AN Mid Lectures

LECTURE 1

Course No. AN – 304 Course Title: Feed Evaluation, Formulation and Processing Technology

A few contents for practical classes were also delivered in this class.

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LECTURE 2

DIGESTION TRIALS

The digestion trials may be carried out by a number of methods as discussed below one by one.

TOTAL COLLECTION METHOD

Following are some prerequisites/requirements for conducting this experiment.

Prerequisites/What we have to do before conducting the experiment?

- Literature on previous research conducted on the project.
- Discuss the matter with other researchers who have knowledge on this topic.
- Precise name of the project
- Location or place of the work.
- Cooperating institutes/organization/departments.
- Objective of the research
- Names of the persons participating
- Justification for doing such experiments.

Selection criteria of animals for the experiments

- Class of the livestock
- Breed of the animal
- Sex of the animal
- Stage (growing/lactating/pregnant) of the animal

  If animal is lactating – Lactation length of the animal

  If animal is growing – Growing stage of the animal

  - Animals should be disease-free.
  - Body weight and body size should be uniform
  - Lactation no., lactation yields as well as lactation stage should be the same.
  - Animals should be free from any type of parasite infection
  - Environmental factors should be the same for all experimented animals.

- Feeding regime should be the same.

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LECTURE 3

PREPARATION OF APPARATUS FOR TOTAL COLLECTION METHOD

1. Analytical Apparatus:

There may be a number of apparatus used according to the need of the experiment.

e.g. Furnace, electric oven, freezer, weighing balance (weighing capacity should be considered while using to weigh the animal), flame photometer, pH meter. For feces dryness --- best temperature is 65-70 C.

For individual feeding—feeding crate/stall → animal keep here in comfort and enjoy stress free environment.

The feeding crate should be well-designed.

2. Record the feed consumption, residual feed and feces of the animal. (in feces, about 80% is moisture)

3. Adjustment Period: It should be given to the animal. It must be 7-14 days before conducting the experiment.

Feeding adjustment for the animal is also done during this period.

4. Collection Period: It must be 3-7 days.

5. Feeding Trial Period: It must be 21-18 days but some people suggest 14 days for this period.

CALCULATION OF DIGETSIBILITY

Digestion Coefficient (DC) of nutrients

a) when there is no refused feed (no ort):

$$\text{Digestion Coefficient (DC)} = \frac{\text{Kg of nutrients eaten} - \text{Nutrient in feces}}{\text{Kg of nutrient eaten}} \times 100$$

To calculate the digestibility of a whole feed is of no use, but it is calculated of each nutrient present in it.

b) When there is refused food

$$\text{Digestion Coefficient (DC)} = \frac{\text{Kg of nutrient offered} - \text{Kg of nutrient refused} - \text{Kg of nutrient in feces}}{\text{Kg of nutrients offered}} \times 100$$

FECES MARKERS

These are inert, indigestible substances that have no effect on the physiology of digestion and possess the same passage rate to that of the feed.

Characteristics Of Good Marker

- It should be insoluble

- It should be inert; no effect on the physiology of digestion as well as on the passage rate of the feed. No reaction with any other feed nutrient.

Examples

Barium sulphate, Chromic acid, Ferric acid, Polythene, Lignin, etc

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LECTURE 4

Calculate the Digestibility of the nutrients IF we use Indicator/Marker

Digestibility of nutrients = $100 - (100 \times \frac{\%\text{ indicator in feed}}{\%\text{ indicator in feces}} \times \frac{\%\text{ nutrients in feces}}{\%\text{ nutrients in feed}}$

NYLON BAG TECHNIQUE

Synonyms: Silk Bag Technique, Dacron Bag Technique.

In this method, the quality of the material with which the bag is made, is very important.

If we use cotton bag in this experiment

As we know that cotton is made up of cellulose and hemicellulose, thus the cotton bags can be digested/destroyed by the attack of bacteria and microbes present in the rumen.

Therefore, the bag should be made up of indigestible material i.e. nylon, silk and Dacron etc.

The rate and extent of digestion can be measured through this method by recording the loss of dry matter, loss of nutrients and loss of contents from the sample.

