Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.3, No.4, 2013

Review of Livestock Feed Formulation Techniques

Omidiora, Elijah Olusayo[1], Adegoke, Benjamin Olusesan[2*] & Aderounmu Ganiyu Adesola. [3]
[1]Department of Computer Science and Engineering, Faculty of Engineering, LAUTECH, Nigeria;
[2]School of Engineering, Osun State Polytechnic, Iree, Nigeria..
[3]Department of Computer Science and Engineering, Faculty of Engineering,
Obafemi Awolowo University, Ile-Ife, Nigeria.
[*]E-mail of the corresponding author: adegokebo@yahoo.com

Abstract
This paper reviews animal feed formulation methods, the conventional methods and intelligent system method. Highlighting their cons and pros. The intelligent system method (neuro-fuzzy) incorporated fuzzy conjunctive into levenberge training of artificial neural network. The neuro-fuzzy system was trained with dataset and validated using Amino acid elements of chicks feed. With 0.05 level of significance on NCCS 2000 platforms, output of the neuro-fuzzy system produced a correlation coefficient of 0.888608 and p-value of 0.97. Intelligent system can be employed to increase productivity in the field of animal feed formulation.
Keywords: animal feed formulation, linear programming, neuro-fuzzy, ration.

1. Introduction

Ration can be defined as the total amount of feed given to the animals on daily basis. Animal feed formulation can be defined as the process by which different feed ingredients are combined in a proportion necessary to provide the animal with proper amount of nutrients needed at a particular stage of production, (Afolayan and Afolayan 2008).
As the world population increases, one of the major problem facing developing countries of the world is their ability to cope with protein requirement for the growing population, (Oladoja and Olusanya, 2009). Poultry, which offer meat and egg on account of its short gestation, short generative interval and handy size is expected to play a major role in the bid to provide protein of animal source, (Oladoja and Olusanya). It is reported that the most commonly kept livestock is poultry and that over 70% of those farmers kept chickens (Udoh and Etim 2008). Feed formulation is very important in raising animals because feed cost between 65% and 70% of the total cost of production in poultry production as identified by literatures (Bamiro *et al.* 2001; Bamiro *et al.* 2009).

2 Livestock Feed Formulation Methods

There are about six conventional livestock feed formulation methods identified by Imamidoost,
1992 and Jerry, 2003. These methods include; Pearson Square method,

2.1.1 Pearson Square Method.

This method is relatively simple and easy to follow. Some of its merits as identified by Afolayan and Afolayan include: its simplicity of use and secondly its usefulness for balancing protein requirement. Its disadvantages include, its usability for only two(2) requirements at the same time and secondly, its reduced consideration given to other nutritive requirements especially, vitamins and minerals

2.1.2 Simultaneous Equation Method

This is an alternative method for the square method using a simple algebraic equation. Here, a particular nutrient requirement is satisfied using a combination of two feed ingredients.

Merits of Simultaneous Method

The system is easy to use both by beginners and the experienced feed millers. It is used to introduce feed formulation to students in teaching classes. Advantages of simultaneous equation over Pearson method are:
Firstly, farmer can balance for both protein and energy. Secondly, it is useful in considering more than two feed ingredients at once when balancing more complex ration. Finally, as the requirement increases, the system of equation increases.

Limitations of Pearson Square and Simultaneous Method

The limitations includes firstly, it satisfies only one nutrient requirement and uses only two feed ingredients. Another limitation is that the level of the nutrient being computed should be intermediate between the nutrient concentrations of the two feed ingredients being used.

2.1.3 Two-By-Two Matrix Method.

This method solves two nutrients requirement using two different feed ingredients. A 2 by 2 matrix is formed a set and a series of equations are solved to come up with the solution to the problem.

2.1.4 Trial and Error Method.

This is the most popular method of formulating ration for the swine and poultry. It is a type of feed formulation used in many developing nations of the world (Adejoro 2004), Nigeria inclusive. As the name implies, the formulation is manipulated until the nutrient requirements of the animal are met. This method makes possible the formulation of a ration that meets all the nutrient requirements of the animal. In poultry feed formation, various cases of mineral deficiency such as osteomalacia, rickets and shellessness or soft shell formation may not be properly addressed if care is not taken to comprehensively analyze or calculate the level of calcium and phosphorus of the ration in question.

