Fish Feed Technology

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Diet formulation1

1- التجربة والخطاء
Trial and Error

2- مربع بيرسون
Trial and Error

3- البرمجة الخطية
Linear Programming

4- معادلات جبرية
Algebraic diet formulation

5- افضل شراء
Best-Buy Ingredients

6- معادلات أنية
Simultaneous Equations

7- برنامج اكسل
Excel diet formulation

Step 1: Make a list of the ingredients with their nutrient compositions available for possible inclusion in the ration to be formulated
Step 2: Fix the requirements of the ration to be composed
Step 3: Proceed to balance the ration as follows:

Step 3.1 : Reserve 2% for minerals / vitamins.

 Step 3.2 : Include ingredients a certain minimum percentage of which needs to be incorporated for various reasons.

 Step 3.3 : Include ingredients with an energy value higher than that required in the ration to constitute 30%. Here, priority should be given to those ingredients with the lowest price per unit of energy. You should, however, be careful not to exceed the safe maximum levels for the ingredients.

 Step 3.4 : Include ingredients with protein contents higher than the required level in the ration you want to prepare. To start with, limit the level of inclusion of such ingredients to 18%. Here, again, priority should be given to those ingredients with the lowest price per unit of protein without exceeding the safe maximum levels.

 Step 3.5 : Now, add the percentage and quantities of the various nutrients and compare the nutrient quantities with requirements of the target class of animal.

 Step 3.6 : Select an ingredient that is a good source of the nutrient (energy, protein) missing the most. The selected ingredient is included to constitute 10% of the final ration. Continue to do the same until you reach 100% by repeating step 3.5 after every addition.

 Step 3.7 : It may be necessary to substitute some ingredients by others in order to obtain proper levels and ratios of the required nutrients. This is usually done when proceeding from 90 to 100%.

Total Digestible Nutrients (TDN)

1- قائمة بالمواد الأولية وتركيبها

- Dry matter (%);
- Energy content
- Protein (Crude or Digestible-in %);
- Price/quintal;
- Price/unit of energy;
- Price/unit of Protein;
- Safe maximum percentage;
- Absolute maximum percentage

2- تثبيت الاحتياجات

- Acceptable range for TDN considering price per unit of TDN (another measure of energy e.g. ME may be used).

This gives the opportunity to select feeds that are cheaper sources of energy.

- Range of acceptable crude protein or digestible protein values (maximum and minimum) and price per unit of protein, etc.

Feed Formulation Calculations

.1. Best-Buy Ingredients

Aside from the other limitations, ingredients should be selected in a formulation on the basis of value. If several fish meals are available and suitable for use in a formulation, and the fish meals are equal in protein content and protein availability, the decision about which to select is simple: choose the least expensive. If, however, the meals differ in protein content or protein availability and price, calculations are required to determine which is the best value. For example, suppose that one wants to choose between white fish meal having a protein content of 64% and costing $425 per metric ton (mt) and anchovy meal having a protein content of 69% and costing $450 per mt. To compare the two meals, compute the cost per kilogram protein as follows.

$$(1)\ \text{White fish meal: } \frac{\$425/\text{mt}}{640\ \text{kg protein/mt}} = \$0.664/\text{kg protein.}$$

$$(2)\ \text{Anchovy meal: } \frac{\$450/\text{mt}}{690\ \text{kg protein/mt}} = \$0.652/\text{kg protein.}$$

Feed Formulation Calculations

The results of this example show that anchovy meal, although it is more expensive per metric ton, is the best value, since the cost per kilogram protein is lower than that of white fish meal.
Often protein supplements are compared on the basis of cost per unit protein, or “protein unit.” This simple calculation is made by dividing the price per metric ton by the percentage protein in the product. Some examples follow:

(1) White fish meal: $\frac{\$425/\text{mt}}{64} = \$6.64$ per protein unit.

