesting these microorganisms.

By-pass protein : refers to the portion of intake protein in a feed that is not broken down in the rumen but is digested directly in small intestine. By-pass protein is another name for undegradable intake protein (UIP), rumen undegradable protein (RUP) or escape protein.

Escape protein : see by-pass protein or undegradable intake protein (UIP).

Degradable intake protein (DIP) : portion of intake protein that is digested or degraded in rumen by microbes to ammonia and amino acid. DIP is expressed as a percentage of CP. DIP consists of rumen soluble nitrogen, non-protein nitrogen, plus soluble true protein. It may also be referred to as rumen degradable protein (RDP).

Undegradable intake protein (UIP): portion of intake protein that escapes rumen degradation and is digested directly in small intestine. About 80-85% of the microbial protein and UIP or true protein that flows out of the rumen is digested in the small intestine. UIP is expressed as a percentage of CP. It is also called bypass protein or escaped protein or rumen undegradable protein since it is the amount of feed protein that escapes the rumen to small intestine.

Rumen degradable protein (RDP) : that portion of the consumed protein digested in the rumen. It may also be referred to as degradable intake protein (DIP).

Non-protein nitrogen (NPN): nitrogen that comes from other than organic protein sources (plant or animal) that can be used by ruminants to make animal protein. NPN sources are compounds like urea and ammonia.

True protein : a nitrogenous compound that will hydrolyze completely to amino acids .

Crude protein : the total amount of protein present as calculated from the total nitrogen present . unless otherwise stated , protein values given in lap. Reports , feed tables and feed tags are crude protein , laboratory analysis measures the total amount of nitrogen present in a feed . the percent nitrogen is converted to percent protein by multiplying by 6.25 .

Digestible protein (DP) : the amount of crude protein actually absorbed by the animal (crude protein intake minus the protein lost in feces) .

Amino acid : any one of a class of organic compounds that contain both the amino group NH_2 and the carboxyl COOH .

Essential amino acid : any one of several amino acids that are needed by farm animals and cannot be synthesized by them in the amount needed and so must be present in the protein of the feed such as methionine , lysine , tryptophan , phenylalanineetc .

Non-essential amino acid : any one of several amino acids that are required by animals but can be synthesized in adequate amount by an animal in its tissues from other amino acids .

Total digestible nutrient (TDN) : the concept of total digestible nutrients comes from the old system of measuring available energy of feeds and energy requirements of animals involving a complex formula of measured nutrients . it is very hard to measure , but is used widely in some parts of the USA and Canada .TDN values are usually quoted as percentage for feeds and as amounts per day for requirements . the values are usually calculated on feed analysis reports . the simplest and most commonly used formula for estimating TDN is $\text{TDN} = \text{DE}/0.044$. one

kilogram of TDN is equivalent to 4.4 mega calories of DE .

Dry matter : the part of feed that is not water (DM) .sometimes referred to as substances or total solids .it is the sum of crude protein , crude fiber , ether extract ,nitrogen free extract and ash .

Organic matter : the total weight of the feed minus the weight of the mineral matter (or ash) in feed .

Ash : the incombustible residue remaining after incineration at 600 C° for several hours .

Crude fiber : chemical method used to describe the indigestible portion of plant material . however , some of these substances can be partially digested by microorganisms in the rumen of cattle .

Cellulose : one of the major structural materials in the plant cell walls that can be utilized by microorganism in rumen .

Hemicelluloses : polysaccharide fraction existing in the cell wall of plant .it is similar to cellulose but only partially digestible in the rumen .

Calorie : the amount of energy as heat required to raise the temp. of 1 gm of water 1 C° .

Food : is an edible material that provides nutrient .

Feed : (noun) refers to food but more commonly is used to designate animal food .

Foodstuff or feedstuff : is any material made into or used as food or feed , respectively .

Diet : is a mixture of feedstuffs used to supply nutrients to an animals .

Ration : is a daily allocation of food or feed .

Lec: 3

The gastrointestinal tract (GI) :

Some knowledge of the GI tract is important to those who study nutrition because of its influence on the utilization of food and nutrients . the organs , glands , and specialized structures of the GI tract are concerned with procuring , chewing , and swallowing food ; with digesting and absorbing nutrients; and with performing secretory and excretory functions.

