What is a Ration?

- **A RATION** is the amount of feed an animal receives in a 24-hour period.
- **A BALANCED RATION** is the amount of feed that will supply the proper amount and proportions of nutrients needed for an animal to perform a specific purpose such as growth, maintenance, gestation, lactation, or laying.
Problems of Animal Feed in Indonesia

- **Poultry Feed:**
  - Poultry animal feedstuffs are still largely imported, therefore the price is expensive.
  - Availability of local feed ingredients fluctuated and the quality varies. Quality Control are very important.

- **Ruminant Feed:**
  - Forage availability is fluctuate, especially during the dry season.
  - Use of concentrates to overcome forage quality, but low-quality concentrate

Computer Formulation of Feed

- **Least-cost feed formulation:** A feed formula that is both nutritionally-complete (within limits) and with a minimum ingredient cost (within limits)

- **Now-a-days is developed and completed through the use of computers using linear-programming software**

- **Typical packages:** WinFeed, Brill, Format, BestMix, etc

- **Used by most feed mills/manufacturers**
A systematic approach on Ration Formulation

- **Determine the nutrient requirements** of the animal being fed. This means determining the sex, size and production level of the animal. With this information, nutrient requirements are available from a table.

- **Determine the feeds available for use.** List their composition on a dry matter basis from a composition table or a chemical analysis and check the price.

- Now **the amounts of the feeds necessary** to balance the ration can be determined (feed limitation).

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Least-Cost Feed Formulation

- Combining many feed ingredients in a certain proportion to provide the target animal with a balanced nutritional feed at the least possible cost.

- Least-cost feed formulations require that the following information be provided:
  1. Cost of feed ingredients
  2. Nutrient content of feed ingredients
  3. Nutrition requirement of the animal
  4. Availability of the nutrient to the animal
  5. Minimum-maximum restrictions on levels
Type ration (depending on the type of animal, age, weight, production, etc.)
- Beef cattle: calf, growing, fattening
- Dairy cattle: calf, growing, lactation, dry cattle
- Broiler: starter, growing, finishing
- Layer: starter, growing, laying

Feed ingredients (nutritional composition, the content of anti nutrients and limit the use of feed materials).

Prices of feed materials (Quadrant Price Method)
- Prices in DM and the price per unit of nutrient

Nutrient Requirement

- Basic living requirement (maintenance), namely the need for animals to basic activities (breathing, circulation base, maintaining body temperature) with no change in body weight
- Production requirement (production) such as for meat, milk, eggs, etc.
Nutrient

- Energy
- Protein
- Mineral
- Vitamin
- Fatty Acids
- Water

Partisi Energi

- **GE (Gross Eenergy)**
  - Feces Energy
- **DE (Digestible Energy)**
  - Urine Energy (+ ruminally fermentation gas)
- **ME (Metabolizable Energy)**
  - Heat Increment, loose lost in the form of heat or used by the body
- **NE (Netto Energy)**
  - Maintenance (NEm) (basal metabolism, basic activity, keep body temperature)
  - Production (NEp) (growth, milk, egg, feather, energy etc)
Carbohydrate

- Carbohydrate is the main component of feed: starch, cellulose, hemicellulose, glucose.
- Cellulose, hemicellulose is a source of energy for ruminant, but difficult to digest for ruminants

Protein and Amino Acids

- As a component of the body, tissue development, immune system, control the chemical reactions of the body
- There are 22 amino acids, but only eight essential.
- In the poultry ration formulation, CP requirement based on the requirement of AA
- In ruminants, the requirement of CP depends on degradation in rumen into ammonia (rumen degradable protein DP and rumen ungradable)
**Relationship of Amino Acids**

- Methionine + Cystin
- Penilalanine + Tyrosin
- Glycin + Serin
- Niacin can be synthesis from Tryptophan
- Need AA balance

**AA Synthetic**

- Such as:
  - L-Lysin
  - DL-Methionin
- Depend on:
  - Digestible AA requirements
  - Price
  - AA digestibility
Lipids

- As a source of energy (2.25 x carbohydrate) is used as the cell membrane, regulation in cells, the brain function, structures are at the body, reproductive and nervous systems.
- In the poultry, unit ME (Metabolizable Energy)
- Increase the net energy production (low heat increment)
- Sources of essential fatty acids
- The use of too high in the ration causes easy rancid (oxidation)

