

# Programming Technique for Animal Diet Formulation: A Non-linear Approach

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**Abstract** This paper proposes a technique for animal diet formulation using Non-linear programming and C language. Objective of this technique is to maximize animal weight gain. Most of the existing techniques use linear approximation of objective function. This technique uses Non-linear programming, which overcomes this drawback. C language program explores the area of programming in the field of animal diet formulation. Outcome of this technique is applied on sample data and provides optimized set of nutrient ingredients to animal which fulfill the nutrient requirement better than the linear programming technique.

**Keywords** Animal diet formulation, Non-linear programming, C programming

## 1. Introduction

Animal diet formulation techniques are in use for more than hundred years. Main objective of animal diet formulation is to provide necessary energy at different stages of animal as growth, reproduction, metabolism and lactation. Basic knowledge of animal nutrition, nutrition level of feed ingredients, feed composition and diet formulation techniques are used to formulate the animal diet.

As feedstuffs vary in composition, feed analysis is an important step of diet formulation. A balanced diet should provide all necessary nutrition to animal and should simulate feeding behaviours. A nutritionally balanced diet should be economic, easily digestible, concise, efficient and practical. Absorption and efficiency of the diet also depends on physiological function, productive function and nutritional status of animal. Different techniques have been derived in this regard using linear programming, stochastic programming, goal programming and dynamic programming. Diet should be highly digestible and should have very less adverse environmental effect.

In 1960, short cut methods of solving linear programming technique were analysed[1]. A model is proposed by applying economic analysis to animal growth data[2]. A model is solved by linear programming in which elements of the tableau are stochastic[3]. A quadratic programming model is proposed and is compared to linear programming model[4]. Basics of ration formulation were firstly

described by computerized linear programming[5]. It describes basic assumptions of linear programming, its application for animal diet formulation, modelling ratios, upper and lower bounds on individual feedstuffs, combinational feedstuffs and their programming by computer programs. Chance-constrained programming is used to formulate commercial feeds for animals[6]. Application of Genetic Algorithm is proposed to obtain minimum cost diet for farmed animal[7]. A linear fuzzy model is developed in which composition based inference function works for single input and single output systems[8]. Cattle diet is formulated in an Argentinean farm by applying fuzzy linear programming[9]. Excel Solver Nonlinear Programming is used to optimize performance response for broiler feed formulation[10]. Iterative linear programming is used to formulate two nonlinear optimization problems as an iterative sequence of linear programming problems[11].

Every nutrient has specific role for production, metabolism, energy, lactation and growth. Diet formulation is based on the need of specific amounts of various classes of nutrients. Nutrient classes are defined by their function in metabolism. Protein is major component of diet and is measured as Crude Protein percentage (CP). Energy is expressed as percentage of Total Digestible Nutrients (TDN). Dry Matter (DM) represents composition of chemical constituents and biological attributes of feeds. These three nutrient ingredients are necessary to formulate an effective diet. Complexity of different nutrient ingredients would possibly be better described by nonlinear relationship between them. Introduction of nonlinear programming to optimize yield and minimize feed cost in animal feed formulation may lead to better approximation as compared to linear cases. Objective of this technique is, to maximize

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Published online at <http://journal.sapub.org/food>

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animal weight gain by optimum use of nutrient ingredients. In this paper, it is envisaged to develop a programming technique using non-linear programming to take simultaneous effects of all nutrient ingredients. 'C' programming is used as a tool for formulation of programming problem. After developing the technique, result is demonstrated by using sample data.

## 2. Developing Environment and Technique

### 2.1. Data Network Operating System

This unit of code can be installed on any earliest version of Windows operating system edition. It can be used on a single machine or on the network as per the requirement. It can also be used as ODBC and OLEDB network. This technique can be integrated with HTML, VBScript or JSP format. In order to reduce the complexity, no GUI languages are used. For quick access, it can be set as hierarchy in cloud environment.

### 2.2. The Programming Language

C language is used as programming language because of fast compilation, more secure LINUX environment and less computational time. Nonlinear programming is used to formulate and optimize the diet as mathematical programming method.