Factors Affecting the Digestibility of the Nutrients

i) Size and type of the bag

ii) Mesh size (pore size) of the bag

iii) Size of the sample

iv) Methods of suspension (how bag is suspended in the rumen?)

v) Location of suspended bag

vi) Time of suspension of the bag

vii) Methods of cleaning of bag after removing from the rumen

viii) Method of rinsing of bag after removal (it should be rinse in distilled water)

Procedure

a) Weigh the bag (3 grams)
b) Take 10 gram of sample in it. (total 3 +10 = 13 grams now)
c) Coding on the sample bag
d) Suspend it in the rumen by the help of a thread and bound with a hook.
e) Keep it suspended for desired time and then remove it from the rumen.
f) Wash it with distilled water and then place it in the oven to measure the residual dry matter present in it.
g) When the weight will remain the constant, then weigh it finally.

For example, now weight of the residual sample is 8 grams then calculate as:

Digestibility of the nutrients (%) = (Total weight of the sample – residual sample weight) x 100

= (10 – 8) x 100 = 2 %

Numerical No. 1

Calculate the Digestion Coefficient (DC)

Chemical Composition of Feed (i.e. Hay) and Feces

Contents of a feed	Hay (%)	Feces (%)
Moisture	16.00	75.00
Ash	6.00	2.00
Crude Protein (CP)	12.57	3.22
Crude Fiber (CF)	27.78	9.50
Nitrogen Free Extract (NFE)	35.15	9.78
Ether Extract (EE)	2.50	0.54
Total	100	100

TABLE 1.1

Calculate Chemical composition by proximate analysis

Daily Average	DM (gm)	CP (gm)	CF (gm)	NFE (gm)	EE (gm)
A) 4 kg Hay intake	3360	502.80	1111.20	1406.00	100.00
B) 8.5 kg Feces outlet	1450	186.76	551.00	564.92	31.32
C) Digested part (A – B)	1910	316.04	560.20	841.08	68.68
Digestion Coefficient % DC = C/A x 100	56.84	62.85	50.41	59.82	68.68

TABLE 1.2

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LECTURE 5

Computation of Digestible Nutrients and Total Digestible Nutrients (TDN)

Calculate the Digestible Nutrients

- First of all, determine the digestion coefficient of all the nutrients.

$$\% \text{ Digestible Nutrients} = \frac{\% \text{ nutrients x Digestion coefficient (DC) of the nutrients}}{100} = \frac{\% \text{ nutrient X DC}}{100}$$

Feed Contents	Composition (%) fresh basis	Digestion Coefficient (DC)	% Digestible Nutrients
	(a) See from Table 1.1	(b) See from Table 1.2	(c) = a / b x 100

Dry Matter (DM)	84.00	56.84	= 47.74
Crude Protein (CP)	12.57	62.85	= 7.90
Crude Fiber (CF)	27.78	50.41	= 14.00
Nitrogen Free Extract (NFE	35.15	59.82	= 21.02
Ether Extract (EE)	2.50	68.68	= 1.71

TABLE 1.3

Calculate Total Digestible Nutrients (TDN)

TDN = % digestible CP + % digestible CF + % digestible NFE + (% digestible EE x 2.25)

TDN = 7.90 +14.00 + 21.02 + (1.71 x 2.25) = 7.90 + 14.00 + 21.02 + 3.85

TDN = 46.76

Calculation of Digestibility via Indicator/Marker Method

In this method, digestibility can be measured without measuring either the feed intake or feces output.

This method is regarded as an indirect method for calculation of digestibility.

Step 1: Calculate the Fecal Dry Matter (DM) as follows:

$$\text{Dry Matter (DM) in Feces} = \frac{\text{Amount of indicator intake (mg/day)}}{\text{Amount of Indicator in the feces (mg/ g of DM)}}$$

Step2: Calculate the percent Indigestibility.

$$\%\ \text{indigestibility} = 100 \times \frac{\text{Indigestible DM in diet (\%)}}{\text{Indigestible DM in Feces (\%)}}$$

Step 3: Calculate the % Digestibility

$$\%\ \text{Digestibility} = 100 - \%\ \text{indigestibility}$$

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LECTURE 6

Frequently Used Equations in Feed Evaluation

Digestible DM (gm) = DM intake (gm) – DM in feces (gm)

$$\text{Digestible DM (\%)} = \frac{\text{DM intake (gm)} - \text{DM in feces (gm)}}{\text{DM intake (gm)}} \times 100$$