Digestion may be defined simply as the preparation of food for absorption . in the broad sense , it may include mechanical forces (chewing or mastication ; muscular contractions of the GI tract) , chemical action (hydrochloric acid in the stomach ; bile in the small intestine) , or hydrolysis of ingesta by enzymes produced in the GI tract or from microorganisms in the various sites in the tract . the overall function of the various digestive processes is to reduce food to a molecular size or solubility that allows absorption and cellular utilization of the individual nutrients released in the process .

Absorption consists of the processes that result in the passage of small molecules from the lumen of the GI tract through the mucosal cells lining the surface of the lumen and into the blood or lymph systems .

Anatomy and function of the gastrointestinal tract :

The GI tract of mammals includes the mouth and associated structures and glands , the esophagus , the stomach , the small intestine , and the large intestine (including acecum in some species) . associated organs

that are intimately involved with digestion and absorption are the liver (secretes bile into the small intestine) and the pancreas (secretes digestive enzymes into the small intestine) . the tract itself is essentially a modified tubular structure used for ingestion and digestion of food and the elimination of some of the wastes of metabolic activity produced by the animal body .its ultimate purpose is to provide for the efficient assimilation of nutrients and to reject dietary constituents unnecessary for or potentially harmful to the animal .

Types of GI tracts :

Among the many species of mammals and birds there are wide variations in the structure and functions of individual components of the GI tract . the animal does not , of course , exist in a sterile environment , and in many instances the GI tract has been modified to take advantage of symbiotic relationships with various microorganisms . concentrated microbial populations are found in the large intestine of all species ; some species have developed modifications of the upper GI tract that allow microbes to thrive and generate products that are beneficial to the animal in the process of partially digesting some of the ingested food . mammals with an uncomplicated stomach are sometimes referred to as monogastrics or as nonruminants . existing animal species have evolved many variations in their digestive tracts that allow them to utilize diets of varying composition or quality ranging from nectar (hummingbird and other nectareating birds) to coarse fibrous plant material (elephant and other large herbivorous wild species , horse , some ruminants) .

Carnivores are animals whose diet is composed primarily of nonplant material , for example , meat , fish and insects . in general , the diet of a carnivore is relatively concentrated and highly digestible except of hair , feather and other types of resistant proteins . the GI tract of carnivores is represented by gastric stomach and are

relatively short and uncomplicated intestine . the large intestine is uncomplicated in that it is not sacculated . carnivores are classified as hind gut fermenters ; they are further subdivided into cecal or colonic digesters . they have the capability of digesting limited amounts of fibrous feeds . but the fermentation of fibers is quite limited compared to that in other species .

Omnivores and herbivores (plant eaters) generally have more complicated GI tract that have been modified in some manner to improve utilization of plant tissues . the human , pig , and rats are an example of omnivorous species . note that the pig has a long but simple small intestine , a moderately large cecum , and a sacculated large intestine . the pig (and human) are classified as colonic digesters . in comparison the rat has a shorter but simple small intestine , an enlarged cecum , and an unsacculated large intestine (classed as a cecal fermentor) . both of these species depend on hind gut fermentation to varying degrees ; the pig has fermentation in both cecum and colon , whereas most of the fermentation in the rabbit GI tract occurs in the cecum .

The sheep , pony and rabbit are three examples of herbivores species with quite different adaptations to handle fibrous diets . the sheep , because it is ruminant , has a complex large stomach with extensive fermentation followed by along but simple small intestine , a relatively large cecum , and a rather short large intestine – allowing both pregastric and hind gut fermentation . the horse has a small intestine a large cecum , and a very large sacculated hind gut (large intestine) . on the other hand , rabbit has a medium – sized stomach , a relatively short and simple small intestine , a large sacculated cecum , and a medium-sized unsacculated large intestine . both the horse and rabbit have a substantial amount of hind gut fermentation . within these groups the ruminants represents a highly specialized class because of their ability to digest fiber and

