CHAPTER 5

Measurement of feed and nutrient utilization
• Understanding of nutrient utilization are necessary in evaluating feedstuffs
• Nutrient utilization from a given feedstuff is affected by animal species, age, physiological state, type of GI tract, level of consumption, feed physical form (pellet, ground), disease, parasites, balance of nutrients within the feedstuff.
• The utilization of protein from alfalfa for a young, growing pig, the value will be different from that for a sow.
• Methods: similar for all animal species
  • growth trial
  • digestion trial
  • balance trial
Growth trial

- Growth: increase in body weight resulting from assimilation by body tissues (increase in weight, height, skeletal size) of ingested nutrients.
- Expressed as the increase in absolute weight in a given period or as the increase in relative weight (as a %)
• Growth trial involve *ad libitum* feeding of experiment diet, then measure:
  1. weight gain
  2. total feed consumption (intake)
  3. feed efficiency (feed per gain, or gain per feed)

• meaning of feed efficiency:
  animal utilize less of the total feed consumption for maintenance and more is available for gain.
Pair feeding design

- pair1  A and B (comparable size and equal intake)
- pair2  C and D (comparable size and equal intake)
- Rule out the variation such as physical characteristics of the diet, nutrient content, or palatability
Advantage of growth trial:

1. large amount of data
2. can be maintained in condition similar to normal environment
3. easily measure
4. the result are a reflection of fundamental biological response.
Disadvantage of growth trial:

1. more variable
2. rate of gain affected by many different factors for large numbers of animals. (require 12 – 15 animals per treatment)
3. body weight include tissue mass, water, ingesta, so depending on variation in ingesta mass, time of feed defecation or urination, and interval after ingestion of feed or water.
Digestion trial:

(一) Conventional method:
- Preliminary period of 3~10 days to void the GI tract of residues of pretest feed.
- Collection period of 4~10 days.
- 4~6 animals per treatment
- Excreta include feed residue, endogenous source, such as digestive secretion (enzyme), sloughing mucosal cell.
Apparent digestibility ( %)

\[ \text{Apparent digestibility} = \left( \frac{\text{Nutrient intake} - \text{Nutrient in feces}}{\text{Nutrient intake}} \right) \times 100\% \]
(二) Indicator methods:

- **Internal indicator**: nonabsorbable, nontoxic indigestible, and easily analyzed in feed and feces such as lignin.
- **External indicator**: chemicals, such as chromic oxide ($\text{Cr}_2\text{O}_3$)

**Apparent dig (%)**

$$= 100 - (100 \times \frac{\% \text{ ind.}_{fd}}{\% \text{ ind.}_{fc}} \times \frac{\% \text{ nutr.}_{fc}}{\% \text{ nutr.}_{fd}})$$


- Provide estimate without collection of total feces and feed intake.
(三) Digestibility by difference for ruminant trial

- Protein supplement or feedstuff never used as a complete diet by themselves, must mix with other feed (grass)
- Fed a basal diet and the basal diet plus the test feed at one or more levels

\[
D_T(\%) = \frac{D_{T+B}(\%) - D_B(\%)(N_{B+T})}{N_T \times N_{B+T}}
\]

- \(D =\) digestibility, \(T =\) test feed, \(N =\) fraction of nutrient, \(B =\) basal diet
• Associative effects
• The digestibility of diet with mixture of feedstuffs do not predicted from digestibility values of the individual components of the mixture
Apparent vs. true dig.

- Fecal N = **exogenous N + endogenous N**
  - (fecal metabolic N)
- Fecal metabolic N = sloughed intestinal cells and digestive enzyme
- True dig. of N
  - \( = (\text{intake N} - (\text{N in feces} - \text{endogenous N})) \div \text{intake N} \times 100\% \)
- Apparent dig. of protein is influenced by the level of protein in feed.
- True dig. of protein remain the same for animals fed both a low and high level of protein.
The **method** used to estimate endogenous excretion of nitrogen.

1. feeding a nitrogen free diet.
2. feeding several levels of the nitrogen and calculating the fecal level by regression analysis to a zero intake of the nutrient.
3. feeding a completely digestible protein (casein).
• Ileal end digestibility = measure digestibility at the end of ileum rather than in the feces because protein and amino acid will be synthesized or degraded in the large intestine. A more accurate value for digestibility of amino acid.
Balance trial

1. Providing information on utilization of nutrients after absorption.

2. To get a measure of total intake and excretion to determine whether there is a net retention (positive balance) or loss (negative balance) of the nutrient.

3. Collect feces, urine, sloughed skin, shed hair (feather), sweat, expired gases (CO$_2$), and energy lost.
Purified diet

• Minimizes the presence of unknown constituents present in natural feedstuffs that might affect the utilization of or requirement for the nutrients.
• nutrient supplied from purified form glucose, starch, cellulose, casein.
Rumen digestion techniques

(—) In vitro

1. Batch trials
   rumen-fistulated animal
   → rumen fluid (removed particles)
   → test sample
   → 39°C fermentation 24-48hr
   → analyses of residue (only for forage).

2. Continuous fermenters
   continue feed input and rumen outflow for a period of days or weeks.
(二) Nylon bag technique
    feedstuff placed in a nylon bag
    → suspended in the rumen (by rumen fistula)
    → remove bags after a determined time
    → determine the loss of material in the bag
Factors affect the digestibility and absorption of nutrients

Biological availability of nutrients is not fixed at a constant value. Affected by:

1. Feed intake:
   increase feed intake above maintenance tend to depress digestibility.

2. Rapid passage:
   Less time for microbial or enzymatic activity on the digesta.

3. Other factors:
   Disease, sex, age, stomach capacity, eating rate, amount eaten,
Laboratory animal as model farm animals and human

1. mice, rat, hamster, guinea pig, rabbit and other avian-Japanese quail; pig → human.
2. Shorter life cycle, several generation a year.
3. The National Research Council (NRC) publishes the nutritive requirements of laboratory and farm animal (Appendix Table 1)