2.1.5 Imami Method.

This is an educational way to describe and balance simple rations by a common
calculator with a high accuracy for farmers who do not have access to the computer.

2.1.6 Linear Programming (LP) Method.

This is otherwise called, least cost computerized feed formulation. This method of determining the least cost combination of ingredients using a series of equations which employs Linear Programming methods. This least cost can employed in feed formulation takes basic seven steps.

Advantages of Linear Programming Method

Mark, (1998); Onwurah, (2005); highlight some advantages and disadvantages of Linear Programming. Some of the advantages of Linear Programming method are:

i. *Scientific Approach to Problem Solving.* It is the application of scientific approach to problem solving. Hence it results in a better and true picture of the problems which can then be minutely analyzed and solution ascertained.
ii. *Quality of Decision.* LP provides practical and better quality of decisions that reflect very precisely the limitation of the system i.e; the various restrictions under which the system must operate for the solution to be optimal. If it becomes necessary to deviate from the optimal path, LP can quite easily evaluate the associated costs or penalty It guaranteed the finding of optimal solution
iii. *Evaluation of All Possible Alternatives.* Majority of the problems in animal feed formulation are somehow complicated. LP method ensures that all possible solutions are generated, out of which the optimal solution is selected.
iv. *Flexibility.* LP is flexible mathematical method.

Disadvantages of Linear Programming Method

Although Linear Programming (LP) is a highly successful techniques having wide applications, yet it has some demerits which are as follows:

i. Absence of risk
ii. *Linear Relationship*: It can only be applied to situations where the given problem can be represented in the form of linear relationship. Hence it is based on implicit assumption that the objective as well as all the constraints or the limiting factors can be stated in the form of linear expression. Many practical problems like feed mix problem can be better expressed with a minimum of quadratic equation.
iii. *Constant Value of objective and Constraint Equations*. Before a LP technique could be applied to any feed mix problem, the values or the coefficients of the objective and constraints functions must be completely known and be constant over a period of time. If the values change during the period of study, the LP would loose its effectiveness and may fail to provide optimal solution to the problem. However, in practical sense it is not possible to determine the coefficients of objective function and the constraint equations with absolute certainty. These variables may lie on probability distribution curve and hence at best, only the likelihood of their occurrence can be predicted. Moreover, the values change due to extremely as well as internal factors during the period of study. \due to this, the actual application of Linear Programming tools may be restricted.

iv. *Fractional solutions often have no meaning.* There is absolutely no certainty that the solution to a LP feed mix problem can always be quantified as an integer quite often. It can give fractional answers which are rounded off to the next integer. Hence, the solution would not be the optimal one.

v. *Flexibility Limitation.* Once a problem has been properly quantified in terms of objective function and constraint equations and the tools of Linear Programming are applied to it, it becomes very difficult to incorporate any changes in the system arising on account of any change in decision parameter. Hence, it lacks the desired operational flexibility. Reducing the world to a set of linear equations is usually very difficult.

vi. *Multiplicity of Goal.* The long-term objectives of any farm are not confined to a single goal. Any farm, at any point of time in its operations has a multiplicity of goals or the goals hierarchy- all of which must be attained on a priority wise basis for its long term growth. In a case where farm manager's goals are multiple and conflicting, the LP method fails.

vii. *Degree of Complexity.* Many large-scale real life practical problems can be solved by employing LP techniques even with the help of a computer due to high complexity and lengthy calculations involved. Assumptions and approximations are required to be made so that the given problem can be broken down into several smaller problems and, then solved separately. Hence, the validity of the final result, in all such cases, may be doubtful.

