OPTIMIZATION OF LAYERS MASH FROM SOME LOCALLY SELECTED POULTRY FEED INGREDIENTS.

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ABSTRACT

Modern poultry feed formulations are compounded under nutrient specification without consideration for the cost. This paper considers the least cost of layers feed formulation using Linear programming techniques without violating these nutrients specification. A model containing five locally sourced ingredient such as maize, soya meal, wheat offal, bone meal and limestone was developed with nine constraints, which are nutritional requirements. The cost of these ingredient was obtained from local feed millers in Ogun State. The optimum solution was obtained at the 9th iteration, which reveals that the cost of a bag of layers mash can be reduced to #2395.31 compare to existing cost of #2,480 per bag(25kg).Thereafter, the sensitivity analysis was run, which reflects that the proposed model is stable enough for any farmer to adopt, since a slight variation in the tolerable quantity of the decision variables will not affect the output.

Keywords: Linear programming, elastic programming, Optimum solution, formulation, layers.

INTRODUCTION

Poultry farmers in most cases are faced with the decision relating to the type of feed formation under limited resources without jeopardizing the dietary nutrient requirement of their birds.

Linear programming has a fractional solution to the management of limited resources faced by these farmers. The development of linear programming (LP) and its application have made a considerable impact on agricultural research in recent years. LP was first introduced to the livestock compound feed formulation in the mid-fifties. Since then, its application in optimum formulation of feed for livestock has gained tremendous attention. Least cost feed formulation for poultry in Nigeria on the other hand is a recent innovation which has not been fully exploited. There are still many gaps in our knowledge of LP regarding poultry nutrition and digestibility. This work made an attempt to fill the gaps by employing LP techniques. In this paper, layers feed has been used as a case study to evaluate the effectiveness of this techniques in reducing feeding cost. The cost of feed significantly contributes to the profitability of poultry industry and has been estimated to constitute 60-80% of the total cost of producing eggs (Webster, 1993; Rose, 1997). Therefore, any method of computing low cost feeds is really of great importance. Linear programing is one of such methods which has been widely used in the developed countries such as USA, UK, Canada and others. Application of this method is hoped to encourage both commercial and subsistence farmers.

Modern poultry feed formulations are formulated under nutrient specification, which changes as more advances are made in poultry. Nutrient specification may include minimum or maximum level of nutrients. The ingredients in the formulation of poultry feed differ in content and importance in poultry diet. These ingredients both locally and internationally sourced fall within the classification based on the nutrients of which they have imperative content. Some researchers have highlighted the nutrients which are very crucial in formulation of poultry feed such as metabolizable energy, crude protein, crude fibre, fats and oil, vitamins, amino-acids and minerals (Kekeocha, 1984; Parr, 1988; Pond, David, Kevin, & Schorecht, 2005; and Godfrey , Chipo & Christopher , 2016).

It is not the intent of this paper to discuss poultry feed formulation in the content of foreign feed ingredient. Rather an attempt is made in the context of optimizing the quantity of some locally selected feed ingredient such as maize, soya beans meal (SBM), wheat offals, bone meal (BM) and limestone in order to minimize the cost of feed formulation. The cost of these ingredients was obtained from the local feed millers in Yewa community of Ogun State.

To provide a more realistic model that will blend price and ingredient availability, a case study is used in the western part of Nigeria, where poultry business is developing at a rapid pace and where availability of a fairly wide selection of feed ingredients permits the realistic model of LP.

Therefore, the purpose of this research is to obtain an optimum layer feed mix with locally sourced materials such as maize, soya meal, wheat offal, bone meal and limestone. Other trace elements such as methionine, lysine, enzymes, premix, toxin binder etc. are into regulatory use. Hence, they are not included as materials to be optimized. We hope the study will be able to accomplish the following fact. To identify commonly used local ingredients, to obtain various nutrient composition in each ingredient used, via Pearson's square method. Thereafter, we intend to develop a realistic LP model that will be extended to elastic programming. The proposed model will be solved and sensitivity analysis will be run via TORA PACKAGE.

Vast literature of different approaches exists to minimize the cost of feed formulation. Researchers have engaged several mathematical techniques to provide solution to poultry feed formulation such as trial and error, Pearson's square method, goal programming, multi objectives goal programming, quadratic programming, nonlinear programming, pure integer programming, mixed integer programing and linear programming.

Zhang and Roush (2002), applied a multiple objective programming (MOP) to the feed formulation process with the objectives of minimizing nutrient variance and minimizing ration cost. Where 21 ingredients with 17 nutrients were included in the formulation. They concluded that MOP model is more flexible in providing appreciable solution than a traditional feed formulation.