Mineral

- Macro:
  - Ca, P, Mg, K, Na, S, Cl

- Micro (trace)
  - Co, Cu, I, Fe, Mn, Se, Zn
### Vitamin

- **Fat soluble vitamin:**
  - Vit A, Vit D, Vit E and Vit K

- **Water soluble vitamin:**
  - Vit B and Vit C

### NUTRIENT STANDARD

- NRC (US), ARC (UK)
- University
- Research institutions
- The government (Directorate General of Livestock)
- The Livestock Industry (Rhone Poulenc, Novus, de Gussa)
- Association (ASA)
National Research Council

- NRC for Poultry (1994)
- NRC for Beef Cattle (2000)
- NRC for Dairy Cattle (2001)
- NRC for Goat (1981)
- NRC for Sheep (1985)
- NRC for Swine (1998)
- NRC for Fish (1993)
- NRC for Laboratory Animals (1995)
- NRC for Primate

Nutrient Requirement for Calf (NRC)

- Depending on:
  - Breed
  - Birth weight, Body Weight
  - Body weight gain
  - Dry matter intake

- NEM
- NEG
- TDN
- Crude Protein (UIP, DIP)
Nutrient Requirement for Dairy Cow (NRC)

- Lactase, depend on:
  - Breed
  - Body weight
  - Milk production
  - Quality Milk (fat, protein)
  - Dry matter intake
  - NEL
  - TDN
  - Crude Protein (UIP, DIP)

Nutrient Requirement for Beef Cattle (NRC)

- Growing and Finishing Cattle
- Growing Bulls
- Pregnant Replacement Heifers
- Beef Cows

**Nutrient:**
- NEm
- NEg
- MP
- Ca
- P
Feedstuffs

- Concentrate
- Forage
- Feed supplement
- Additive

Concentrate

- As a source of energy or protein
- The use of concentrates in the diet depends on:
  - The composition of nutrients, such as PK, AA, EM, TDN
  - Palatability
  - Processing
  - Contamination
  - Storage
Forage

- As the main energy source for ruminants
- Consists of grasses and legumes
- Forage quality depends on:
  - Age harvesting
  - Soil fertility
  - Palatability
  - Varieties
  - Bulkiness (fiber)
  - Anti Nutrition (sapinin, tannin, HCN)

Supplement

- Needed in small amounts to increase the nutrients in the ration
- It is usually a micro nutrients (minerals, vitamins, AA)
- Given in the form Premix
Feed Additive

- Feed additive is not a nutrient
- Added in the ration to improve or maintain the quality of rations.
- Example: probiotic, prebiotic, enzyme, hormone (?), anti-fungal, antioxidants, etc.

Ration of Poultry

- Corn-Soybean based ration
  - Corn = as main energy source
  - Soybean meal = as main protein source
- Main feed ingredients:
  - Corn, Soybean meal, rice bran, fish meal, corn gluten meal (CGM), meat bone meal (MBM), crude palm oil, (CPO) mineral, amino acids
Ration of Dairy Cattle

- Forage as the main energy source
- Concentrate: rice bran, cassava, coconut cake, copra oil, pulp, molasses, minerals, etc.
- Ratio of Forage : Concentrate (50:50)

Ration of Beef Cattle

- Beef cattle feedlots use higher concentrations of forage
- Concentrate material: rice bran, cassava, coconut cake, palm cake meal, tofu waste, molasses, minerals, etc.
- Ratio Forage : Concentrate (30:70)
RATION FORMULATION METHODS

- Square (Pearson) Method
- Simultaneous Equation Method
- Matrix Method
- Trial and Error Method
- Computer Method (Linear Programming)

Square Method

Example:
Ration contain CP 20 %, from SBM and Corn

SBM (45%)

Corn (10%)

20%

10 Unit (10/35) = 28.6%

25 Unit (25/35) = 71.4%
Simultaneous Equ. Method

*Use mathematical equations*

- If $X =$ used corn and $Y =$ used SBM, then the nutrient requirement can be calculate with this equation $18 = 0.10X + 0.45Y$; and if $X + Y = 100$, then both equations can be used to calculate the level of $X$ and $Y$.