### 2.3 Formulation Technique

As the first step, a linear relationship is established between animal weight gain and nutrient ingredients. This relationship is established to determine the weightage and impact of these nutrient ingredients on animal weight gain. This relation is obtained by program 1.

```

Program 1
main()
{Declare the variable ()}
Initialized all variable equal to 0
//double a1, a2, a3, b1, b2, b3, c1, c2, c3, d1, d2, d3,det,
deta, detb, detc;
//double x1[max],x2[max],x3[max],y[max];
Initialize the loop body for x1 {statements}
Initialize the loop body for x2 {Statements}
Initialize the loop body for x3 {Statements}
Initialize the loop for y {Body of code}
start of loop body(all possible combination){ Statements}
a1= expression1
b1= Expression2
c1=Expression3
d1=Expression4
a2=Expression5
b2=Expression 6s
c2= Expression 7
d2=Expression 8
a3=Expression 9

```

```

b3= Expression 10
c3= Expression11
d3=Expression 12
printf("\n a1: %lf ,c1: %lf d1:%lf a2: %lf b2:%lf
c2:%lf d2: %lf a3: %lf b3: %lf c3:%lf
d3:%lf",a1,b1,c1,d1,a2,b2,c2,d2,a3,b3,c3,d3);
det=finddet(a1,a2,a3,b1,b2,b3,c1,c2,c3);
deta=finddet(d1,d2,d3,b1,b2,b3,c1,c2,c3);
detb=finddet(a1,a2,a3,d1,d2,d3,c1,c2,c3);
detc=finddet(a1,a2,a3,b1,b2,b3,d1,d2,d3);
printf("\n det:%lf ",det);
a=deta/det;
b=detb/det;
c=detc/det;
d=sig_y-a*sig_x1-b*sig_x2-c*sig_x3;
Perform comparision for solution
//if(d1==0 && d2==0 && d3==0 && det==0)
//printf("\n Infinite Solutions\n ");
//else if(d1==0 && d2==0 && d3==0 && det!=0)
//printf("\n x=0\n y=0, \n z=0\n ");
//else if(det!=0)
//printf("\n a=%lf\n b=%lf\n c=%lf d=%lf\n", a,b,c,d);
//else if(det==0 && deta==0 && detb==0 && detc==0)
//printf("\n Infinite Solutions\n ");
//else
//printf("No Solution\n ");
}
double finddet(Refernce the all variable with size declared
as above)
{
return
}
As second step, relationships between individual nutrient
ingredients and animal weight gain are established. These
relationships are established by Program 2. These
relationships may be nonlinear in nature.
Program 2
void main()
{
//clrscr();
int i=0,n;
float x[5],y[5],xy[5],x2[5],a,b;
float s x= 0.0,sy=0.0,s xy=0.0,s x2=0.0;
printf("How many terms : ");
scanf("%d",&n);
printf("Enter the values of x\n ");
for(i=0;i<n;i++)
{
printf("Enter the value of x%d : ",i+1);
scanf("%f",&x[i]);
}
printf("\nEnter the values of y\n ");
for(i=0;i<n;i++)
{
printf("Enter the value of y%d : ",i+1);
scanf("%f",&y[i]);
}

```

```

}
for(i=0;i<n;i++)
{
sx+=x[i];
sy+=y[i];
xy[i]=x[i]*y[i];
x2[i]=x[i]*x[i];
}
for(i=0;i<n;i++)
{
sxy+=xy[i];
sx2+=x2[i];
}
a=(sy*sx2-sx*xy)/(n*sx2-sx*sx);
b=(sy-n*a)/sx;
printf("\nEquation is");
printf(" y=%fx",a+b);
printf("\nPress enter to exit");
//getch();
}

```

As the third step, residuals are calculated by program 3 and then F-test is applied to choose best fit relation between nutrient ingredients and animal weight gain.

Program 3

Define both variable in dynamic memory allocation

A=(double \*) malloc (n\*sizeof(double));

A12 = (double \*) malloc (n\*sizeof(double));

Size of the variable may be vary as per required during declaration.

assume A = x

A12=y

Equeston of straight line is delienated

y = mx + b

m=slope of the line the line (for given x or A)

b = of the y-intercept line

For a set of n points {(x1,y1), (x2,y2),..., (xn,yn)},

Assume that:

SUMx = x1 + x2 + ... + xn

SUMy = y1 + y2 + ... + yn

SUMxy = x1\*y1 + x2\*y2 + ... + xn\*yn

SUMxx = x1\*x1 + x2\*x2 + ... + xn\*xn

The slope and y-intercept for the least-squares line can be calculated using the following equations:

slope (m) = Expression 1

y-intercept (b) = Expression 2

Where

Expression1=( SUMx\*SUMy - Total number of selected point\*SUMxy ) / ( SUMx\*SUMx - Total number of selected point\*SUMxx )

Expression2=( SUMy - slope\*SUMx ) / Total number of points

( All point are given by the user)

For sum of residue (SUMres = 0;)

Start the body of loop(for i)

y estimate = caculate slope of x + intercept of y

Resdue = value of y(positional value )- value of y estimate;

SUMresdue = Expression for the resdue

end of loop body

Then objective function is formulated with the help of output of program 1. Constraints are substituted according to guidelines of NRC standards[12]. Metabolic weight is used for calculations[13].