Olorunfemi (2007), in his classical use of linear programming approach to least cost ration formulation for poultry, used a computer-based technique to investigate, analyse and indicate how best the available local ingredient can be combined effectively to formulate least cost ration for poultry. He concluded that utilization of diet containing fillers at 7.94% is cost effective and reduce cost of feeding by as much as 24.95%.

Nabasirye, Mugisha, Tibayungwa, and Kyarisima., (2011) demonstrated how to formulate a least cost diet using linear programming and discussed extensively the importance of proper interpretation of the sensitivity report on micro Excel solver output format.

Oladokun and Johnson (2012) developed an optimization feed formulation model, using locally available feed ingredients, for the Nigeria poultry industry. They also carried out the sensitivity analysis to take a position on their model and the existing method on the farm under study.

Piyaratue, Dias and Attapahu (2012) in their study, they focused on the development of linear model-based software with inclusion of digestible amino acid for least cost poultry ration formulation. Their model yielded ration with equalizing major nutrients requirement at the average inclusion level of commercial lysine 0.05% and methionine 0.02%. They realized that equal nutrient requirement gave up to 12 major nutrients with ideal amino acid profiles.

Wagner and Stanton (2014), used the Pearson's square method to balance animal rations. They found the nutritional requirement of an animal for a specific nutrient using Pearson's square. One of the short comings of this method is that it cannot handle a situation where ingredients are many.

Samuel, et al. (2015) employed linear programing to propose optimal formulation of the LP model which gives about 7.48% and 9.96% reduction in feed formation costs compared to the existing formulation in case of broiler starter and finisher. The proposed model also reduced the amount of fat contained in the existing ration but adding more flesh by significantly increasing the metabolizable energy needed for physiological structure of the birds.

Godfrey, et al (2016), employed mixed integer programming to poultry feed ration optimization using the bat algorithm. In their research, they used findings of previous research to investigate the effects of moringa oleifera inclusion in poultry feed ration using the bat algorithm to obtain the optimum solution.

In the thesis developed by Efeduma, (2016). Developed a LP model to determine the optimal feed mix of broiler starter and finisher at least cost using linear programing technique. He used 10 feed ingredients and solved using an excel solver application to obtain optimal feed mix.

A weighted goal programing DASH (Dietary approaches to stop Hypertension) diet model that minimizes the daily cost of the DASH eating plan as well as deviations of the diet nutrients content from the DASH diets was presented by (Iwuji and Agwu, 2017).

MATERIALS AND METHODS

Data used in this study was obtained from twenty feed millers in Ogun State. The average prevailing market price per Kg of maize, soya meal, wheat offal, bone meal and limestone, obtained from these feed millers.

Definition 1.0

If the feasible region is a subset of the non-negative portion of R^n, define by linear equation and inequalities, and the objective function to be minimized or maximized is linear, then we have a linear programming problem (Meyer, 1985). Therefore, a linear programming is the problem of maximizing or minimizing a linear function subject to a limited number of linear constraints. Such that:

/ $\sum$

Subject to

$\sum$ $\geq (\leq)(=)$

With $x_j \geq 0$

for i = 1,2 …m

j = 1,2 …n

Where x_j are the decision variables

c_j is the co-efficient of the objective function

a_{ij} is the co-efficient of the constraints.

b_i is the boundary associated with the constraints.

Mathematical Formulation of the Model

With the nine constraints imposed on five set of local ingredients, and the nutrient requirement to be met, the following assumptions are made:

% All ingredients into the ration are infinitely divisible.

% All the coefficients are known with certainty.

% The total of all activities equals the sum of individual activities.

Mathematically, in algebraic terms our model has the form below:

( ) = …………………………….( )

Subject to

$\geq (\leq,=)$ …………………………….( )

i. = …………………………….( )

$\leq$ $\leq$ ……………………….( )

≥ 0 ………………………….( )

Where Z is the total cost of the feed per bag.
Cj is the cost of ingredient j.
xj is the quantity of ingredient j.
aij is the quantity of nutrient i in ingredient j.
bi is the required amount of nutrient i in the feed.
q is the weight value of the feed.
is the lower limits of nutrient i in a bag of the feed
is the upper limits of nutrient in a bag of the feed.

The inclusion of (iv) is necessary because we need to set an upper limit due to undesirable characteristics or simply to avoid unevenness of nutrients especially if these nutrients cost less than other nutrients and lower limits due to some desirable characteristics.

