IOSR Journal of Mathematics (IOSR-JM)
e-ISSN: 2278-5728, p-ISSN: 2319-765X. Volume 13, Issue 4 Ver. III (Jul. – Aug. 2017), PP 43-49
www.iosrjournals.org

Optimization of Landmark Poultry Farm Products Using Simple Linear Programming

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Abstract: *This paper deal with the optimization of Landmark Poultry farm products using Simple Linear Programming whereby we investigate and examine the cost invested and as well as cost of producing each poultry farm products and the turn over for the same products in other to find the trend of its' production and predict the possible economics future using Simple Linear programming for an effective decision making in Landmark University poultry farm production.*

Keywords: *Linear, Optimization, Poultry, Programming, Simple*

Date of Submission: 15-06-2017 Date of acceptance: 05-09-2017

I. Introduction

Poultry is a place where domesticated birds are kept and raised majorly for the production of meat and eggs for human consumption and provides nutritionally beneficial food containing high-quality protein accompanied by a low proportion of fat. These birds are most typically members of the super order known as fowl, which includes chickens, quails and turkeys Statistics shows that Poultry meat is the second most widely eaten type of meat in the world accounting for about 30% of total meat production.

Landmark University in her quest of spearheading an agrarian revolution has join the rest of the world in poultry farm meats and eggs production which has been served to both the staff, students and as well as the entire community. This paper examine the cost invested and as well as cost of producing each farm products and the turn over for the same products in other to find the trend of production and possibly predict the possible economics future using Simple Linear programming for an effective decision making and to optimize its' production in Landmark University poultry farm production.

II. Literature Review

Linear Programming was developed as a Mathematical pattern during World War II to plan expenditures and returns in order to reduce costs to the army and increase losses to the enemy as [1] was commonly credited with being the "father" of linear programming techniques when he was involved in military strategic challenges in the US Air force during the World War II and developed and formulated the Simplex method as a basic solution of the Linear programming model in 1947.

[2] Developed an LP model to determine the optimal crop patterns and the optimal number of breeding sows. The results obtained by using LP were compared with those obtained from using existing plans by the farmer. The strategies obtained by using LP techniques yields more income than strategies from existing plans and [3] developed another LP model for a farmer in Marondera, Zimbabwe. The objective of the study was to maximize net income through optimal enterprise combination subject to resource constraints. The results showed that LP model suggestions are worthy putting into practice.

Comparison and supply chain optimization of poultry firm using mixed integer and linear fractional program by [4] shows that mixed integer and linear fractional program for manufacturer and retailer system of poultry firm in Bangladesh is one of the most promising but unstable sectors in Bangladesh. The paper maximizes the profit, minimizes the cost and finally estimates the optimum selling prices. [5] Applied linear programming in agriculture: case study in region of development South-Mounten and observed that the production structure of farms can be highly diversified to reduce risk and uncertainty related to unsealing the products.

The current concepts of feed formulation for livestock using mathematical modeling, Animal Nutrition and Feed Technology by [6] considered Feed cost as the single most factors which determine the profitability of animal farming. In an attempt to economizing the ration formulation several mathematical models was used with varying success

[7] Optimized nutrients diet formulation of Broiler poultry rations in Nigeria using Linear Programming and opined that the diet problem is a classic problem, one among the earliest problems formulated as a linear programming. The goal of the diet problem is to select a set of nutrients that will satisfy a set of daily nutritional requirement at minimum cost and [8] applied a mixed integer programming poultry feed ration optimization problem using the Bat algorithm where a feed ration problem is presented as a mixed integer programming problem. An attempt to find the optimal quantities of Moringa oleifera inclusion into the poultry feed ration was done and the problem was solved using the Bat algorithm and the Cplex solver.

III. Research Methodology

3.1. Linear programming

A Linear programming (LP) is one of the most widely used optimization techniques and perhaps the most effective method. The term linear programming was coined by [1] to refer to problems in which both the objective function and constraints are provided.