other carbohydrates more completely than the other groups . some pregastric fermentation occurs in other species of nonruminants , such as kangaroos , that have sacculated stomachs but it has not been described as well in literature as that of ruminants . among the hind gut fermenters , the large herbivores (horse , rhinoceros , elephant) depend on fermentation of fiber in the large intestine . their diet may be as fibrous as that of some ruminants , but such animals tends to eat more per unit of metabolic size while digesting less of low-quality feeds. In human , the secum is reduced to a point of little if any function , but the colon is sacculated and fermentation occurs there . when animals depend heavily on cecal fermentation ,there is often an association with COPROPHAGY (feces eating) , as in rabbits , such adaptations often result in two kinds of feces . only the finer material is selected for recycling through coprophagy . this practice allow these small herbivores to consume fibrous diets that would otherwise be inadequate in some the essential nutrients such as essential amino acids or vitamins . microbial activity in the GI tract provides a more complete supply of some vitamins and amino acids which , when coprophagy is practiced , is beneficial to the animal .

Rumen metabolism :-

Rumen microorganisms : in the GI tract of the ruminant animal , in contrast to that of other types of animals that have no pregastric fermentation , ingested feeds is exposed to very extensive microbial fermentation before it reaches the glandular stomach (abomasums) or intestinal juices . the reticulorumen provides a very favorable environment for survival and activity of anaerobic microbes ; it is moist and warm , and there is an irregular introduction of new digesta and a generally continuous removal of fermented digesta and end products of digestion so that metabolites such as acids do not build up to inhibitory levels . most of

the bacteria are obligate anaerobes meaning that such organisms grow best in an atmosphere that has very low oxygen levels .

Rumen fermentation :-

Carbohydrates : carbohydrates make up the major portion of the diet of herbivorous animals and can be classed as fibrous (hemicellulose , cellulose , xylans) or readily available (primarily sugars , starches) . that carbohydrate will fermented in rumen to volatile fatty acids VFA (acetic , propionic , butyric) and carbon dioxide , methane and heat . the animal in turn uses that VFA as a source of energy for its life processes . this is in contrast to the situation in most animal species , in which the major product of carbohydrate digestion is glucose . glucose is the principal energy source for cell metabolism in animals .

Protein : although some rumen bacteria may require amino acids or peptides . there are many proteolytic organisms that attack dietary protein , with the result that a considerable amount of it is degraded to ammonia and organic acids . these in turn ,may be utilized by other species to synthesis amino acids and bacterial protein .

Lipids: lipid consumption by herbivores animals is low because most forage contains only limited amounts .in the rumen , the microbes do not greatly alter the fat fraction , although some lipids may be synthesized . when fed low to moderate levels of dietary fat , the rumen microorganisms hydrolyze fat , producing free fatty acids and glycerol . rumen microbes modify the unsaturated fatty acids by either saturating them or causing changes in the location of double bond . the rumen microbial population is intolerant to high dietary levels of fat . when fat is added to the diet , it is fed normally at no more than 5-7 % of the total diet . higher levels are apt to result in abnormal rumen fermentation unless the fat is protected from the organisms

by coating fat droplets with casein , and then treating the complex with formaldehyde .

Gas production : anaerobic fermentation such as those that occur in the rumen result in the production of copious amounts of gases . a fairly typical composition of the gases would be 65% CO₂ , 25-27% CH₄ , 7% N and trace amounts of O₂ , H₂ and H₂S . calorimetry data indicate that cattle may produce up to 600 L of gases per day . methane , which has a high heat equivalent , represents a direct loss of energy to the animal . it is produced under anaerobic fermentation as a means of getting rid of excess hydrogen . if eructation is inhibited , bloat may result ; bloat can be chronic or acute , and the acute form can cause death very rapidly .

Vitamin synthesis : rumen microorganisms have the capability of synthesizing essentially all of the B-complex vitamins required by the host animal. Although some synthesis may occur in the large intestine or cecum of other species , the amount synthesized in the rumen is probably greater than that in the lower GI tract .

The role of GI – Tract secretions in digestion :

Digestive secretions have very important roles in the overall digestive processes . in nonruminant mammals and avian species , the digestive enzymes attack the food before it is subjected to microbial action in the cecum and large gut . in ruminant the digestive secretions are supplementary to the digestion that occurs first in the rumen as a result of microbial fermentation .