TDN (gm) = (DM intake x Chemical composition of feed) – (DM in feces x Chemical composition of feces)

$$\text{TDN (\%)} = \frac{(\text{DM intake x Chemical comp. of feed}) - (\text{DM in feces x Chemical comp. of feces})}{\text{DM intake (gm)}} \times 100$$

Digestible Energy (Kcal) = Energy intake (kcal) – Energy in feces (kcal)

$$\text{Digestible Energy (\%)} = \frac{\text{Energy Intake (kcal)} - \text{Energy in feces (kcal)}}{\text{Energy Intake (kcal)}} \times 100$$

TDN (%) = % dig. CP + % dig. NFE + % dig. CF + (% dig. EE x 2.25)

Relationship between TDN and Digestible Energy (DE)

1 kg of TDN = 4400 kcal Digestible Energy

= 4.4 kcal/ gram of TDN

1.87 TDN = 8228 Kcal

Relationship between TDN and Metabolic Energy (ME)

I kg of TDN = 3520 kcal ME

= 3.52 kcal / gram of TDN

Relationship between TDN and Equivalent Starch

1 kg of TDN = 0.869 starch equivalent

Factors Affecting TDN value:

1. % of DM in the feed

   DM in the feed – TDN Moisture in the feed - TDN
2. Digestibility of DM

   Digestibility of DM – TDN
3. Amount of Fat in the DM

   Fat Content - TDN, because % of fat (i.e. EE) is multiplied with 2.25 in the formula
4. Amount of Minerals in the DM

   % Contents of minerals (i.e. ash) - TDN

Atwater's Physiological Fuel Value → ME value

Carbohydrate	4.00 kcal /gram
Fat	9.00 kcal /gram
Protein	4.00 kcal / gram

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LECTURE 7

Atwater's Average Gross Energy Value Factors

Carbohydrates	4.15 kcal/gram	Carbohydrate (DC)	98%
Fat	9.40 kcal/gram	Fat (DC)	95%
Protein	5.65 kcal/gram	Protein (DC)	92%

Atwater's Digestible Energy Value Factors

Gross energy of carbohydrate = 4.15 kcal DC of carbohydrate = 98% = 0.98

Digestible energy of carbohydrate = gross energy x DC = 4.15 x 0.98 = 4.0 kcal/gram

Gross energy of fat = 9.4 kcal/gram DC of fat = 95% = 0.95

Digestible energy of fat = gross energy x DC = 9.4 x0.95 = 9.0 kcal/gram

Gross energy of protein = 5.65 kcal/gram DC of protein = 92% = 0.92

Digestible energy of protein = gross energy x DC = 5.65 x 0.92 = 5.20 kcal/gram

Atwater's Physiological Fuel Value Factors → ME value factors

Carbohydrates = gross energy x DC = 4.15 x 0.98 = 4.0 kcal/gram

Fat = gross energy x DC = 9.4 x 0.95 = 9.0 kcal/gram

Protein = gross energy – excreted energy x DC = 5.65 - 1.25 x 0.92 = 4.0 kcal /gram

Excreted energy: some part of the digestible energy of protein is excreted in the form of urea, uric acid and ammonia in mammals, birds and fishes respectively. Thus in above equation we subtract 1.25 in terms of EE.

COMPOSITION OF MAIZE AND FECES (on as such or fresh basis)

Hay intake = 4 kg

Maize grains = 4.2 kg

Feces outlet = 8.5 kg

Contents		Maize Grain (%)	Feces (%)
	Moisture/water	12.75	80.95
DRY MATTER(DM)	Ash	1.20	1.75
	Crude Protein (CP)	9.65	3.55
	Crude Fiber (CF)	1.90	6.50
	Nitrogen Free Extract (NFE)	70.85	6.75
	Ether Extract (EE)	3.65	0.50
	Total	100	100