A linear programming is a problem of optimizing linear objective in the decision variables $x_1, x_2 \ldots\ldots x_n$ subject to linear inequality or inequality constraints on the X .The standard form of linear programming is given as:

$$Maximize \quad F = \sum_{j=1}^{n} C_i X_j$$

$$Subject \quad to$$

$$\sum_{j=1}^{n} a(i\ j) X_j = b_i . i = 12 \ldots . n \qquad (1)$$

$$l_j \le X \le u_j . j = 12 \ldots . n$$

$Where \quad C_j \; are \; the \; n \; objective \quad function \quad coefficien \quad ts \; a(i\ j) and \quad b \; are \quad parameters \quad in$
$the \; m \; linear \quad inequality \quad constrants \quad and \; l_j and \; u_j \; are \; lower \quad and \; upper \quad bounds \quad with \; l_j \le u_j .$
$Both \; l_j \; and \; u_j \; may \; be \; positive \quad ornegative \quad .,$

3.2 Blending problems

Blending problems arise whenever a manager is to decide how to combine two or more ingredients together in order to produce one or more products. In these application mangers should decide how much of each resource to purchase in order to satisfy product specification and product demand at a minimum cost.

3.3 Formulation of LP model

Mathematical models were constructed for Starter and Finisher types of Broiler ration using limited ingredients. The objective of the model was to minimize cost of producing a particular diet after satisfying a set of constraints. These constraints were mainly those from nutrients requirements of the birds and ingredients constraints. The variables in the models were the ingredients while the cost of each ingredients and the nutrient valued of each ingredient was the parameter.

The specified L.P model for the attainment of the objective function is as follows:

$$
\begin{aligned}
&Minimize \quad Z = \sum C_j X_i \\
&Subject \quad to \\
&x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 = b_1 \\
&a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + a_{14}x_4 + a_{15}x_5 + a_{16}x_6 + a_{.17}x_7 + a_{18}x_8 \le b_2 \\
&a_{21}x_1 + a_{22}x_2 + a_{23}x_3 + a_{24}x_4 + a_{25}x_5 + a_{26}x_6 + a_{27}x_7 + a_{28}x_8 \le b_3 \\
&a_{31}x_1 + a_{32}x_2 + a_{33}x_3 + a_{34}x_4 + a_{35}x_5 + a_{36}x_6 + a_{37}x_7 + a_{38}x_8 \le b_4 \\
&a_{41}x_1 + a_{42}x_2 + a_{43}x_3 + a_{44}x_4 + a_{45}x_5 + a_{46}x_6 + a_{47}x_7 + a_{48}x_8 \le b_5 \\
&a_{51}x_1 + a_{52}x_2 + a_{53}x_3 + a_{54}x_4 + a_{55}x_5 + a_{56}x_6 + a_{57}x_7 + a_{58}x_8 \le b_6 \\
&a_{61}x_1 + a_{62}x_2 + a_{63}x_3 + a_{64}x_4 + a_{65}x_5 + a_{66}x_6 + a_{67}x_7 + a_{68}x_8 \le b_7 \\
&a_{71}x_1 + a_{72}x_2 + a_{73}x_3 + a_{74}x_4 + a_{75}x_5 + a_{76}x_6 + a_{77}x_7 + a_{78}x_8 \le b_8 \\
&a_{81}x_1 + a_{82}x_2 + a_{83}x_3 + a_{84}x_4 + a_{85}x_5 + a_{86}x_6 + a_{87}x_7 + a_{88}x_8 \le b_9 \\
&a_{91}x_1 + a_{92}x_2 + a_{93}x_3 + a_{94}x_4 + a_{95}x_5 + a_{96}x_6 + a_{97}x_7 + a_{98}x_8 \le b_{10} \\
&a_{101}x_1 + a_{102}x_2 + a_{103}x_3 + a_{104}x_4 + a_{105}x_5 + a_{106}x_x + a_{107}x_7 + a_{108}x_8 \le b_{11} \\
&x_1 \ge 0,\ i = 1,2,3,\ldots.n
\end{aligned}
$$

This can be transformed into the following equation:

$$
\begin{aligned}
&Minimize \quad Z = \sum C_j X_i \\
&Subject \quad to \\
&x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 && = b_1 \\
&x_1 + && \le b_2 \\
&+ x_2 + && \le b_3 \\
&+ x_3 + && \le b_4 \\
&+ x_4 + && \le b_5 \\
&+ x_5 + && \le b_6 \\
&+ x_6 + && \le b_7 \\
&+ x_7 + && \le b_8 \\
&+ x_8 + && \le b_9 \\
&+ x_9 + && \le b_{10} \\
&+ x_{101} + && \le b_{11} \\
&x_1 \ge 0,\ i = 1,2,3,\ldots.n
\end{aligned} \tag{2}
$$

Where Z = Total cost of ration, X_i = Ingredient quantity, C_j = Cost of ingredients.