The model is designed to consider five selected locally sourced ingredients maize (yellow), soya beans meal (SBM), wheat offal, bone meal (BM) and limestone, constrained with the nutrient requirement namely, crude protein, metabolizable energy, ether extract(oil), crude fibre, lysine, methionine, calcium and available phosphorus.

The case study farm "Morac farms Ltd", Ogun- state, Nigeria, has an existing layers feed formulation of 25kg per bag with the composition of 13kg of maize, 5.5kg of SBM, 3.5kg of wheat offal, 1kg of BM and 2kg of limestone per bag. Since the inclusion per bag of amino acids like lysine, methionine and premix (vitamins) and salt (minerals) are of regulatory use, they are all exempted from the model. The various nutrient level composition of each ingredient is obtained by Pearson's square method in the table 1.0

Decision variables:

Let x1 be one unit of the quantity of yellow maize.

Let x2 be one unit of the quantity of SBM.

Let x3 be one unit of the quantity of wheat offal.

Let x4 be one unit of the quantity of BM.

Let x5 be one unit of the quantity of limestone.

Table 1.0: Derived nutrient composition of existing feed formulation

Ingredient	Price #(kg)	Quantity (kg)	Crude Protein%	Energy ME Kcal	Ether Extract %	Crude Fibre %	Lysine %	Methionine %	Calcium %	Available Phosphorus %
Maize (yellow)	100	13	5.2	1785.7	20.8	0.04	0.13	0.09	0.05	0.05
SBM	155	5.5	9.24	594	0.77	0.43	0.62	0.13	0.04	0.13
Wheat offal	55	3.5	2.38	261.8	0.49	1.00	0.13	0.04	0.01	
BM	75	1							1.48	0.6
Limestone	30	2							2.8	

Source: Computed nutrient level of ingredients by Pearson's square method

The information in table 1.0 together with nutrient requirement can thus be expressed in LP form as given below:

$\text{Min}(z) = 100x1 + 155x2 + 55x3 + 75x4 + 30x5.$
subject to
$x1 + x2 + x3 + x4 + x5 = 25$ (demand requirement)
$5.2\,x1 + 9.24\,x2 + 2.38\,x3 \geq 16.5$ (crude protein)
$1785.7x1 + 594x2 + 261.8x3 \geq 2530$ (metabolizable energy)
$20.8x1 + 0.77x2 + 0.49x3 \geq 3.7$ (Ether extract)
$0.04x1 + 0.43x2 + 1.00x3 \leq 6.5$ (Crude fibre)
$0.13x1 + 0.62x2 + 0.13x3 \geq 0.7$ (Lysine)
$0.09x1 + 0.13x2 + 0.04x3 \geq 0.27$ (Methionine)
$0.05x1 + 0.04x2 + 0.01x3 + 1.48x4 + 2.8x5 \geq 3.5$ (Calcium)
$0.05x1 + 0.13x2 + 0.6x4 \geq 0.45$ (Available Phosphorus)

With $x1, x2, x3, x4, x5 \geq 0$

The following upper and lower limit are also imposed on the ingredient (kg)
x1 is between 13-12kg
x2 is between 6-5kg
x3 is between 5- 3.5k
x4 is between 1.25- 0.75kg
x5 is between 2.5- 2kg

For the demand requirement 1 bag of the feed must be equal to 25kg. For a good laying hen the protein level must not be less than 16.5% crude protein, energy requirement must not be less than 2530ME, fat & oil not less than 3.7%. Crude fibre has limiting capacity, it must not be greater than 6.5% of the feed. Lysine, methionine, calcium and available phosphorus must not be less than 0.7%, 0.27%, 3.5% and 0.45% respectively

Cost Analysis of Existing Feed Formulations

Table 2: Quantity and Cost of Existing Layers Feed

Ingredient	Quantity(kg)	Cost/kg(#)	Cost of ingredient
Maize	13	100	1300
SBM	5.5	155	852.50
Whaetoffal	3.5	55	192.50
BM	1	75	75
Limestone	2	30	60
Total	25		2480

Table 3: Nutrient composition of existing formulation.

Nutrient	Composition
Crude Protein	16.82
Energy	2641.5
Ether (oil)	3.34
Crude Fibre	1.47
Lysine	0.88
Methionine	0.26
Calcium	4.38
Phosphorus	0.78

RESULTS AND DISCUSSION

The proposed model in this paper was initially not feasible until when we extended the LP model to elastic programing model. The extended model was then solved by TORA package. The optimum solution of the model is obtained as #2,395.31, with 12.40kg of maize, 5.00kg of SBM, 3.85kg of wheat offal, 1.25kg of BM and 2.5kg of limestone. This ration meets all the nutritional requirement needed for layers.