Digestive enzymes are found in saliva in small amounts . the glandular stomach (or abomasum or proventriculus) is a major source of proteolytic enzymes and hydrochloric acid . the pancreas is an important source of enzymes that act on proteins , starches and fats , and glands in the wall of the duodenum produce a variety of enzymes that act on sugars , protein fragments , or lipids . the enzymes

produced in the glandular stomach of the animal are made in the peptic gland region and are released into the lumen of the organ .

<u>Type</u>	<u>name</u>	<u>origin</u>
<u>substrate</u>	<u>action</u>	<u>end product</u>

Amylolytic

salivary amylase	saliva	starch ,
dextrin	dextrin, maltose	pancreatic
amylase	pancreas	starch , dextrin
maltose , isomaltose	maltase , isomaltase	sm.
Intestine	maltose , isomaltose	glucose
lactase	sm. Intestine	lactose
glucose , galactose	sucrose	sm.
Intestine	sucrose	glucose , fructose

Lipolytic

salivary lipase	saliva	
triglycerides	diglycerides+1 fatty acid	
pancreatic lipase	pancreas	triglycerides
monoglycerides +2 F A	intestinal lipase	sm.
Intestine	triglycerides	glycerol + 3 F A
lecithinase	pancreas , sm . intestine	lecithin
lysolecithin + free F A		

Proteolytic

pepsin	gastric juice	native pepsin
proteoses,peptones,polypep.		rennin
abomasums	clots milk (casein)	Ca caseinate
trypsin		abomasums
peptides	with terminal arginine	chymotrypsine
pancreas	native protein	peptides with terminal
aromatic AA		

A summary of the major actions in the GI-Tract :-

Omasum :- the combination of the reticulo- omasal orifice and the omasum obviously act as filters to prevent excessively large particles of ingesta from passing into the abomasum and small intestine . forage or other food particles found between the leaves of the omasum are usually rather small in size .some absorption of components such as volatile fatty acids occurs in the omasum .

Stomach / abomasum / proventriculus :- the function of different types of glandular stomach in various species is quite similar . chyme entering from proximal organs is acidified by the addition of HCL , and initial digestion of proteins by pepsins occurs . in young mammals , milk is clotted by the acid and enzymes , thus prolonging its stay in this part of the stomach . some fat digestion may occur in young mammals .

Gizzard :- in birds , the proventriculus flows into the gizzard where , with the aid of grit picked up by the bird , the digesta is ground to a fineness suitable for better utilization in the intestine .

Small intestine :- bile from the liver enters the intestine producing an alkaline medium that is conducive to digestion by the pancreatic and intestinal enzymes which enter with the bile via the common bile duct in most species . some absorption occurs in the duodenum , but most occurs in the jejunum and ileum . the bile salts are absorbed (and recycled to the liver) , lowering the PH , thus allowing a gradual increase in microbial activity .

Cecum :- the cecum is of little importance in carnivores and in some omnivores such as man . in other species digesta from the ileum enters the cecum where a considerable amount of microbial activity occurs . among other things , the microorganisms may produce microbial protein of much better quality than that in the diet . in addition , vitamin synthesis occurs . for species that practice coprophagy , the fecal material consumed thus allows them to exist on a diet of lower quality than otherwise might to be the case . note also that some interspecies benefits of intestinal production of vitamins and proteins may occur . dogs , as well as other species such as swine , often eat some feces of other species such as horses or cattle , and it is probable that they derive some nutritional benefit from this practice .

Large intestine :- continued microbial fermentation occurs in the large intestine , although there is uncertainty about the quantity of absorption of amino acids , peptide or vitamins from the large gut . excretion of a number of mineral elements occurs in the large gut . large amounts of water may be absorbed , especially in species adapted to arid climate . many species adapted to dry climates produce fecal pellets , example being kangaroo , rats , rabbits , sheep , goats , deer , and antelope of various species .



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Lec 4:

Water and its functions , regulation and comparative use by farm animals

Life could not be sustained without water . it makes up about one-half to two-thirds of the body mass of adult animals and up to 90% of that newborn animals , and it accounts for more than 99% of the molecules in the body .

Functions :

- 1- as a major component in body metabolism .
- 2- as a major factors in body temperature control .

Water and body metabolism :

From a functional viewpoint , water is essential for life . the death of plants and animals occurs quickly when water is insufficient , as contrasted to relatively long-term life when the supply of other nutrients is restricted . all of the biochemical reactions that take place in an animal require water .

