Lecture 6

NUTRIENT PARTITIONING

PROTEIN PARTITIONING

The protein in the diet contains intake protein which is normally called crude protein. Immediately it is digested, it is divided into Digestible Crude Protein and Indigestible Crude Protein particularly in ruminant animals.

1. CRUDE PROTEIN (CP)

The common practice is for the nitrogen status of livestock feeds and food to be stated in terms of crude protein because most of the feed nitrogen is present as protein and most of the nitrogen required by the animal is used for protein synthesis. Chemically, the protein content of a feed is calculated from its nitrogen content determined by the modification of the classical Kjeldahl technique. This gives a figure which improves most form of nitrogen except nitrite, nitrate and certain cyclic nitrogen compounds which require special techniques for their recovery. The assumption was that all the nitrogen of the feed is present as protein and that all feed protein contain160g N/kg. Thus, the nitrogen content of feed is expressed in terms of crude protein.

$$CP\ (g/kg) = gN/kg \times 6.25$$

$$Cp\ (g/kg) = gN/kg \times \frac{1000}{160}$$

With time, these two assumptions were found to be unsound because;

a) Different feed proteins have different N content and therefore different factors should be used in the conversion of N to protein for individual feeds. Factors for converting N to protein for some feeds are as follows:

Feed protein source	Nitrogen (g/kg)	Conversion factor
Maize, egg, meat	160.0	6.25
Barley, Wheat, Oats	171.5	5.83
Milk	156.8	6.38
Soyabean	175.1	5.71
Cotton Seed	188.7	5.30

Although, the use of an average conversion factor of 6.25 for all feed protein is globally in practice, because protein requirement of farm animals is normally expressed in terms of nitrogen x 6.25.

b) Many nitrogenous compounds such as amides, amino acids, glycosides, alkaloids, ammonium salt and compound lipids occur along with feed nitrogen naturally. Only the amides and amino acids are important and these are present in large amount in only a few feeds such as young pasture, silage or immature root crops.

c) The assumption did not take into account the species of animal for which the feeds were intended. In the diets of pigs and poultry, cereals and oil seed predominate which contain little non- protein nitrogen (NPN), thus their nitrogen source may not need to be partitioned but in ruminant animals, variable amount of NPN are fed. Allowance therefore, need to be made for this in the evaluation of ruminant feeds.

2. DIGESTIBLE CRUDE PROTEIN (DCP).

The crude protein figure only provides a measure of the N present in feeds but gives little indication of its value to the animal. Before the feed becomes available to the animal, it must undergo digestion, during which it is broken down into simpler substances which are absorbed into the body system. Thus, the digestible protein in the feed is determined by digestibility trial in which nitrogen intake is measured along with the nitrogen voided in faeces. The assumption is that the difference between the quantities of N in the feed and faeces or digesta represents the quantity absorbed in the utilizable form by the body and that all N which appears in the faeces is of dietary origin. These assumptions are untenable in most cases particularly in ruminant animals because of the presence of nitrogen of metabolic origin in faeces and the production of ruminal ammonia gas. Thus, the figures obtained are called APPARENTLY DIGESTIBLE PROTEIN. This however, gives a measure of the protein status of a feed for livestock feeding.

3. **TRUE PROTEIN (TP)**

When crude protein is to be determined, it can be separated from NPN compounds by precipitation with cupric hydroxide or heat coagulation in some plant materials. The protein is then filtered off and the residue subjected to a kjeldahl analysis. Determination of the digestibility of true protein (true digestibility) always take account of the contribution of nitrogen of endogenous origin to take of the digesta. The endogenous N is derived from non – food substances entering the intestine such as saliva, bile, gastric and pancreatic secretions, and cell sloughed off the mucous membrane of the gut. This measurement always present difficulties and the result may vary widely with the diffe4rent techniques employed. Most figures in current use are apparent values minus the metabolic nitrogen which is taken principally as urine nitrogen. True digestibility = TP- (faecal N + MFN +UN) where MFN = Metabolic faecal Nitrogen and UN= Urinary Nitrogen. The concept of true protein and its attendant intricacies has given rise to many concepts which are now used more valuably to measure protein quality. These however, differ widely in application between monogastric and ruminant animals. In ruminant nutrition, certain proportion of the intake protein is degraded in the rumen by the microbes while some are lost in their complex compartments. This has made the evaluation of ruminant diets with CP or digestible CP later modified to Protein Efficiency Ratio (PER) unsatisfactory. Thus, estimation of protein quality and digestibility for ruminant animals which will take into account their microbial and endogenous losses is rather complex.

4. **PROTEIN EFFICIENCY RATIO (PER)**

Digestible protein figure as stated above are not entirely satisfactory measures of the value of a protein to an animal. This is because the efficiency with which the absorbed protein is used differs considerably from one source to another. PER always give the ratio of weight gain of animals to the amount of protein it consumed for each feed.

$$PER = \frac{\text{Weight gain of animals (g)}}{\text{Protein consumed (g).}}$$

5. **NET PROTEIN RATIO (NPR)**

This entails feeding of a group of animal with protein and compare with another group fed no protein as a ratio of protein consumed

$$NPR = \frac{\text{Wt gain of TPG – Wt loss of NPG}}{\text{Wt of protein consumed}}$$

TPG = Test Protein Group; NPG = Non – Protein Group.