Table 4 Summary of output
Objective value =#2,395.31

Variable	Value	Objective Coefficient	Objective Value Contribution
	12.40	100.00	1239.58
	5.00	155.00	775.00
	3.85	55.00	211.98

	1.25	75.00	93.75
	2.50	30.00	75.00

Table 5 Limitations

Constraint	RHS	Slack(-)/Surplus(+)
1st	25	0.00
2nd	16.50	103.33(-)
3rd	2530.00	23584.26(-)
4th	3.70	259.87(-)
5th	6.50	0.00
6th	0.70	4.41(-)
7th	0.27	1.65(-)
8th	3.50	6.21(-)
9th	0.45	1.57(-)
LB;	12.00	4.00(+)
UB;	13.00	0.60(-)
LB;	5.00	0.00
UB;	6.00	1.00(-)
LB;	3.50	0.35(+)
UB;	5.00	1.15(-)
LB;	0.75	0.50(+)
UB;	1.25	0.00
LB;	2.00	0.50(+)
UB;	2.50	0.00

Table 6 Sensitivity Analysis:

Variable	Current Obj coefficient (#)	Min. Obj coefficient (#)	Max. Obj coefficient (#)	Reduced Cost(#)
	100	74.20	223.42	0.00
	155	81.72	∞	-73.28
	55	-860.00	100	0.00
	75	$-\infty$	101.88	-26.88
	30	$-\infty$	101.88	-71.88

Table 7 Limitation

Constraint	Current RHS	Min. RHS	Max. RHS	Dual Price
1	25	24.62	25.58	101.88
2	16.5	$-\infty$	119.83	0.00
3	2530	$-\infty$	26114.26	0.00
4	3.70	$-\infty$	263.57	0.00
5	6.50	6.16	6.88	-46.88
6	0.70	$-\infty$	5.11	0.00
7	0.27	$-\infty$	1.92	0.00

8	3.50	$-\infty$	9.71	0.00
9	0.45	$-\infty$	2.02	0.00

From the analysis above, optimum solution is obtained as #2,395.31 with corresponding value

of our decision variables to be $_1$ = 12.40 . $_2$ = 5.00 . $_3$ = 3.85 . $_4$ = 1.25 . $_5$ = 2.50 . These variables have different contributions to the objective function

i.e #1239.58, #775, #211.98, #93.75and #75 respectively. This implies that

$_1$□ 52% □ □ , □

32%. $_3$=9%. $_4$=4%. $_5$=3%

This model is flexible to the extent that the input data of the model can be changed within certain limit without causing the optimum solution to change. Sensitivity analysis reveals that the optimum solution remains unchanged within the range of objective coefficient in table 4 which implies that the optimum solution obtained is robust. The range of nutritional requirement that would permit a feasible solution is shown on table 7. The Dual prices which are zero have no economic importance on the feasibility range.

The following table makes a comparison of the results of the model and the existing trial and error formulation of the farm under study.

Table 8: Comparison of Existing Formulation and Proposed LP formulation

Ingredient	Cost per kg (#)	Quantity(kg) Existing formulation	Cost(#)	Quantity(kg) LP formulation	Cost(#)
MAIZE	100	13	1300	12.40	1240
SBM	155	5.5	852.5	5	775
WHEAT OFFALS	55	3.5	192.5	3.85	211.75
BM	75	1	75	1.25	93.75
LIMESTONE	30	2	60	2.50	75
TOTAL		25	2,480	25	2,395.5

CONCLUSION

The model developed has been successful in reducing the total cost of producing 1 bag of layers mash by #84.69 with appreciable increase in the minimum nutrient requirement. The model also proposed the inclusion of 12.40kg of maize, 5kg of SBM, 3.85kg of wheat offal, 1.25kg of BM and 2.5kg of limestone as compared to the existing feed mix of 13kg maize, 5.5kg SBM, 3.5kg wheat offals, 1kg BM, and 2kg limestone.

This is really significant when considered at a larger capacity. Morac farms consumes an average of 25 bags per day, which implies that, if the farm adopts the proposed model formulation, the farm will be able to save #2,117.25 per day on feed consumption. The optimum solution obtained in this study shows that utilization of LP in feed formulation is of great economic importance and this will surely increase profitability in poultry industry

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