\[
0.10X + 0.45Y = 20
\]
\[
0.10X + 0.10Y = 10 \quad \text{from} \quad (X + Y = 100)/0.10
\]
\[
0 + 0.35Y = 10
\]

then $Y = (10/0.35) = 28.6%$; \hspace{1cm} SBM = 28.6%

$X = 100 - 28.6 = 71.4%$; \hspace{1cm} Corn = 71.4%

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Matrix Method

*similar with Simultaneous Method*

\[
a_1X + b_1Y = C_1
\]
\[
a_2X + b_2Y = C_2
\]

\[
\begin{bmatrix}
a_1 & b_1 \\
a_2 & b_2
\end{bmatrix}
\begin{bmatrix}
X \\
Y
\end{bmatrix}
= \begin{bmatrix}
c_1 \\
c_2
\end{bmatrix}
\]

\[
X = (c_1 b_2 - c_2 b_1) / (a_1 b_2 - a_2 b_1)
\]

\[
Y = (c_1 c_2 - a_2 c_1) / (a_1 b_2 - a_2 b_1)
\]
Trial and Error Method

- Requires experience
- Done by trial and error
- Do not pay attention to the price of feed/ration
- Trial and Error method can use Excel

Computer Method

- Based on Linear Program
- Least Cost Ration
- LP, QM, Lindo, Excel Solver.
- Feed formulation programs: Mixit, Spartan, FeedMania, UFFDA, WinFeed, FeedLive, Bestmix, Feedsoft, Brill, Format, etc.
Linear Programming

- Linear Programming (LP) is a technique for optimization of a linear objective function, subject to linear equality and linear inequality constraints. Informally LP determines the way to achieve the best outcome (such as maximum profit or lowest cost).
- Developed by George B. Dantzing, published the simplex method in 1947.

Mathematic model of LP

- **Minimize** \( c_1x_1 + c_2x_2 + c_3x_3 + \ldots + c_jx_j \)
- **Constraints**
  - \( a_{i1}x_1 + a_{i2}x_2 + a_{i3}x_3 + \ldots + a_{ij}x_j \geq b_i \)
  - \( a_{i2}x_1 + a_{i2}x_2 + a_{i3}x_3 + \ldots + a_{ii}x_i \geq b_2 \)
  - \( \ldots \)
  - \( a_{i3}x_1 + a_{i3}x_2 + a_{i3}x_3 + \ldots + a_{ij}x_j \geq b_i \)
  - \( x_1 + x_2 + x_3 + \ldots + x_j = 1 \)
- **Assume:**
  - \( x_1, x_2, x_3, \ldots, x_j \geq 0 \)

- \( c_i \) = ingredient prices
- \( x_i \) = use of ingredients
- \( a_{ij} \) = nutrient contents
- \( b_i \) = nutrient requirements
Ration Formulation using Excel Solver

- The objective function
- The decision variables
- The constraints

Ration Formulation using QM

- No simple
- Need to entry feed database
WinFeed

- Developed by University of Cambridge UK
- Useful for ruminants, poultry, pets, fish, etc.
- Simple and user friendly
- Compatible for Window 98, 2000, XP, Vista
- www.winfeed.com

FeedLive

- Developed by Feed Live Informatics Company, Nothaburi, Thailand
- Useful for monogastric and ruminant animals
- Simple and user friendly
- Compatible for Window 98, 2000, XP.
- www.feedliveinformatics.com
**Feedsoft**

- Developed by Feedsoft Corporation, USA
- Useful for monogastric and ruminant animals
- Supports for client and plants
- Support multi blending
- Compatible for Windows 98, 2000, XP.
- [www.feedsoft.com](http://www.feedsoft.com)

**Brill Feed Formulation**

- Developed by Feed Management System Inc., USA.
- Advance feed formulation software
- Useful for monogastric and ruminants
- Minimize cost of a formula, multiple formulas in multiple feedmills (multi blending)
- Compatible for Windows
- [www.feedsys.com](http://www.feedsys.com)
Summary

- LP is the basis for the formulation of livestock rations
- All ration formulation software does not pay attention to the performance of livestock
- Nutritionist responsible for the quality of rations

Thank You