2.2 Limitations of Existing Feed Formulation Methods.

Computer allows rapid formulation of rations that meet nutrient specifications at minimum cost. Because of the precision possible with the use of computers, it is tempting to forget that the formula produced is only reliable as the input data given to the computer. Nutritional specifications must be reviewed to take care of changes due to new research findings. Close attention to ingredient quality is essential for reliable formulation. Madueke (2004) while trying to look at the way to solve the problem of an ever increasing animal protein gap in Nigeria, recommended that there should be massive increase in livestock production at lowest possible cost. Though policy programmes in Nigeria Livestock Industry are still centered on the conventional livestock (cattle, sheep, goats, pigs and poultry) , their production has consistently remained low. The reason for this has being the huge capital requirements, high feed costs and poor management (Madubuike *et. al.* 2003; Mbanasor and Nwosu 2003). Oyenuga (1968) identified poultry as being animal produced in more percentage in Nigeria. Esonu *et al* (2001) reported that more than 50 percent of Nigeria's poultry farms have closed down and another 30 percent forced to reduce their production capacity due to high costs of livestock feeds. This livestock feed actually account for 70 to 80 percent of cost of livestock production against the 55 percent to 70 percent earlier reported by Pond and Maner, (Madubuike and Ekenyem, 2001).

3. Material and Methods

Neuro-fuzzy Animal Feed Formulation

Neuro-fuzzy animal feed formulation employs hybridization of two synergies in formulation of the animal feed. Lakhmi and Martin (1998) stressed the fact of the hybridization has many advantages over individual paradigms. Robbert (2001) described the OR and AND fuzzy neuron. Akinyokun (2002) employed the hybridized strength of neuro-fuzzy for evaluating human resources performance of academic staff of higher institution of learning. Rahib et. al (2005) developed neuro-fuzzy system for electricity comsumption prediction model.

Neuro-fuzzy algorithm for animal feed formulation

Enumerated below is the algorithm for the system

Step 1: Start

Step 2: *(Select the target vector from the recommended component levels for the animal type to be formulated for, which invariably forms the target vector).*

- Capture the recommended percentage nutrient level for the type of ration to be formulated. Specifically, those to be used as the control parameters.
- Organize the percentage parameters into a vector.
  The target will generate an input vector *p= (1x m) where m* is the number of feed requirement to be satisfied in the feed formulation.

Step 3: *(Select the available feed ingredients to be used in the feed formulation).*

- Select the feed ingredients to be used in the formulation

- Enter their percentage nutrient contents levels
- Organize these parameters into an m by n vector

  Vector *q*= *m x n*

  where *m* is the number of ingredients to be used in the formulation

  n in the number of the control parameters which is determined by the number of feed requirement to be satisfied in the formulation.

Step 4: Normalize the input vector *p* (*using minmax pre-processing function*)

Step 5: Fuzzify the input vector using sigmoidal membership function

$$f(x_k, \text{a}, \text{b}) = \frac{1}{1 + e^{-a(x_k - b)}} \quad (1)$$

where a is the maximum value for feed ingredient x_k

b is minimum value for feed ingredient x_k

and $1 < k \leq m$

Step 6: Adjust the weight of the elements of the network by training the

i. Network using the Levenberge training algorithm

$$\text{Q}x_{k+1} = x_k - [J^T J + \mu I]^{-1} J^T e \quad (2)$$

where x_{k+1} is the output of $(i+1)^{th}$ iteration

x_k is the output of the previous iteration

J is the Jacobian matrix that contains the first derivatives of the network

J^T is the transpose of the Jacobian matrix

e is the vector of the network errors.

μI is a scalar which is usually decreased at each consecutive iterations.

ii. Employ fuzzy multiple conjunctive antecedent inference method to form the inference layer of the system.

IF *x* is $P^{1,1}$ AND $P^{1,2}$ ... AND $P^{1,m}$ THEN *y is* Q^1
IF *x* is $P^{2,1}$ AND $P^{2,2}$ ... AND $P^{2,m}$ THEN *y is* Q^2
:
:
IF *x* is $P^{n,1}$ AND $P^{n,2}$ ... AND $P^{n,m}$ THEN *y is* Q^m

where $P^{n,r} = P^{n,1}$ AND $P^{n,2}$ ...AND $P^{n,m}$

$$\mu P^{n,r}(x) = \min\,[\mu p^{n,1}(x), \mu p^{n,2}(x), \ldots, \mu p^{n,m}(x)\,] \quad (3)$$

wher $p^{n,i}$ is membership value for nutrient content *n* of feed ingredient *i* $1 < i \leq m$; $1 < n \leq m$

Step 7: Deffuzify the output of the training (*Simulated output*) using (*minmax post-processing function*).

$$l(x_i) = \frac{\int \sum_{k=1}^{n} \mu p_k(x)dx}{\int \sum_{k=1}^{m} \mu p_k(x)dx} \quad (4)$$

where $l(x_i)$ is the defuzzified output value of feed ingredient x_i.