Water as a solvent :

Many of the biological functions of water are dependent on its property of acting as a solvent for a wide variety of compounds , many compounds ionize readily in water .

Water as a transport medium :

In addition , water serves as a medium for transportation of semisolid digesta in the GI tract , for various solutes in blood , tissue fluids , cells and secretions , and in excretions such as urine and sweat .

Water as a diluents :

Water provides for dilution of cell contents and body fluids so that relatively free movement of chemicals may occur within the cells and in the fluids and GI tract . thus

,water serves to transport absorbed substances , conveying them to and from their metabolism sites .

Water in hydrolysis and oxidation :

Water is involved in many chemical reactions , in hydrolysis ,water is a substrate in the reaction ,and in oxidation , water is a product of the reaction .

Metabolic water :

Water of oxidation results from the oxidation of organic components in the cells of the body . oxidation of 1 mol of glucose requires 6 mol of O₂ and produces 6 mol of CO₂ and 6 mol of water . the metabolic water produced per gram of food is much higher for fat (1.07) than for protein (0.40) and carbohydrate (0.56) .

Ingestion and metabolism of fat , carbohydrate and protein results in increased respiration and heat dissipation and , for protein , increased urinary excretion of urea , the principal excretory products on N metabolism in mammals . large amounts of water are required for dilution and excretion + via the kidney of the urea and the amount of water derived from oxidation is not sufficient to meet the increased respiratory and excretory demands .

Water and body temperature regulation :

Water has several properties that allow it to have a marked effect on temperature regulation . its high specific heat , high thermal conductivity , and high latent heat of vaporization allow accumulation of heat , ready transfer of heat , and loss of large amounts of heat on vaporization . these physical properties of water are enhanced by physiological characteristics of animals . the fluidity of the blood and the rapidity with which it is circulated in the body , the large evaporative surfaces in the lungs and body surface for sweating . as 1 gram of water changes from liquid to vapor ,whether by panting or sweating it takes up about 580 Cal of heat . in terms of heat exchange , this is a

very efficient use of water when it is realized that to heat 1 gram of water from freezing to boiling require only 117 Cal . because of this great capacity to store heat , any sudden change in body temperature is avoided .

Water absorption :

Water is readily absorbed from most sections of the GI tract . in ruminants , usually there is a net absorption from the rumen and omasum . in the abomasum of ruminants or the glandular stomach in other species , usually there is a marked net out flow of fluids (which accompany gastric secretions) . in all species , there is a net absorption from the ileum , jejunum , cecum and large gut , but the amount absorbed (and moisture in the feces) varies considerably from species to species and from diet to diet within a species .

Body water :

Water content of the animal body varies considerably , over the long term it is influenced by the age of the animal and the amount of fat in the tissues . water content is highest in fetuses and in newborn animals , declines rapidly at first ,and then slowly declines to adult levels . when body water is expressed on the basis of the fat-free body , the water content is relatively constant for many different animal species, including cattle , sheep , swine , mice , rats , chickens and fish . the range is from 70 to 75% of fat – free weight . fat content of the tissues may be calculated by the formula :

$$\text{Fat \%} = 100 - \% \text{water} / 0.732$$

Water turnover :

The term water turnover is used to express the rate at which body water is excreted and replaced in the tissues . water turnover is greatly affected by climatic factors such as temperature and humidity or by ingestion of compounds

such as sodium chloride (common salt) that increase urinary or fecal excretion .

Water sources :

Water available to an animals tissues is derived from the following ..

1- drinking water .

2- water contained in or on feed .

3- metabolic water .

4- water liberated from metabolic reactions such as condensation of amino acids to peptides .

5- performed water associated with body tissues catabolized during a period of negative energy balance .

The importance of these different sources differs among animal species , depending on diet , habitat and ability to conserve body water .

Water losses :

Loss of water from the animal body occurs by way of urine , feces , insensible water (that lost via vaporization from the lungs and dissipation through the skin) and sweat from the sweat glands in the skin during warm or hot weather . water excreted via urine acts as a solvents for products excreted from the kidney . some species have greater ability to concentrate urine than others . in some cases , urine concentration is related to the type of compound excreted , for example birds excrete primarily uric acid rather than urea as an end product of protein metabolism . these species excrete urine in semisolid form with only small amounts of water . however , mammals cannot concentrate urine to nearly such an extent . birds also have another slight advantage in that production of uric acid results in production of more metabolic water than does urea .