$i = 1,2,3.......... ....m;\ j = 1,2,3.......... .... .n$

a_i = Technical coefficients of nutrient components in feed stuffs.

b_i = Constraints of the rations

Assumptions

The following were the assumption made in formulating the linear programming model:

1 All the projects and constraints are independent on each other.

2 Equal investment opportunities are assumed for the projects for each period.

3 The cash flows. Resources and constraints are known with certainty.

IV. Data Collection And Analysis Of Results

Secondary data were collected from the recommended nutrient requirements schedule from bird and veterinary service. Feedstuffs used in ration formulation for poultry farms in Landmark University include Maize (x_1). Soya bean (x_2), Wheat brown (x_3), Fish meal (x_4) Lysine (x_5) premix (x_6) Bone meal (x_7) Cotton (x_8) Metheonine (x_9) and Lime stone (x_{10}). Cost implications of feedstuffs and nutrient levels of feed ingredients. Constraint imposed on the selection of feedstuff for broiler rations and least-cost formulation restrictions on nutrients were collected.

Ten (10) decision variable and eight (8) constraints were identified and used for the LP model for least cost rations for broilers (Tables 1.2.3. and 4).

Table 1 below shows the cost implication of feedstuffs and Nutrients on feed ingredient

Nutrients	Cost/ Kg	Crude protein (%)	Fat (%)	Crude Fiber (%)	Calcium (%)	Phosphors (%)	Lysine (%)	Methionine (%)	Me (k/cal) (%)
x_1	130	8.5	4	2	0.05	0.20	0.3	0.18	3300
x_2	167	48	3.5	6.4	0.20	0.37	3.2	0.60	2558
x_3	72	13	0	5.1	0.02	0.2	0.5	0.42	3153
x_4	750	60	4.5	1	6.5	3.5	4.5	1.8	2950
x_5	600	94	0	0	0	0	100	0	0
x_6	340	12	0.25	4.75	1.50	1.50	0.2	0.16	1250
x_7	45	0	0	0	0	0	0	0	0
x_8	11	50.4	10.0	0.25	10.3	4.8	2.6	0.7	2551
x_9	2230	0	0	0	38	0	0	0	0
x_{10}	68	0	4	0	20	0	0	0	0

Table 2 below shows the constraint imposed on the selection of feedstuffs for Starter broiler rations

Nutrients	Maximum level	Minimum level
Crude protein (%)	-	23
Me(Keal/kg)	3300	2900
Calcium (%)	15	10
Phosphorus (%)	-	45
Fat (%)	50	-
Crude fiber (%)	50	-
Lysine (%)	-	11
Methionine (%)	-	5

Table 3 below Shows the constraint imposed on the selection of feedstuffs for Finishers broiler Rations

Nutrients	Maximum level	Minimum level
Crude protein (%)	-	18
ME(Keal/kg)	3500	3300
Calcium (%)	25	10
Phosphorus (%)	-	55
Fat (%)	60	-
Crude fiber (%)	50	-
Lysine (%)	-	11
Methionine (%)	-	5

Table 4 below shows the constraint imposed on Nutrients

Item	Starter stage	Finisher stage
Weight	1001	1001
Crude protein (%)	23	18
Me (Keal/kg)	2900	3300
Calcium (%)	15	10
Phosphorus (%)	45	45
Fat (%)	50	60
Crude fiber (%)	50	50
Lysine (%)	11	11
Methionine (%)	5	5

4.1 Linear Programming Model implementation

The model is implemented in two ways

1. Linear programming model for least cost starter ration
2. Linear programming model for least cost finisher ration

4.1.1 Implementation of Linear programming model for Least cost Starter Ration

We substitute the various ingredients in the table 1 and 3 above into the model which yields:

$$Min\ (Z) = 130x_1 + 167x_2 + 72x_3 + 750x_4 + 600x_5 + 340x_6 + 45x_7 + 11x_8 + 2230x_9 + 68x_{10}$$