Step 8: Generate the percentages combination for the feed formulated for each components x_i for i = 1 to n.ʅ(x_1), ʅ(x_2), . ., ʅ(x_n)

Step 9: Multiply each Ƥ(x_1) by component digestible nutrients of individual ingredients in the feed ƕ(y_i).

Ƥ(x_1)*{ ƕ(y_1), ƕ(y_2), . ., ƕ(y_m)}

Ƥ (x_2)*{ ƕ(y_1), ƕ(y_2), . ., ƕ(y_m)}

Ƥ (x_n)*{ ƕ(y_1), ƕ(y_2), . ., ƕ(y_m)}

where ƕ(y_i) the percentage of the digestible nutrient *i* in each feed ingredient.

Step 10: Calculate the percentage nutrient and digestible nutrient contents.

Percentage digestible nutrient is calculated by equation (5)

$$q_i = \sum_{k=1}^{n} ƕ\, y_i \qquad (5)$$

where q_i is the total digestible nutrient *i* in the formulated feed.

Stop11: Stop

This study employs the output from the neuro-fuzzy animal feed formulation method in its study against National Registration Council (NRC) standards for chicks feed standard.

The specific research questions in this paper are listed below. They are tested at 0.05 levels of significance.

i) What type of relationship exist between the output of Neuro-fuzzy (NF), NRC 1971 and NRC 1994.
ii) What is the degree of relationship between the two (2) results ie. NF & NRC 1994.

To examine the above research question, statistical analysis tools to be employed are:

i) Scatter diagram will be used to depict the direction and the nature of the relationship that exist between NF and NRC 1994.
ii) T- test will be used to examine the nature of the relationship

$$H_0: \mu_d = 0$$

vs

$$H_1: \mu_d \neq 0$$

$$t_{n-1} = \frac{\bar{x} - \mu_0}{s/\sqrt{n}}$$

4. Results and discussion

The output of the neuro-fuzzy system compared with National Registration Council (NRC, 1994) is shown in table 1. Integrity of the system is test by comparing it with the control (NRC 1994).Analysis of the result is done on NCSS 2000 with alpha α=0.05.

(i) Plot section

The normal distribution plot of differences in fig 1a indicates normality that exist between the data (treatments).

(ii) Assumptions section: The test of assumption in fig 2 indicates that normality cannot be rejected for the treatments and that 0.889 correlation exist between the treatments.

(iii) T-test section : From fig 3, the p-value for this test is 0.977, which is much greater alpha (α) 0.005. Thus, the conclusion of this hypothesis is acceptance, i. e. there is no difference in the two treatments. (i e. NF and NRC 1994).

iv) Descriptive statistics: Fig 4 showed that the mean difference is 3.138375E-02 %, with standard deviation being 4.315441. the 95% interval estaimate for the mean difference ranges from -2.268152 to 2.33092.

Advantages of neuro-fuzzy animal feed formulation system.

Some of the advantages of neuro-fuzzy system which neuro-fuzzy animal feed formulation system inherited are as follows:

i. A multi-objective, purpose-driven animal feed formulation method.
ii. It is simpler to use because it involve simple input from the users while the system does the processing (all the complex computations) and produces the desired output to the system users.
iii. It incorporates the knowledge of miller's expertise into the feed formulation.
iv. It can compound as many target nutrient components as possible with a number of available feed ingredients
v. It combines the feed ingredients within a reasonable affordable limit.
vi. It can be applied for any type of animal feed once the recommended nutrient level and the nutrient contents of the available feed ingredients are known.

Limitation

With the neuro-fuzzy system, the number of targeted feed nutrients contents determines the number of feed ingredients to be employed in the formulation.

References

Adejoro S. O. (2004). A Hand Book of Poultry Feed Formulation in the Tropics. SOAVET Nig. Ltd, Ibadan and Center for Livestock Management Training Courses: 37-53.

