

AN OPTIMIZATION TECHNIQUE FOR ECONOMICAL DIET MEETING NUTRITIONAL REQUIREMENTS

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Introduction

Sri Lanka which is a country depends largely on agriculture has a significant livestock sector. The profit from livestock production is directly determined by the production cost. It can be shown that feed cost is one of the main contributors to the production cost. Least-cost feed mix means combining required feed ingredients into a certain proportion to feed the target animal with a balanced nutritional feed at the least cost (Pesti, 1999).

In this paper, we present an optimization technique to solve the least-cost feed mix problem. We use Microsoft Excel to implement and solve the model with the help of "solver add-in". A case study is performed by collecting data from Veterinary Investigation Centre, Anuradhapura and National Livestock Development Board (NLDB) Horrakelly Farm, Kudawewa.

Methodology

General formulation of the Least-Cost Feed-Mix Model

Let a feed-mix be prepared from r ingredients and n nutrients and also let c_j be the cost per unit of

ingredient j , $j = 1, 2, \dots, r$,

x_j be the units of ingredient j needed to make M units of mixed feed, $j = 1, 2, \dots, r$,

$(nt)_{ij}$ be the amount of nutrition i in one unit of ingredient j , $i = 1, 2, \dots, n$, $j = 1, 2, \dots, r$,

$(nlb)_i$ be the minimum amount(lower bound) of nutrition i in M units of mixed feed, $i = 1, 2, \dots, n$,

$(nub)_i$ be the maximum amount(upper bound) of nutrition i allowed to be in M units of mixed feed, $i = 1, 2, \dots, n$,

$(rlb)_j$ be the minimum units(lower bound) of ingredient j in M units of mixed feed, $j = 1, 2, \dots, r$ and

$(rub)_j$ be the maximum units(upper bound) of ingredient j in M units of mixed feed, $j = 1, 2, \dots, r$.

The general formulation of the least-cost feed-mix is given below:

$$\text{Minimize } \sum_{j=1}^r c_j x_j \quad \dots(1)$$

Subject to the constraints:

$$\sum_{j=1}^r (nt)_{ij} x_j \geq (nlb)_i, \quad i = 1, 2, \dots, n \quad \dots(2)$$

$$\sum_{j=1}^r (nt)_{ij} x_j \leq (nub)_i, i = 1, 2, \dots, n \dots (3)$$

$$x_j \geq (rlb)_j, j = 1, 2, \dots, r \dots (4)$$

$$x_j \leq (rub)_j, j = 1, 2, \dots, r \dots (5)$$

$$\sum_{j=1}^r x_j = M \dots (6)$$

$$x_j \geq 0 \quad j = 1, 2, \dots, r \dots (7)$$

Formulation of the Mathematical Model of the case study

National Livestock Development Board (NLDB) Horrakelly Farm-Kudawewa has a feed mill. The purpose of the feed mill is to run livestock feed mixing with the minimum total production cost to supply requirements of sister farms.

We collected data only for poultry farming due to the following reasons:

- More than 90% of poultry farms depend on concentrated poultry feed with intensive poultry management.
- 85% of total cost for poultry production is feed cost.
- Good quality (fulfilling of nutrient requirements of chicken) and low cost concentrated feed will give high profit margin to poultry farm.

Results

The proposed method is applied to calculate the least cost for poultry feed. The results are given in Table 1 (Appendix)

“Tornado sensitivity chart”(Cliff, 2003) is used to analyze the sensitivity of the solution. It provides a clear picture of how the

optimal solution to the problem is affected by changing the costs of the ingredients. To display this information, a bar is constructed for the cost of ingredient concerned with the width of the bar showing how the cost of ingredient affects the value of the optimal solution. The widest bar corresponds to the cost of the ingredient that is most sensitive.

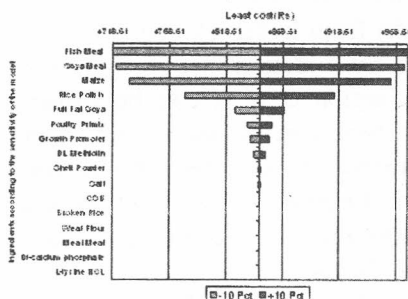


Fig. 1. Tornado sensitivity chart

According to the tornado chart given in Fig. 1, the ingredient Fish Meal affects the most to the production cost followed by Soya Meals.

Discussion

It can be observed by analyzing the optimal solution obtained by solving the model, the ingredient Maize is the main contributor to the production of poultry feed. It can also be observed that the feed-mix can be prepared with the minimum cost while satisfying the nutritional requirements without using every prescribed ingredient. For example, in the case study, in the absence of ingredients CSB, Wheat Flour and Meat Meal, the feed-mix is prepared with the

minimum cost while satisfying the stipulated requirements.

The cost of any individual ingredient may vary from week to week, and it is quite important to know the range with respect to the cost for which the solution remains optimum. Sensitivity analysis chart provides a clear picture of how the optimal solution to the problem will change if the costs of ingredients change.

Conclusion

The feed-mix problem is a general problem in the optimization theory of linear programming which can be applied to variety of industrial applications. In this paper, we use

this theory in finding a cost effective way of preparing poultry feed. This paper illustrates that, it

is not necessary to have every prescribed ingredient to meet the nutritional requirements of the feed-mix. Post-optimality analysis has been carried out so that the decision maker will be provided several alternatives in selecting the ingredients to prepare the feed-mix at the least cost.

References

Cliff T. R, (2003). Spreadsheet Modeling and Decision Analysis, (A practical introduction to management science) 4th edition.
 Pesti, G. M. and Seila, A. F., (1999). The Use of an Electronic Spreadsheet to Solve Linear and Non-linear Stochastic Feed Formulation Problems. J.Appl. Poultry Res. 8:110-121.

Appendix

Table1. Mix proportion of ingredient to produce poultry feed-mix of 100kg.

Ingredient	Cost	Ingredient Lower Bound	Amount	Ingredient Upper Bound
	Rs/1kg	%	%	%
Rice Polish	22.00	0.00	30.00	30.00
Maize	30.00	5.00	38.57	40.00
CSE	8.50	0.00	0.00	0.00
Broken Rice	30.00	0.00	0.00	20.00
Soya Meal	75.00	0.00	16.90	35.00
Shell Powder	6.00	0.00	1.42	6.00
Full Fat Soya	90.00	0.00	2.39	100.00
Fish Meal	130.00	5.00	10.00	10.00
Wheat Flour	85.00	0.00	0.00	0.00
Meat Meal	60.00	0.00	0.00	0.00
Di-calcium phosphate	60.00	0.00	0.00	2.00
Poultry Premix	350.00	0.30	0.30	0.30
Salt	20.00	0.25	0.25	0.25
DL Methiolin	400.00	0.00	0.12	0.30
Growth Promoter	1631.40	0.05	0.05	0.05
L-lysine HCL	375.00	0.00	0.00	0.20
TOTAL			100.00	
Least Cost (Rs)			4848.61	