In animal production, feed has important role. Feed cost is as major variable cost (60-80%) in animal production. Therefore, the ration formulation is very important as major contribution on farmer’s profit. To formulate a Least-Cost Ration need computer to running a ration formulation program.
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
- Use Linear Programming
- Need computer program

RATION FORMULATION

- Animal nutrient requirement (depend on type, age, sex, weight, production, etc)
- Feed ingredient and composition
- Limitation of feedstuff usage
  - Nutrient content
  - Antinutrient content
- Ingredient price
  - Price in nutrient unit
Nutrient Requirements

- Maintenance (nutrient for basic activities (breath, blood flow, low activities) without body weight change
- Production (milk, meat, egg, wool, reproduction, etc.)

Nutrient Standard

- As some nutrients which need by the animal for maintenance and production purposes such as for growth, fattening, egg production, lactation, reproduction etc.
Nutrient

- Energy
- Protein (Amino Acids)
- Vitamin
- Mineral
- Fatty Acids
- Water

Energy Utilization in Poultry

- RATION 4000 kkal
- Heat Increment 600 kkal
- Maintenance 1500 kkal
- EGG 800 kkal
- FAESSES 800 kkal
- URINE 300 kkal
Protein and Amino Acids

- Principal body component, tissue development, immune system, controlling body chemical reaction.
- There are 22 amino acids, but 8 essential.
- In poultry the CP level based on the AA requirement
- In ruminant, CP is degraded in rumen into amonia (RDP and RUP)

Relationship between AA

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

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

Fat

- As energy source (2.25 x carbohydrate), cell membrane, process regulation in cell, improvement brain structure, nerve and reproduction system
- ME value varies
- Increase net energy production (low heat increment)
- As essential fatty acids sources
**Charbohydrate**

- Consist of carbon atom, hydrogen dan oxygen; the major part feed; provide fiber component (cellulose, hemicellulose), glucose, starch.
- Cellulose, hemicellulose, pentosan dan oligosacharide difficult to digest in monogastric.

**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

**Sources of Nutrient Req Standard**

- NRC (US), ARC (UK)
- University
- Government (Dirjen Peternakan)
- Commercial Industry (Rhone Poulenc, Novus, de Gussa)
- Association (ASA)
- Research
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 Primat

>> NRC for Poultry

- Broiler
- Layer
- Turkey
- Gees
- Duck
- Quail
>> NRC for Beef Cattle

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

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

>> NRC for Dairy Cattle

- Cows
  - small (450kg) and large (680 kg) breed;
  - early and midlactation
- Heifers: small (450kg) and large (680 kg) breed
- Calves: young, calves, weaned

**Nutrient:**
- NE$_I$
- RDP
- RUP
- CP
- Ca
- P
Feedstuffs

- Concentrate
- Roughage
- Feed Supplement
- Additive

Concentrate

- As energy and protein sources
- Use of concentrate depend on:
  - Processing
  - Palatability
  - Amino acid composition
  - Contamination
  - Storage
**Roughages**

- Important as energy source in ruminant

- Quality of roughages depend on:
  - Harvesting
  - Soil fertility
  - Palatability
  - Variety
  - Bulkiness
  - Laxativeness effect

**Supplement**

- Need in small amount for enrichment of nutrient

- As micro nutrient sources (mineral and vitamin) or AA syntetis

- Composited in Premix
Feed Additive

- Non nutrient
- Probiotic, enzyme, hormon, anti mould, etc.)

Poultry Ration
Dairy Ration

Energy sources: 50%
Protein sources: 20%
Others: 5%
Forage: 25%
Others: 20%

RATION FORMULATION METHODS

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

Formulate a ration (CP 20%) from Soybean Meal (SBM) and Corn

SBM (45%) \[ \rightarrow \] 10 Unit (10/35) = 28.6%

Corn (10%) \[ \rightarrow \] 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 \( 0.10X + 0.45Y \); and if \( X + Y = 100 \), then both equations can be used to calculate the level of \( X \) and \( Y \).

\[
\begin{align*}
0.10X + 0.45Y &= 20 \\
0.10X + 0.10Y &= 10 & \text{from } (X + Y = 100)/0.10 \\
0.35Y &= 10 \\
Y &= (10/0.35) = 28.6%; \quad \text{SBM} = 28.6% \\
X &= 100 - 28.6 = 71.4%; \quad \text{Corn} = 71.4%
\end{align*}
\]
Matrix Method

*Similar with Simultaneous Method*

\[
\begin{align*}
\begin{bmatrix} a_1 & b_1 \\ a_2 & b_2 \end{bmatrix} \begin{bmatrix} X \\ Y \end{bmatrix} &= \begin{bmatrix} c_1 \\ c_2 \end{bmatrix} \\
X &= \frac{(c_1 b_2 - c_2 b_1)}{(a_1 b_2 - a_2 b_1)} \\
Y &= \frac{(c_1 c_2 - a_2 c_1)}{(a_1 b_2 - a_2 b_1)}
\end{align*}
\]

Trial and Error Method

- Need experiences
- No consider lowest cost
- Trial and Error method can use Microsoft Excel Spreadsheet
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, 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**
  - \( a_{11}x_1 + a_{21}x_2 + a_{31}x_3 + \ldots + a_{ij}x_j \geq b_1 \)
  - \( a_{12}x_1 + a_{22}x_2 + a_{32}x_3 + \ldots + a_{ij}x_j \geq b_2 \)
  - \ldots \)
  - \( a_{i2}x_1 + a_{i3}x_2 + a_{i4}x_3 + \ldots + a_{ij}x_j \geq b_i \)
  - \( x_1 + x_2 + x_3 + \ldots + x_j = 1 \)

- **Assume:**
  - \( x_1, x_2, x_3, \ldots, x_j \geq 0 \)

- **Ration Formulation using Excel Solver**

  - The objective function
  - The decision variables
  - The constraints
Ration Formulation using QM

- No simple
- Need to entry feed database

Feed Mania

- Developed by Mania Software Ltd.
- Simple
- Stand-alone DOS program
UFFDA

- Developed by G.M. Pesti and BM Miller
- Stand-alone DOS program
- www.poultry.uga.edu/poultrysoftware.htm

WinFeed

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

- Developed by Feed Live Informatics Company, Nonthaburi, Thailand
- Useful for monogastric and ruminant animals
- Simple and user friendly
- Compatible for Windows 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
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 MS Window
- www.feedsys.com

Conclusions

- Feed formulation software use LP as basic analysis
- All softwares do not consider animal performance
- Animal nutritionist is responsible for the best result of the formula