TABLE 1.4

Calculate Chemical composition by proximate analysis

All the values for Hay has been taken from the TABLE 1.2

Daily Average	DM (gm)	CP (gm)	CF (gm)	NFE (gm)	EE (gm)
A) 4 kg of hay per day	3360.00	502.80	1111.20	1406.00	100.0
B) 4.2 kg of maize grain per day	3664.50	405.30	79.30	2975.70	153.30
C) Maize grain + Hay (A+B)	7024.50	908.10	1191.00	4381.70	253.30
D) Total feces	169.25	301.75	552.50	573.50	42.50
E) Total digested part (C-D)	5405.25	606.50	638.50	3807.95	210.80
F) Estimated dig. from hay	1910.0	315.50	560.20	841.08	68.68
G) Estimated dig. from	3495.25	290.85	78.30	2966.87	142.12

maize					
H) Digestion Coefficient of Maize DC = G / B x 100 = %	95.38	71.76	98.12	99.70	92.70

TABLE 1.5

Determination of Digestible Nutrients in Maize Grain

Feed Contents	Composition (%) fresh basis	Digestion Coefficient (DC)	% Digestible Nutrients
	(a) See from Table 1.4	(b) See from Table 1.2	(c) = a / b x 100
Dry Matter (DM)	87.25	95.38	= 91.48
Crude Protein (CP)	9.65	71.76	= 6.92
Crude Fiber (CF)	1.90	98.12	= 1.864
Nitrogen Free Extract (NFE	70.85	99.70	= 70.64
Ether Extract (EE)	3.65	92.70	= 3.38

TABLE 1.6

TDN (Maize grains) = % digestible CP + % digestible CF + % digestible NFE + (%digestible EE x 2.2.5)

= 6.92 + 1.86 + 70.64 + 1.864 + (3.38 x 2.25) = 87.03

LECTURE 1 (Remaining)

Techniques used for Determination/Evaluation of Feed

a) Chemical Analysis

It is the starting point for determining the nutritive value of any feed stuff. Chemical analysis method has its own history of more than 100 years ago. So far millions of feed stuffs have been analyzed and their data have been written in different forms.

b) Proximate Analysis

It is the scheme of study of feed stuffs which gives us an idea about the nutritive value of feed. It is used to calculate the moisture and DM contents i.e. CP, CF, Ash, EE, and NFE etc.

It tells us nutritive value of nutrients before giving them to the animal. This was devised by Stoman and Heniburg in 1865 at veni experimental center in Germany.

LECTURE 8

EVALUATION OF PROTEIN QUALITY

There are different methods which are applied for this purpose.

1. Protein Efficiency Ratio (PER)

It can be calculated as;

$$PER = \frac{\text{Weight gain (gm)}}{\text{Protein intake (gm)}}$$

Limitations

i) It is only applicable for monogastric animals.

ii) If only protein is given, no energy source then some pert of protein will burnt to produce energy. For sustaining of life but regardless of loss of weight.

iii) Dietary caloric value should be optimum.

iv) Protein intake should be optimum, not excessive. In case of excessive protein intake, body have to pay in the form of energy loss. Energy is lost for burning purposes.

v) A.A. profile of protein in PER must be adequate in quantity and proportion.

2. Biological Value (BV)

It is usually determined in non-ruminants as follows;

Apparent BV

$$BV = \frac{\text{Nitrogen intake} - (\text{Fecal } N_2 + \text{urinary } N_2)}{N_2 \text{ intake} - \text{Fecal } N_2} \times 100$$

$$BV = \frac{\text{Retained N2}}{\text{Absorbed N2}} \times 100$$

True BV

$$BV = 100 \times \frac{N_2 \text{ intake} - (\text{Fecal } N_2 - MFN) - (\text{Urinary } N_2 - EUN)}{N_2 \text{ intake} - (\text{Fecal } N_2 - MFN)}$$

Whereas; MFN = Metabolic Fecal Nitrogen, EUN = Endogenous Urinary nitrogen

EXAMPLE (NUMERICAL)

Data

Feed Consumed Daily	(gm)	= 6.0
N_2 in feed	(%)	= 1.043
Daily N_2 intake	(mg)	= 62.6
Total urine N_2 excreted daily	(mg)	= 32.8
Endogenous Urinary N_2 daily	(mg)	= 22.0
Total N_2 excreted in feces daily	(mg)	= 20.9
Metabolic Fecal N_2 excreted	(mg)	= 10.7

Formula

$$BV = 100 \times \frac{N_2 \text{ intake} - (\text{Fecal } N_2 - MFN) - (\text{Urinary } N_2 - EUN)}{N_2 \text{ intake} - (\text{Fecal } N_2 - MFN)}$$

By putting the values,

$$BV = 100 \times \frac{62.6 - (20.9 - 10.7) - (32.8 - 22.0)}{62.6 - (20.9 - 10.7)} = 79 \text{ Ans.}$$

LECTURE 9

BIOLOGICAL VALUE (BV)

It is the %age of absorbed N_2 retained within the body for maintenance and growth, production, reproduction etc.