## 2.4. Solution of the Diet Model

Diet model can be solved any of the existing nonlinear programming method. In the sample data formulation, Kuhn-Tucker conditions are used to solve diet formulation model.

## 3. Discussion: Example for Demonstration

Computation is carried over secondary data of research project experiment at National Dairy Research Institute, Karnal[14]. Briefly, the study consists of lactating sahiwal cows of second to fifth lactation number, selected from the National Dairy Research Institute herd, and divided into four groups which were switched over four times (as the number of treatments) in a Latin-square change over design. The 4 groups A, B, C and D were fed with isonitrogenous and isocaloric concentrate mixtures, containing ground nut cake, cotton cake, cotton seedcake (undecorticated) and cotton seed cake (decorticated), respectively. In addition to the maintenance requirements, 50 gm DCP requirement, 50 percent was met through the concentrate mixture. A green fodder was given ad libitum to provide rest of the DCP and also to meet the dry matter and energy requirements. Table 1 gives composition of concentrate mixtures in respect of DCP and TDN.

**Table 1.** Computation of concentrate mixtures in respect of DCP and TDN

Ingredients	Control (G.N.Cake)			Cotton seed (whole)		
Groundnut cake	22	7.8	17	10	3.54	7.74
Cotton seed	0	0	0	57	8.69	45.6
(undecorticated)	0	0	0	0	0	0
(decorticated)	0	0	0	0	0	0
Wheat bran	75	8.09	47.6	30	3.23	19
Common salt	2	0	0	2	0	0
Mineral mixture	1	0	0	1	0	0

Data is used to formulate mathematical model by using non-linear programming technique and results obtained by C programs. Assuming a linear relationship between milk yield of cows and dry matter, crude protein and total digestible nutrient, weightage of these variables is decided. Program 1 formulates the relation given by eq. (1).

$$Y = 0.00403908701533x_1 + 0.254694855 \quad (1)$$

$$41324x_2 + 0.02110699233x_3 - 8.67895696598672$$

Nonlinear objective function is established by using Program 2 and program 3. It and is defined by eq. (2).

$$Y = 4.179244219x_2^2 - 4.082239204 \times 10^{-6}x_3^2$$

$$+ 0.114836671x_1 - 560.0786654x_2$$

$$+ 4.145857585 \times 10^{-3}x_3 + 19255.68675 \quad (2)$$

Constraints are:

$$608.6718 \leq x_1 \leq 782.978,$$

$$60.641 \leq x_2 \leq 75.943, 366.0412 \leq x_3 \leq 508.9343 \quad (3)$$

Introducing Kuhn-Tucker conditions, the milk yield of the cows is maximized using eq. (4)

$$L = 4.179244219x_2^2 - 4.082239204 \times 10^{-6}x_3^2$$

$$+ 0.114836671x_1 - 560.0786654x_2$$

$$+ 4.145857585 \times 10^{-3}x_3 - \lambda_1 [x_1 - 782.978]$$

$$- \lambda_2 [x_2 - 75.943] - \lambda_3 [x_3 - 508.9343] \quad (4)$$

Solving these equations, the optimum values of three nutrient ingredients are obtained and these values maximize the milk yield. We have,  $x_1 = 782.97800$ ,  $x_2 = 67.00717$ ,  $x_3 = 507.79209$  gm/ Kg. metabolic body weight, subject to the condition  $\lambda_1 \neq 0$ ,  $\lambda_2, \lambda_3 = 0$  satisfying all the conditions.

## 4. Conclusions

This technique presents a method to develop nonlinear formulation of animal diet for the objective of maximum weight gain. The technique presented in this paper formulates and solves a nonlinear program with optimum use of nutrient ingredients. It explores the use of mathematical and computerized programming in the field of animal nutrition and can be investigated in future for more variables.

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