6. **BIOLOGICAL VALUE (BV).**

Bv is defined as the proportion of the absorbed nitrogen which is retained by the body. It is a direct measure of the proportion of the feed protein which can be utilized by the animals for synthesizing body tissues and compounds.

$$\text{Biological value} = \frac{\text{N intake – (Faecal N – MFN) - (Urinary N - EUN)}}{\text{N intake – (Faecal N- MFN).}}$$

EUN = Endogenous Urinary N; MFN= Metabolic faecal N.

In determining BV, dietary protein should be provided by the feed under test. The protein intake must also be sufficient to allow adequate N intention but must not be in excess of that required for maximum retention.

7. **NET PROTEIN UTILIZATION (NPU)**

NPU is the product of biological value and digestibility. It is the proportion of feed N that is retained in the animal's body under specified condition. It entails doing a nitrogen balance study and carcass analysis. The higher the retention of a given dietary intake, the better the quality of the protein.

ENERGY PARTITIONING

1. **GROSS ENERGY (GE)**

When a feed is completely burnt to its ultimate oxidation product (CO_2, H_2 and gasses), the heat given off is known as Gross Energy or Heat of Combustion. Gross energy is determined with the aid of a bomb calorimeter and is just the starting point in determining the energy value of feeds because not all of it is utilized within the animal's body system. The fraction not utilized is wasted as faecal or urine energy.

2. **FAECAL ENERGY.**

This is the energy lost through the faeces i.e. heat of combustion of faeces. It includes energy of metabolic product of the body as well as that of undigested feed. Faecal energy is important because it is used to compute the apparent digestible energy. It can further be used to obtain the True Digestible Energy (TDE) by subtracting the faecal energy of feed origin only from the gross energy.

3. **DIGESTIBLE ENERGY**

This is the difference between the gross energy intake from feed and energy voided in faeces. It is also determined by the use of bomb calorimeter to obtain gross energy of feed and faeces.

4. **METABOLISABLE ENERGY**

This is the proportion of energy ingested by the animal which is actually transformed and used for metabolic processes in the body. It is the apparent digestible energy minus energy lost in gaseous product of digestion and that lost in urine (UE). These gaseous losses (CH_4, H_2) are particularly very important in ruminant animals and to a lesser extent in monogastric such as man, dog, swine and chicken. These gaseous losses are usually not accounted for when metabolisable energy is being calculated for monogastrics.

5. **URINARY ENERGY**

Urine which comes out of urinary tract of animals contains some energy which constitutes further loss to the animal's energy economy. The urine loss result from the excretion of incompletely oxidized nitrogenous products. The urinary loss is both from the blood and body cells. Therefore it is called Endogenous urinary Nitrogen (EUN).

6. **HEAT ENERGY (HE)**

This is energy lost as heat in the body. This heat is used by the body to maintain the thermo-neutral balance of body tissues. Sometimes, small amount of energy are lost in form of perspiration, epidermal loss (loss through epidermal scales) and shed hair. They could also be accounted for and subtracted from gross energy to obtain metabolizable energy. However, they are normally regarded as insignificant for specific dynamic action. As a result of continuous metabolic reaction in the body, which is a manifestation of life processes, heat is produced within the body in form of chemical energy and it is lost as heat energy. This heat increases with the amount and and type of food consumed and the increase is known as Heat Increment (HI). This consists of heat of fermentation and heat of nutrient metabolism.

The heat of fermentation is the heat produced in the GIT especially rumen of ruminant animals as a result of microbial action. Thus, it is more relevant in ruminant animals than any other species. The heat energy produced in an animal will therefore depend on:

i) Nature of the diet/ration (whether soluble or insoluble carbohydrate or proteinous feed. Heat is more generated when carbohydrate is fed to ruminant than roughages).

ii) The level at which it is fed (production or maintenance).

iii) The purpose for which it is fed i.e the body functions the feed suppose to support (maintenance, growth, fattening, lactation etc.)

iv) The environment under which it is fed. The ambient temperature will determine the amount of heat generated by the animal's body. For instance, the heat generated within the body of an animal in cold environment will be more than that of animal in hot environment. This is because of the demand of animal in cold environment to generate more heat to keep its body temperature up to normal within the thermo-neutral level. This will call for more chemical reaction and tissue breakdown in the animal.

v) Physiological state of the animal. A sick animal may not have enough appetite to eat food. Consequently, its body metabolism may not be able to cope with environmental demand. The result of this is heat stress which could bring down the animal.

7. NET ENERGY

Net energy is the proportion of feed energy which is completely useful to the body and thereby appears as a product in form of energy for tissue maintenance, growth, milk, egg, wool and fur. It can be obtained by subtracting the heat increment expressed in terms of a given unit of intake from metabolisable energy of the same intake. In ruminants fed concentrate, this value must be added to a basal roughage

ration to know the actual net energy value. Energy partitioning has given rise to many concepts one of which is Total Digestible Nutrients (TDN) which represents values commonly used in ruminant animal feed
evaluation. It is calculated as:

TDN = % DCP + % NFE + %CF + % EE + 2.25

The 2.25 comes from the fact that fats are concentrated source of energy (1g of fat = 2.25g CHO).