(2) Anchovy meal: $\frac{\$450/\text{mt}}{69} = \$6.52$ per protein unit.

(3) Herring meal: $\frac{\$500/\text{mt}}{72} = \$6.94$ per protein unit.

(4) Meat and bone meal: $\frac{\$204/\text{mt}}{50} = \$4.08$ per protein unit.

Feed Formulation Calculations

Anchovy meal is the best value among the fish meals listed in the examples above, at least based on the price per protein unit. Meat and bone meal is the best value on a protein unit basis. Comparing ingredients in this fashion is valuable, but it does not take into consideration the quality of the protein, which is determined by its amino acid content and the apparent digestibility of protein and amino acids. This process of comparing feed ingredients on the basis of cost per unit nutrient can be applied to any nutrient and to the energy content. For example, suppose that one wishes to determine if it is less expensive to add dl-lysine or increase the level of fish meal in a feed formulation to increase the lysine content. One approach is to calculate the cost of lysine in each product as follows.

At these prices, it would be less expensive to add dl-lysine than to increase the level of herring meal in the formulation to satisfy the dietary lysine requirement of the fish.

(1) DL-Lysine costs U.S. $3.90 per kg and contains 98% DL-lysine, or 49% L-lysine. The cost per unit is

$$\frac{\$3900/\text{mt}}{49} = \text{U.S. } \$79.59 \text{ per unit lysine}$$

(2) Herring meal costs U.S. $500/mt and contains 5.36% lysine. The cost per unit is

$$\frac{\$500/\text{mt}}{5.36} = \text{U.S. } \$93.28 \text{ per unit lysine}$$

Feed Formulation Calculations

The same calculation can be used to compare the costs of adding energy to a fish feed from various ingredients or to compare the costs of obtaining energy from dietary protein or lipid. For example, if herring meal costs U.S. $500/mt and contains 4717 kcal of digestible energy (DE)/kg, the cost per 1000 kcal is U.S. $0.106. Although fish oil contains more calories per gram than protein, the exact amount that is available to fish is uncertain. A close estimate based on the fat digestibility values of 90% given by Halver and Shanks (1969) is 8000–8100 kcal DE/kg. Using a value of 8000 kcal/kg, one can calculate the price below which fish oil must sell to warrant replacing herring meal with fish oil as an energy source.

(1) The price per 1000 kcal DE for herring meal is U.S. $0.106.

(2) The DE content of fish oil is 8000 kcal/kg, so $(0.106) × (8000) = 0.848/kg or $848/mt.

This is the price one could afford to pay for fish oil to provide energy to the fish diet equivalent to the cost of energy from herring meal. If the price of fish meal increases, the cost advantage of providing dietary energy from fish oil increases.

2. Simultaneous Equations for Solving Least-Cost Analysis

Simultaneous equations can be used to solve simple feed formulations once the ingredients have been chosen. An experienced formulator can produce a very good formulation in a short time by substitution and recalculation.

The process of formulating a fish feed is divided into several steps

1- The first step is to define the nutrient levels desired in the feed (Table 1). In the example, we wish to formulate a feed containing 45% protein and 4000 kcal of digestible energy per kilogram of feed.

Nutrient Levels Desired in Feed

Feed (kg)	Protein (kg)	Digestible energy (kcal)
100	45.0	400,000 (4000/kg feed)

Feed Formulation Calculations

2- The second step in the formulation process is to choose ingredients and to list the protein and digestible energy content of each (Table 2).

Table 2

Composition of Dietary Ingredients on a Dry Matter Basis

Ingredient	Protein (%)	Digestible energy (kcal/kg)
Fish meal (herring)	70.0	4490
Poultry by-product meal	58.0	3320
Soybean meal	48.0	3224
Wheat middlings	17.0	1672
Fish oil	—	9000
Vitamin premix	—	—
Mineral premix	—	—
Choline chloride	—	—
Ascorbic acid	—	—