The kidney of most species has great flexibility in the amount of water that may be excreted . minimal amounts required for excretion (called obligatory water) . consumption of excess water during periods of heat stress or consumption of diuretics (caffeine , alcohol in humans) may increase kidney excretion of water considerably .

Fecal losses of water in humans are usually about 7 to 10 % of urinary water . in ruminants such as cattle , fecal water loss usually exceeds urinary losses , although not during heat stress . animals that consume fibrous diet usually excrete a higher percentage of total water via feces , and those that form fecal pellets (sheep , goats and deer) usually excrete drier feces and , presumably , are more adapted to drier climates and more severe water restriction than is the case for species that do not form fecal pellets .

Loss of water via sweat may be very large in species such as humans and horses whose sweat glands are distributed over a large portion of the body surface . sweating is used as a means of dissipating body heat and is said to have an efficiency of about 400% compared to respiratory heat loss .



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ENERGY METABOLISM :

The topic of energy and its metabolism by animals is known as (bioenergetics) .

Bioenergetics : is the part of biochemistry concerned with the energy involved in making and breaking of chemical bonds in the molecules found in biological organism .

Some of major bioenergetics processes :

1- **Glycolysis** : is the process of breaking down glucose into pyruvate , producing two molecules of ATP / 1 molecule of glucose in the process . when a cell has a higher concentration of ATP than ADP (high energy charge) , the cell can undergo glycolysis , releasing energy from available glucose to perform biological work . (pyruvate) is one product of glycolysis ,and can be shuttled into other metabolic pathways . (gluconeogenesis) as needed by the cell additionally , glycolysis produces reducing equivalents in the form of NADH (nicotinamide adenine dinucleotide) .

2- **Gluconeogenesis** : is the opposite of glycolysis , when the cells energy charge is low (the concentration of ADP is higher than that of ATP) , the cell must synthesize glucose from carbon-containing biomolecules such as (protein , amino acids ,fats , pyruvate) .

3- **Citric acid cycle** : is a process of cellular respiration in which acetyl coenzyme A , synthesized from pyruvate dehydrogenase , is first reacted with oxaloacetate to yield citrate .

4- **Oxidative phosphorylation** , and the Electron transport chain : is the process where reducing equivalents such as NADPH and NADH .

5- **Photosynthesis** : another major bioenergetics process ,is the metabolic pathways used by plants in which solar energy is used to synthesize glucose from carbon dioxide and water .

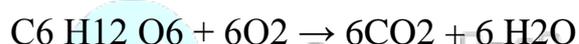
Measurement of energy metabolism :

On a practical basis , energy metabolism of animals is assessed by measuring some general aspects of metabolism . for example , in the utilization of carbohydrates , lipids and amino acids as energy sources , oxygen is consumed and carbon dioxide with water and heat are end products . all of these (except water) can be measured in animals confined in special chambers called (respirometers) .

Gaseous exchange is obtained by measuring oxygen consumption and carbon dioxide output . the ratio of these gases (mole carbon dioxide produced / mole oxygen consumed) = RQ ,, respiratory quotient , this gives an indication of the nature of the metabolic fuel being used .

Examples of RQ determinations are as follows :

Carbohydrate catabolism :



$$RQ = CO_2 / O_2 = 6/6 = 1$$

Estimation of feed energy :

In the USA , feed energy is expressed in Calories , in most other countries , the joule is used as the measure of energy .although the use of the joule in nutrition is not logical (joules are measures of electrical energy) , it has been adopted because it is the unit of energy measurements used in the metric system . feed energy is actually measured as calories by Bomb calorimetry , and then converted to joules by conversion factors below .

1- calorie (small calorie) = the amount of heat required to raise the temperature of 1 gm of water by 1 C° degree .

1 Kilocalorie (kcal) = 1000 calories .

1 Mega calorie (Mcal) = 1000 kcal .

1 calorie = 4.184 joules (j) .

1 kilocalorie = 4.184 kilojoules (KJ) .