A N_2 balance trial is conducted in which N_2 intake and urinary and fecal excretions are measured, and from these observations BV is determined.

BV for Human Food

Animal Source	BV	Protein Source	BV
Whole milk	80	Potato	67
Whole egg	94	Wheat	67
Egg white	83	Oats	65

Higher the adequate and proportionate of essential amino acid in the diet ---- Higher will be the BV and vice verse in other case.

Increased BV ---- Better protein source

Decreased BV ---- Poor protein source

BV value depends upon the quality, quantity and proportion of essential amino acids. For example, in maize, methionine is less and lysine is more while in Soyabean, methionine is more but other amino acid contents are low. Thus their BV is very low.

Animal protein always have higher BV than that of vegetable protein due to reason that animal protein are composed of well distributed essential amino acids and secondly they are in right amount and proportion, required for the animal growth and production etc.

Merit

It is the best parameter for determining the protein quality

Disadvantages/Limitations

1. Not applicable for ruminants because of presence of microbes in the rumen and these microbes have ability to synthesize amino acids from a variety of N_2 compounds.

2. BV may judge protein quality to combine functions such as growth, maintenance and production etc. but not for a single one.

LECTURE 9

3. There is a difficulty in measuring the endogenous nitrogen fractions. Especially in the poultry, it is more difficult where they excrete urine and feces together.

4. The BV determinate at a specific level of protein (N) intake may not apply on a feed having different levels of protein (N).

5. Adequate non-nitrogenous sources to provide energy and also of minerals and vitamins should be present in all test diets.

METHODS TO EVALUATE PROTEIN QUALITY

1. Net Protein Utilization (NPU)

It is the %age of dietary protein which is converted into body protein.

Formula:

$$NPU = \frac{\text{Retained } N_2}{\text{Intake } N_2} \times 100 \quad \text{--->} \quad \frac{\text{Retained protein}}{\text{Intake protein}} \times 100$$

Nitrogen retention may be estimated by carcass analysis such as;

NPU = BV x digestibility

It is limited to those animals that can only use for carcass analysis.

Although it is not laborious

2. Nitrogen Balance (NB)

NB technique is mostly conducted to determine protein quality in ruminants and some time in non-ruminants as well. In this, required parameters are "total intake of N_2 and total out take of N_2".

LECTURE 11

3. Nitrogen Balance Index (NBI)

It accounts the same data on intake and out go of N_2, as used in determination of BV.

It can be calculated by the following equation;

$$NBI = \frac{B - B}{A}$$

Whereas: B = Nitrogen balance
B = Nitrogen balance when N_2 intake is zero.
A = Absorbed N_2

5. Net Protein Ratio (NPR)

Net protein Ratio indicates the weight gain of a group of animals fed on test diet (containing protein) plus the weight loss of a similar group fed on a protein free diet, the total divided by the weight of protein consumed by the first group.

→ Weight loss occurs due to feeding of protein free diet.

→ It is applied specifically on the non-ruminants.

It can be calculated as;

$$\text{NPR} = \frac{\text{weight gain + weight loss}}{\text{weight of protein intake}}$$

6. Evaluation of Protein Quality from Amino Acid Profile

It is also known as EAAI (Essential amino acid index)

There are two types of dietary amino acids;

i) Dietary essential a.a. ii) Non-dietary essential a.a.

In Soyabean, a.a. profile required by bird is very good but overall, vegetable source are quite poor protein source due to imbalance a.a. profile.

7. Protein Digestibility

It is of great important in ruminants. How much will bypass and how much will be degraded at ruminal level. In high yielding animals, bypass proteins are mostly used. As single cell protein quality is not better than the bypass protein.

Less degradability ----- means high protein quality and vice versa.

8. Urea Fermentation Potential

This technique is used the potential of animal to utilize urea. Fermentation potential is higher in ruminants particularly in buffalo and cattle. Urea is a cheaper source of N_2 required for microbes multiplication/ to enhance biomass in the rumen.

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