Subject to

$$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 = 1001$$

$$8.5x_1 + 48x_2 + 13x_3 + 60x_4 + 94x_5 + 12x_6 + 50.4x_8 \le 23$$

$$4x_1 + 3.5x_2 + 4.5x_4 + 0.25x_6 + 10x_8 + 4x_{10} \le 50$$

$$2x_1 + 6.4x_2 + 5.1x_3 + x_4 + 4.75x_6 + 0.25x_8 \le 50$$

$$0.05x_1 + 0.2x_2 + 0.02x_3 + 6.5x_4 + 1.5x_6 + 10.3x_8 + 38x_9 + 20x_{10} \le 15$$

$$0.2x_1 + 0.37x_2 + 0.2x_3 + 3.5x_4 + 1.5x_6 + 4.8x_8 \le 45$$

$$0.3x_1 + 3.2x_2 + 0.5x_3 + 4.5x_4 + 100x_5 + 0.2x_6 + 2.6x_8 \le 11$$

$$0.18x_1 + 0.6_2 + 0.42x_3 + 1.8x_4 + 0.16x_6 + 0.7x_8 \le 5$$

$$3400x_1 + 2558x_2 + 3135x_3 + 2950x_4 + 1250x_6 + 2551x_8 \le 3300$$

$$x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}$$

Table 5 below show the solution for LP Selection for Least Cost Starter Ration using Maple package

Decision variable	**Variable solution**	**Unit Cost**	**Total Cost**	**Reduced Cost**
Maize (x_1)	480	130	62,400	-112.60
Soya bean (x_2)	100	167	16,700	-340.18
Wheat bran (x_3)	0	72	0.00	5430.60
Fish meal (x_4)	0	750	0.00	5460.00
Lysine (x_5)	1	600	600	-12.90
Premix (x_6)	2.5	340	850	-130.80
Borne meal (x_7)	25	45	1,125	0.00
Cotton (x_8)	0	11	0.00	78.87
Oyster shell (x_9)	32.7	223	7,292.1	22.70
Methionine (x_{10})	2	68	136	-40.60
Total Reduction cost				**10,355.09**

From the TABLE 5, the quality of wheat brain, fish meal and cotton were reduced to zero (0kg) since almost all the nutritional value they offer can also be found in the other ingredients (constraints).The quantity of maize, soya bean, Lysine, concentrate and methionine were increased in order to supplement for the nutritional value that the wheat brain, fish meal and cotton would have offered. The quantity of oyster shell was reduced and the quantity of the premix was obtained in order to balance the nutritional level of the feed. This model reduces the feed cost by almost N10,355.09

4.1.2 Implementation of Linear programming model for least cost Layer ration

We apply the various ingredients in table 1 and table 3 into the Linear programming model which yields:

$$Min\ (Z) = 130x_1 + 167x_2 + 72x_3 + 750x_4 + 600x_5 + 340x_6 + 45x_7 + 11x_8 + 2230x_9 + 68x_{10}$$

Subject to

$$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 = 1001$$
$$8.5x_1 + 48x_2 + 13x_3 + 60x_4 + 94x_5 + 12x_6 + 50.4x_8 \leq 23$$
$$4x_1 + 3.5x_2 + 4.5x_4 + 0.25x_6 + 10x_8 + 4x_{10} \leq 50$$
$$2x_1 + 6.4x_2 + 5.1x_3 + x_4 + 4.75x_6 + 0.25x_8 \leq 50$$
$$0.05x_1 + 0.2x_2 + 0.02x_3 + 6.5x_4 + 1.5x_6 + 10.3x_8 + 38x_9 + 20x_{10} \leq 15$$
$$0.2x_1 + 0.37x_2 + 0.2x_3 + 3.5x_4 + 1.5x_6 + 4.8x_8 \leq 45$$
$$0.3x_1 + 3.2x_2 + 0.5x_3 + 4.5x_4 + 100x_5 + 0.2x_6 + 2.6x_8 \leq 11$$
$$0.18x_1 + 0.6_2 + 0.42x_3 + 1.8x_4 + 0.16x_6 + 0.7x_8 \leq 5$$
$$3300x_1 + 2558x_2 + 3135x_3 + 2950x_4 + 1250x_6 + 2551x_8 \leq 3200$$
$$x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}$$

Table 6 shows the solution for LP Selection for Least Cost Layer Ration using Maple package

Decision variable	**Variable solution**	**Unit Cost**	**Total Cost**	**Reduced Cost**
Maize (x_1)	568	130	73,840	-120.60
Soya bean (x_2)	120	167	20,040	-360.18
Wheat bran (x_3)	0	72	0.00	5430.60
Fish meal (x_4)	0	750	0.00	5460.00
Lysine (x_5)	0	600	0.00	-120.90
Concentrate (x_6)	145	340	49,300	-130.80
Premix (x_7)	2	45	90	0.00
Cotton (x_8)	0	11	0.00	78.87
Oyster shell (x_9)	35	223	7,805	22.70
Methionine (x_{10})	4	68	272	-40.60
Total Reduction cost				**10,219.09**

