Fish Feed Technology

PhD. student

Dr.A.Y.Al-Dubakel

Diet formulation 3

Feed Formulation Calculations

Linear programming (LP) is a mathematical procedure by which limited resources are allocated, selected, scheduled, or evaluated to achieve an optimal solution to a particular objective. These resources may be capital, raw material, manpower, or production facilities and the objectives may be minimum cost or maximum profit. Linear programming, therefore, has wide application in industrial operations such as blending, mixing, and machine tooling; and in business activities such as purchasing, planning, bidding, transportation, and distribution.

Linear programming was first introduced to the animal compound feed industry in the mid fifties. Since then, its application in least cost formulation of feed for livestock and poultry has gained widespread acceptance in most countries with well-developed compound feed industries.

Least cost feed formulation for fish on the other hand is a recent innovation. There are still many gaps in our knowledge regarding fish nutrition and digestibility of common feedstuffs by cultured species of fish. Among the few species where such knowledge is more complete, LP techniques for diet formulation have been attempted.

LINEAR PROGRAMMING BASICS

The Linear Equation

Linear programming involves the simultaneous solution of a number of linear equations which consist of a left-hand side (LHS) and a right-hand side (RHS), as follows:

C + C2 + C3.....+Cn = R (1)

Where R is the row variable and C represents a column variable.

In formulating feeds by LP, the nutritionist first lays down a set of constraints. He then lists all available raw materials which he wishes to be considered for selection by the computer to achieve his objective. This objective is a least-cost ration that will satisfy all the constraints.

Feed Formulation Calculations

The LP Matrix

To illustrate the use of the programmer, consider first a single hypothetical feed mix problem: to formulate a catfish diet using limited available feeds tuffs while satisfying nutrient and feed ingredient constraints, as shown in Table.

Ingredient	Cost, $/kg	Protein, %	Digestible energy (DE)	Calcium, %
Maize	2.15	9	1.10	0.02
Fishmeal	8.0	65	3.90	3.7
Soymeal	6.0	44	2.57	0.3
Ricebran	2.0	12	1.99	0.1
Limestone	0.4	0	0	38.0

Feed Formulation Calculations

Constraints:

(1) Total weight of mix = 100 kg

(2) Total protein, at least 30 kg

(3) Total digestible energy, at least 250

(4) Total calcium, at least 0.5 kg

(5) Total calcium, not more than 1.5 kg

(6) Amount of fishmeal, at least 8 kg

(7) Amount of ricebran, not more than 20 kg

(8) The total cost of the blend to be minimal.

Feed Formulation Calculations

Putting this into matrix form:

MAIZE	FISH MEAL	SOY MEAL	RICE BRAN	LIMES TONE	ROW TYPE	VALUE	ROW NAME
-2.15	-8.0	-6.0	-2.0	-0.4			COST
1.0	1.0	1.0	1.0	1.0	=	100	WEIGHT
0.09	0.65	0.44	0.12	0	≥	30	PROTEIN
1.10	3.90	2.57	1.99	0	≥	250	DE
0.000	0.037	0.003	0.001	0.38	≥	0.5	CALCIUM
0.000	0.037	0.003	0.001	0.38	≤	1.5	CALCIUM
	1.0				≥	8	FISHMEAL
			1.0		≤	20	RICEBRAN

Feed Formulation Calculations

Linear programming, applied to least-cost feed analysis, is used to calculate the combination and levels of ingredients that provide the desired nutrient content of the diet at the least cost. To do this, the computer must have access to data on the [1] nutrient content of each potential feed ingredient, which are obtained from feed composition tables or from analyses at the mill itself. The [2] cost of each ingredient must be provided, along with the nutrient [3] specifications of the formulation desired. Ingredient limits, [4] i.e., maximum and minimum levels allowed in the formulation, must be imposed. At this point, the computer is told to begin, and the answer (output) rapidly appears. Outputs vary with different computer software but generally include, in addition to the least-cost formula in which ingredients and levels to add to the mixture are listed, listings of calculated levels of nutrients in the formulation and information on the effects of the restrictions placed on the levels of individual ingredients or desired nutrient levels on the cost of the diet.

Table 1

Feed Formulation Calculations

Diet 1: Least-Cost Formulation and Nutrient Analysis for Salmon Feed[a]

Ingredient	Least-cost formulation[b]		
	Minimum	Actual	Maximum
Fish meal	32.00	32.00	40.00
Corn gluten meal	3.00	3.00	10.00
Meat and bone meal		10.00	10.00
Soybean meal (48 CP)		5.137	20.00
Wheat middlings	5.00	5.00	15.00
Wheat, ground grain	10.00	10.00	
Poultry by-product meal	5.00	17.73	20.00
Fish oil	12.00	15.98	
Ascorbate-2-phosphate	0.10	0.10	0.10
Vitamin premix	0.50	0.50	0.50
Trace mineral premix	0.10	0.01	0.10
Choline chloride	0.35	0.35	0.35
Astaxanthin	0.10	0.10	0.10

Fixed in the formulation

Feed Formulation Calculations

	Nutrient analysis		
	Minimum	Actual	Constraint (decrease)
Crude protein	45.00	45.00	3.024
Crude fat	23.00	23.00	5.477
Crude fiber		2.073	
Phosphorus (total)		1.963	
Phosphorus (available)	0.600	1.332	
Lysine		2.927	
Methionine		1.089	

[a] With minimum dietary protein and lipid set at 45 and 23%, respectively.

[b] Cost is $776.79 per metric ton.

Feed Formulation Calculations

Diet 2: Least-Cost Formulation and Nutrient Analysis for Salmon Feed[a]

Ingredient	Least-cost formulation		
	Minimum	Actual	Maximum
Fish meal	32.00	32.00	40.00
Corn gluten meal	3.00	3.00	10.00
Meat and bone meal		10.00	10.00
Soybean meal (48 CP)		**16.78**	20.00
Wheat middlings	5.00	5.00	15.00
Wheat, ground grain	10.00	10.00	
Poultry by-product meal	5.00	**7.39**	20.00
Fish oil	12.00	**14.68**	
Ascorbate-2-phosphate	0.10	0.10	0.10
Vitamin premix	0.50	0.50	0.50
Trace mineral premix	0.10	0.01	0.10
Choline chloride	0.35	0.35	0.35
Astaxanthin	0.10	0.10	0.10

Feed Formulation Calculations

	Nutrient Analysis		
	Minimum	Actual	Constraint (decrease)
Crude protein	44.00	44.00	0.568
Crude fat	20.00	20.00	1.171
Crude fiber		2.210	
Phosphorus (total)		2.391	
Phosphorus (available)	0.600	1.405	
Lysine		2.871	
Methionine		1.019	

[a] With minimum dietary protein and lipid changed to 44 and 20%, respectively. Changes are in boldface type.

[b] Cost is $735.24 per metric ton.