1 kilojoule = 0.239 kcal .

The caloric content of biological materials is determined in a bomb calorimeter . in brief , the sample is burned in a combustion chamber (bomb) inserted in a vessel containing a known weight of water .as the sample burns ,it releases heat ,which is taken up by the water . from the weight of the sample , weight of the water and rise in temperature of the water , the number of calories of heat energy released can be calculated .

When a feed sample is burned in a bomb calorimeter ,its Gross energy is determined . to determine the fraction of the gross energy that the animal can actually utilize , a metabolism trial must be conducted to account for various losses , yielding values for digestible , Metabolizable and net energy .

Digestible energy (DE) = Gross energy (GE) – Faecal energy .

Metabolizable energy (ME) = DE – (Urinary energy + Rumen Gas losses) .

Net energy (NE) = ME – Heat loss .

Gross Energy (GE) values (dry basis) of various tissues , metabolites or feedstuffs .

Item	GE , kcal / gm
Carbohydrate	
Glucose	3.74
Starch	4.18
Cellulose	4.18
Fats , fatty acids	
Average fat	9.45

Nitrogenous sources

Average protein sources 5.65

Feeds

Corn grain 4.4

Wheat bran 4.5

Soybean meal 5.5

Hibernation :

Is a state of hypo metabolism entered into by some animals as a response to anticipated nutritional stress , while generally viewed as a means of avoiding winter –feed scarcity and cold .

Hibernators are of two types :

1- fat storing : do not consume food during the hibernation season and instead rely on metabolism of stored fat .

2- food storing : are store caches of food , which they ingest during their periodic arousals .

During hypernatremia, several mechanisms shift metabolism from carbohydrate to lipids during the transition to torpor. Several key carbohydrate-metabolizing enzymes are phosphorylated, and thereby inactivated. These include glyceraldehyde 3-phosphate dehydrogenase and pyruvate (end product of glycolysis) to acetyl coenzyme A. (entry to citric acid cycle).

Catabolism of Amino acid :

The use of amino acid as energy sources begins with deamination (removal of the α -amino group) in the liver. The remaining carbon skeleton is then converted to intermediates of either glycolysis or citric acid cycle reaction.

Catabolism of Lipids :

Fatty acids are catabolized by β -oxidation to yield acetyl CoA. Which enters the citric acid cycle reactions. The glycerol liberated from TAG is converted to pyruvate. The final step of β -oxidation yields a three carbon short-chain fatty acid, propionate which is converted to succinate in the citric acid cycle.

Basal metabolism :

May be defined as the condition in which a minimal amount of energy is expended to sustain the body. Determinations are carried out under standardized conditions. And many factors affect it (age, neuroendocrine, species and breed).

Maintenance :

May be defined as a condition in which a nonproductive animal neither gains nor loses body energy reserves.

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Carbohydrate metabolism :

Carbohydrate are the major components in plant tissues . they comprise up to 70% or more of the dry matter of forages . higher concentrations (up to 85%) may be found in some seeds , especially cereal grains . carbohydrates , containing mainly of glucose and glycogen , make up less than 1% of the weight of an animals .

Functions :

In animal nutrition carbohydrates serve primarily as a source of energy for normal life processes .

Metabolism :

Preparation for absorption :

Digestion in the small intestine : only monosaccharides can be absorbed from the GIT except in newborn animals capable of absorbing larger molecules . thus , for absorption to occur , poly , tri and disaccharides must be hydrolyzed by digestive enzymes elaborated by the host or by microflora inhabiting the GIT of the host .

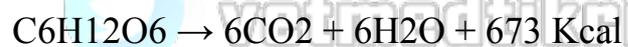
Microflora of the rumen of ruminants and the cecum and colon of some nonruminants , such as the horse and rabbit , produce cellulase , which is capable of hydrolyzing the glucose -4-beta-glucoside linkage of cellulose . consequently , these species can utilize large quantities of cellulose . other nonruminants , including humans and swine , also utilize cellulose by anaerobic fermentation in large intestine by virtue of the production of cellulase by some of the microorganisms residing in the lower intestinal tract but not by mammalian cells .