From the TABLE 6, the quality of wheat brain, fish meal and cotton were reduced to zero (0kg) since almost all the nutritional value they offer can also be found in the other ingredients (constraints).The quantity of maize, soya bean, Lysine, concentrate and methionine were increased in order to supplement for the nutritional value that the wheat brain, fish meal and cotton would have offered. The quantity of soya bean was reduced and the quantity of the premix was obtained in order to balance the nutritional level of the feed. This model reduces the feed cost by almost N10,219.09

4.1.3 Least cost of Layer starter and Finisher rations compared with existing practice

We compared the existing practice of both the Layer starter and finisher rations with our mathematical model to see which one is more cost effective. The results are shown in the table 7 bellow.

Table 7 shows the least cost of Layer rations versus Existing practice

Ingredients	**Cost (N/kg)**	**Existing Practice**		**Proposed solution**	
		Value (kg)	Cost(N)	Value (kg)	Cost(N)
Maize (x_1)	130	480	62,400	480	62,400
Soya bean (x_2)	167	100	16,700	100	16,700
Wheat bran (x_3)	72	365	26,280	0	0.00
Fish meal (x_4)	750	10	7,500	0	0.00
Lysine (x_5)	600	25	15,000	0	0.00

Concentrate (x_6)	340	13	4,420	13	4,420
Premix (x_7)	45	2	90	2	90
Cotton (x_8)	11	1	11	0	0.00
Oyster shell (x_9)	2230	2.5	5,575	2.5	5,575
Methionine (x_{10})	68	2.5	170	2.5	170
Objective function value		**1,001**	**138,146**	**600**	**89,355.00**

The cost of producing a Layer starter feed is N138,146.00 using the existing practice of the farm compared with N89,355.00 .if the feed formulation is based on our proposed mathematical methods. This gives a substantial saving of about 35 %. Obviously feed formulation is more cost effective when based on the valid linear programming model.

Table 8 shows the Least cost of Finisher rations versus Existing practice

Ingredients	**Cost (N/kg)**	**Existing Practice**		**Proposed solution**	
		Value (kg)	Cost(N)	Value (kg)	Cost(N)
Maize (x_1)	130	480	62,400	480	62,400
Soya bean (x_2)	167	100	16,700	100	16,700
Wheat bran (x_3)	72	365	26,280	0	0.00
Fish meal (x_4)	750	10	7,500	0	0.00
Lysine (x_5)	600	25	15,000	0	0.00
Concentrate (x_6)	340	13	4,420	13	4,420
Premix (x_7)	45	2.5	112.5	2.5	112.50
Cotton (x_8)	11	2	22	0	0.00
Oyster shell (x_9)	2230	2.5	5,575	2.5	5,575
Methionine (x_{10})	68	2.5	170	2.5	170
Objective function value		**1,002.5**	**138,179.50**	**600**	**89,377.50**

The cost of producing a Finisher feed is N138,179.50 using the existing practice of the farm compared with N89,377.50 if the feed formulation is based on the proposed mathematical methods. This gives a substantial saving of about 35.3%. Obviously feed formulation is more cost effective when based on the valid Linear programming model.

V. Conclusion

The total reduction cost by our linear programming model for the least cost starter ration is N10,355.09 per ton in Layer starter feed formulations compare with the cost of the existing method in the farm. Whilst the total reduction cost by the linear programming model for the least cost finisher ration is N10,219.09 per ton in the broiler finisher feed formulation.

Also, the cost of producing a Layer starter feed is N138,146.00 using the existing practice of the farm compared with N89,355.00 .if the feed formulation is based on our proposed mathematical methods. This gives a substantial saving of about 35 %. While the cost of producing a Finisher feed is N138,179.50 using the existing practice of the farm compared with N89,377.50 if the feed formulation is based on the proposed mathematical methods. This gives a substantial saving of about 35.3%. Obviously feed formulation is more cost effective when based on the valid Linear programming model.

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N.K Oladejo. "Optimization of Landmark Poultry Farm Products Using Simple Linear Programming." IOSR Journal of Mathematics (IOSR-JM) , vol. 13, no. 4, 2017, pp. 43–49.