Fish Feed Technology

PhD. student

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Diet formulation 2

Feed Formulation Calculations

3- The third step is to list the ingredients which will be in the feed formulation at fixed levels and to calculate the contribution of each ingredient to the total desired levels of protein and digestible energy in the feed (Table.3). These values are then added, and the totals subtracted from the desired levels in the finished feed. In the example, the levels of soybean meal, poultry by-product meal, and vitamin and mineral supplements are fixed, while the levels of fish meal , wheat middlings, and fish oil in the formulation are variable.

Table 3

Contribution of Fixed Ingredients to Nutrient Content of Final Formulation

Ingredient	Percentage	Protein (kg)	Digestible energy (kcal/kg)
Poultry by-product meal	10	5.8	33,200
Soybean meal	10	4.8	32,240
Vitamin premix	2.0	—	—
Mineral premix	0.1	—	—
Choline chloride	0.5	—	—
Ascorbic acid	0.1	—	—
Total of fixed ingredients	22.7	10.6	65,440
Amount needed from ingredients	77.3	34.4	334,560

fixed

100 – 22.7 = 77.3

From Table 1

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

Feed Formulation Calculations

4- The fourth step is to determine the appropriate levels of the various ingredients in the formulation using simultaneous equations (Table 4).

The solution of the simultaneous equations yields the following:

fish meal, 43.7 kg/100 kg feed;

wheat middlings, 22.4 kg/100 kg feed;

fish oil, 11.22 kg/100 kg feed.

(1) WM + FM + FO = 77.3 kg feed

(2) 1672 WM + 4490 FM + 9000 FO = 334,560 kcal DE

(3) 0.17 WM + 0.70 FM + 0 FO = 34.4 kg protein

Ingredient	Protein (%)	Digestible energy (kcal/kg)
Fish meal (herring)	70.0	4490
Wheat middlings	17.0	1672
Fish oil	—	9000

Table 2

(4) From Eq. (1); let WM = 77.3 – FM – FO

Substitute Eq. (4) into Eqs. (2) and (3) as follows:

(a) 1672 (77.3 – FM – FO) + 4490 FM + 9000 FO = 334,560

(b) 0.17 (77.3 – FM – FO) + 0.70 FM + 0 FO = 34.4

Table 4

Feed Formulation Calculations

(1) WM + FM + FO = 77.3 kg feed
(2) 1672 WM + 4490 FM + 9000 FO = 334,560 kcal DE
(3) 0.17 WM + 0.70 FM + 0 FO = 34.4 kg protein
(4) From Eq. (1); let WM = 77.3 − FM − FO
Substitute Eq. (4) into Eqs. (2) and (3) as follows:
(a) 1672 (77.3 − FM − FO) + 4490 FM + 9000 FO = 334,560
(b) 0.17 (77.3 − FM − FO) + 0.70 FM + 0 FO = 34.4
Solve (a) and (b) to make Eqs. (5) and (6)
(5) 2818 FM + 7328 FO = 205,314.4
(6) 0.53 FM − 0.17 FO = 21.259
From Eq. (5); rearrange to make Eq. (7)
(7) FM = 205,314.4 − 7328 FO/2818 or 72.858 − 2.6 FO
Substitute Eq. (7) into Eq. (6)
(8) 0.53 (72.858 − 2.6 FO) − 0.17 FO = 21.259
Solve Eq. (8) for FO to obtain
FO = 11.2
Substitute 11.2 for FO in Eq. (5)
(9) 2818 FM + 7328 (11.2) = 205,314.4
Solve Eq. (9) for FM to obtain
FM = 43.7
Solve for WM using Eq. (4):
WM = 77.3 − 43.7 − 11.22 = 22.4

Solution:
FM = 43.7 kg/100 kg diet
WM = 22.4 kg/100 kg diet
FO = 11.2 kg/100 kg diet

Simultaneous Equations to Determine Levels of Wheat Middlings (WM), Fish Meal (FM), and Fish Oil (FO) Needed in Formulation

Feed Formulation Calculations

5- The last step is to check the final feed levels of protein and digestible energy to ensure that the desired levels are present (Table 5). The levels of individual essential amino acids can also be calculated at this point to make certain that the levels in the feed meet or exceed the dietary requirements of the fish.