Microbial fermentation of cellulose and other plant fibers :

In ruminants and other species with large microbial populations in the GIT . anaerobic fermentation of carbohydrates results in the production of large quantities of volatile fatty acids (VFA) , mainly acetic , propionic and butyric acids , and provides a large proportion of the total energy supply .even in pigs whose ability to utilize cellulose is less than that of ruminants , some of the energy required for maintenance can be provided by VFA produced by microbial action on fiber in the large intestine .

Energetics of glucose catabolism :

The total energy released in the conversion of glucose to CO₂ and H₂O is 673 Kcal/mole . this can be illustrated as follows :



The molecular weight of glucose is 180.2 , thus the gross energy value of glucose is $673 / 180.2 = 3.74 \text{ Kcal / g}$. in the oxidation of metabolites via the citric acid cycle , the 57 Kcal /mole of water formed (total of $6 \times 57 = 342\text{kcal}$) represents heat production and is wasted energy , equivalent to the amount of energy that must be ingested and absorbed for the animal to stay in energy balance .

Catabolism of 1 mole of glucose by the glycolytic pathway is associated with the following amounts of adenosine triphosphate (ATP) trapped at each stage of oxidation to CO₂ and H₂O "

Glycolytic pathways (8 mole of ATP)

2 pyruvate to 2 acetyl CoA (6 mole of ATP)

2 acetate to 2 CO₂ and H₂O (24 mole of ATP)

Total (38 mole of ATP)

ATP serves as a major form of high-energy phosphate bonds . one mole of ATP has a value of about 8 Kcal / mole . that is ..

ATP → ADP + 8 Kcal / mole .

Carbohydrate digestion in ruminants :

Carbohydrate digestion in ruminants is largely the result of microbial fermentation in the rumen . fermentation is anaerobic respiration . dietary carbohydrates are fermented , mainly by rumen bacteria , and the absorbed energy sources for the animal are the bacterial waste products , the VFAs . the VFAs were originally termed steam-volatile fatty acids , because they are volatilized from solution by the action of passing steam through the solution . steam distillation of volatile compounds was a common technique in the early days of biochemistry . they are also known as short chain fatty acids (SCFA) . As a generalization , ruminants meet their protein needs by digesting rumen microbes , while they meet their energy needs by absorbing the waste products (VFAs) of rumen bacterial fermentation .

Rumen fermentation of carbohydrates :

Bacteria , protozoa and fungi are the three types of rumen microorganisms (RMO) . they all have roles in carbohydrate digestion , although bacteria are the most important . bacteria secrete enzymes that split the bonds linking sugars together in oligosaccharides and polysaccharides , resulting in the release of free sugars .these are taken up immediately by the bacteria , and metabolized as energy sources . because the rumen is primarily anaerobic , the bacteria cannot oxidize sugars completely to carbon dioxide and water (luckily for the ruminant) ,they excrete carbon fragments in the form of VFAs , carbon dioxide and methane (CH₄) .small amounts of oxygen may enter the rumen , as air swallowed during

feeding . although oxygen is toxic to obligate anaerobic bacteria , it is quickly utilized by facultative anaerobes .

Cellulose fermentation :

Bacteria that produce cellulase enzyme are called cellulolytic bacteria . they attach to fiber particles and the cell walls of fibrous plant material consumed by the animal . there is little or no free cellulase in the rumen contents . cellulolytic bacteria invade the plant cells and tend to digest them from inside .

Starch fermentation :

Starch is a major dietary constituents of concentrated fed-ruminants , such as dairy and feedlot cattle . starch-digesting or amylolytic rumen bacteria . the rate of degradation of starch depends upon its source and feed processing method .

End-products of rumen fermentation :

The main end products of rumen fermentation are microbial cell mass , gases , heat (the heat of fermentation) and the VFAs. The main gases produced during rumen fermentation are CO₂ , CH₄ and small amounts of hydrogen and hydrogen sulfide . rumen gas is typically about 65% CO₂ and 25% CH₄ , so the methane in the rumen is a hydrogen sink . the proportions of the three major VFAs , acetate (C₂) ,propionate (C₃) and butyrate (C₄) , produced in the rumen are influenced by diet . cellulolytic bacteria tend to produce more C₂ so acetate makes up 75% or more of total VFAs with a roughages based diet . with high concentrate diets propionate is the major VFAs .

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