Table 5

Feed Formulation Calculations

Recalculation of Feed Formulation to Check Nutrient Levels

Ingredient	Amount (kg)	Nutrient contribution	
		Protein (kg)	Digestible energy (kcal)
Fish meal	43.7	30.6	196,200
Poultry by-product meal	10	5.8	33,200
Soybean meal	10	4.8	32,240
Wheat middlings	22.4	3.8	37,500
Fish oil	11.2	—	100,800
Vitamin premix	2.0	—	—
Mineral premix	0.1	—	—
Choline chloride	0.5	—	—
Ascorbic acid	0.1	—	—
Total	100	45	399,940
Nutrient Levels Desired in Feed	100	45.0	400,000

Feed Formulation Calculations

Table 4 Simultaneous Equations to Determine Levels of Wheat Middlings (WM), Fish Meal (FM), and Fish Oil (FO) Needed in Formulation

(1) $WM + FM + FO = 77.3$ kg feed

(2) $1672\ WM + 4490\ FM + 9000\ FO = 334{,}560$ kcal DE

(3) $0.17\ WM + 0.70\ FM + 0\ FO = 34.4$ kg protein

(4) From Eq. (1); let $WM = 77.3 - FM - FO$

Substitute Eq. (4) into Eqs. (2) and (3) as follows:

(a) $1672\ (77.3 - FM - FO) + 4490\ FM + 9000\ FO = 334{,}560$

(b) $0.17\ (77.3 - FM - FO) + 0.70\ FM + 0\ FO = 34.4$

Solve (a) and (b) to make Eqs. (5) and (6)

(5) $2818\ FM + 7328\ FO = 205{,}314.4$

(6) $0.53\ FM - 0.17\ FO = 21.259$

- 0.17FM+0.70FM=0.53
- 0.17FO+0 FO=0.17

from Table 2

	Protein (%)	Digestible energy (kcal/kg)
Fish meal (herring)	70.0	4490
Wheat middlings	17.0	1672
Fish oil	—	9000

Feed Formulation Calculations

205314.4/2818=72.858

From Eq. (5); rearrange to make Eq. (7)

(7) $FM = 205{,}314.4 - 7328\,FO/2818 = 72.858 - 2.6\,FO$

7328/2818=2.6

Substitute Eq. (7) into Eq. (6)

(8) $0.53\,(72.858 - 2.6\,FO) - 0.17\,FO = 21.259$

(6) $0.53\,FM - 0.17\,FO = 21.259$

Solve Eq. (8) for FO to obtain

$FO = 11.2$

Substitute 11.2 for FO in Eq. (5)

(9) $2818\,FM + 7328\,(11.2) = 205{,}314.4$

(5) $2818\,FM + 7328\,FO = 205{,}314.4$

Solve Eq. (9) for FM to obtain

$FM = 43.7$

Solve for WM using Eq. (4):

(4) $WM = 77.3 - FM - FO$

$WM = 77.3 - 43.7 - 11.22 = 22.4$

Solution:

$FM = 43.7$ kg/100 kg diet

$WM = 22.4$ kg/100 kg diet

$FO = 11.2$ kg/100 kg diet

Feed Formulation Calculations

The solution of the simultaneous equations yields the following:

Solution:

FM = 43.7 kg/100 kg diet
WM = 22.4 kg/100 kg diet
FO = 11.2 kg/100 kg diet

The last step is to check the final feed levels of protein and digestible energy to ensure that the desired levels are present (Table 5). The levels of individual essential amino acids can also be calculated at this point to make certain that the levels in the feed meet or exceed the dietary requirements of the fish.

Feed Formulation Calculations

Recalculation of Feed Formulation to Check Nutrient Levels

Ingredient	Amount (kg)	Nutrient contribution	
		Protein (kg)	Digestible energy (kcal)
Fish meal	43.7	30.6	196,200
Poultry by-product meal	10	5.8	33,200
Soybean meal	10	4.8	32,240
Wheat middlings	22.4	3.8	37,500
Fish oil	11.2	—	100,800
Vitamin premix	2.0	—	—
Mineral premix	0.1	—	—
Choline chloride	0.5	—	—
Ascorbic acid	0.1	—	—
Total	100	45	**399940**
Nutrient Levels Desired in Feed	100	45.0	400,000 (4000/kg feed)

Feed Formulation Calculations

3. Linear Programming

Computers are used in the feed industry to calculate least-cost formulations. The process by which this is done is called linear programming, which involves the simultaneous solution of a series of linear equations. Linear programming has been used in animal feed formulation for over 40 years and is used almost exclusively in modern feed formulation in agriculture today. In the past, linear programming required access to a mainframe computer and specialized knowledge in mainframe use, i.e., programming ability. While the actual computer time required to arrive at a least-cost formulation was short, the time required for data input and setting up was lengthy. For simple formulations or for small feed manufacturers, hand calculations were often more practical. Today, personal computers can be used to "least-cost" feed formulations.