Afolayan, M. O. and Afolayan, M.,(2008). Nigeria oriented poultry feed formulation software requirements. Journal of applied Sciences Research, 4(11), 1596-1602.

Akinyokun O. Charles. (2002). *Neuro-Fuzzy Expert System for Evaluation of Human Resources Performance,* First Bank of Nigeria Plc Endowment Fund Lecture, FUTA: 3, 7.

Bamiro, M.O., Shittu A. M. and Kola Olutokun, A. S. (2001). Private feed production as cost Reduction strategy: Effects on profitability of poultry business in Ogun state, Nigeria. The Ogun Journal ofAgricultural Sciences, 1(1):37 -51.

Bamiro, M. O., Momoh S. and Philip, A. O., (2009). Vertical integration and profitability in Poultry industry in Ogun and Oyo states, Nigeria, Journal of Hum Ecol, 27(2): 149-154.

Imamidoost, K. (1992). Using IMAMI Method in Ration Formulation.

Jerry, D. (2003). *Feed Reference Standards*, Philippine, PHILSAN.

Lakhmi C. Jain and Martin N. M (1998). Fussion of Neural Networks, Fuzzy Systems and Genetic Algorithms: Industrial Applications. CRC Press LLC. Santa Clara, CA 95052, USA. pp. 90 – 96.

Madubuike, F. N. (2003). *The Potential use of white Star Apple seed (Chrisophyllum albidum) an Physic nut (Jatropha curcas) as feed ingredients for rats.* Journal of Agriculture and Food Science. 1(2); 97-105.

Madubuike, F. N. (2004). *Arresting Animal Protein Insufficiency in Nigeria*: *A Multi-Sectorial Approach.* Journal of Agriculture and Food Science. 2(2); 141-145.

Madubuike, F. N. and Ekenyem. B. U. (2001). *Ruminant Animal Production and Handling in the Tropics.* Alphabet Nigeria Publisher, Owerri, Nigeria.

Mark A. Schulze, (1998). Linear Programming for Optimization. Perspective Scientific Instruments, Inc.

Nbanasor, J. A. and Nwosu. A. C (2003). *Livestock Sector in Nigeria Economy:Policy Direction.* Journal of Agriculture and Food Science. 1(2); 141-147.

Oladoja, M.A. and Olusanya, T.P., (2009). Impact of private feed formulation and production as a tool for poverty alleviation among poultry farmers in Ogun state, International Journal of Poultry Science 8(10), 1006 -1010.

Onwurah, F. B., (2005). Excel Feed Formulation and Feeding Models, Proceeding of 1st International Technology, Education and Environment Conference, African Society for Scientific Research (ASSR), pp 192-199.

Oyenuga V. Adenuga (1968), *Nigeria's Feeds and Feeding-Stuffs: Their Chemistry and Nutritive Value*. University Press, Ibadan; 6-8.

Rahib A.; Vasif H. A. and Cemal Ardil (2005). Electricity Consumption Prediction Model using Neuro-Fuzzy System. World Academy of Science, Engineering and Technology, 8: 128- 131.

Thomas S. Ferguson, (). Linear Programming: A Concise Introduction.

Udoh, E. I. and N. A. Etim, (2008). Determinants of technical efficiency in poultry production. The case study of Urban Broiler Farms in Calabar, Nigeria.33rd Annual conference of the Nigeria Society for Animal Production. Ogun-NSAP, 320

Table 1 Output from Neuro-fuzzy (NF) and NRC 1994 for amino acid content in chicks feed.

Ingredients	**NF**	**NRC (1994)**
Arginine	0.558	1.4
Histidine	0.127	0.65
Isoleucine	0.28	10.18
Leucine	0.4588	2.2
Lysine	0.33234	1.22
Phenylalanine	0.3049	1.41
Tyrosine	0.184	0.79
Cystine	0.075	0.53
Methonine	0.1334	0.52
Threonine	0.2316	0.94
Tryptophan	0.073	0.39
Valine	0.3111	1.3
Crude protein	31.71	23.85
Ether Extract	16.97	6.5
Crude Fiber	9.54	8.38
Metabolizable Energy (Kj/g)	2.749	3.276

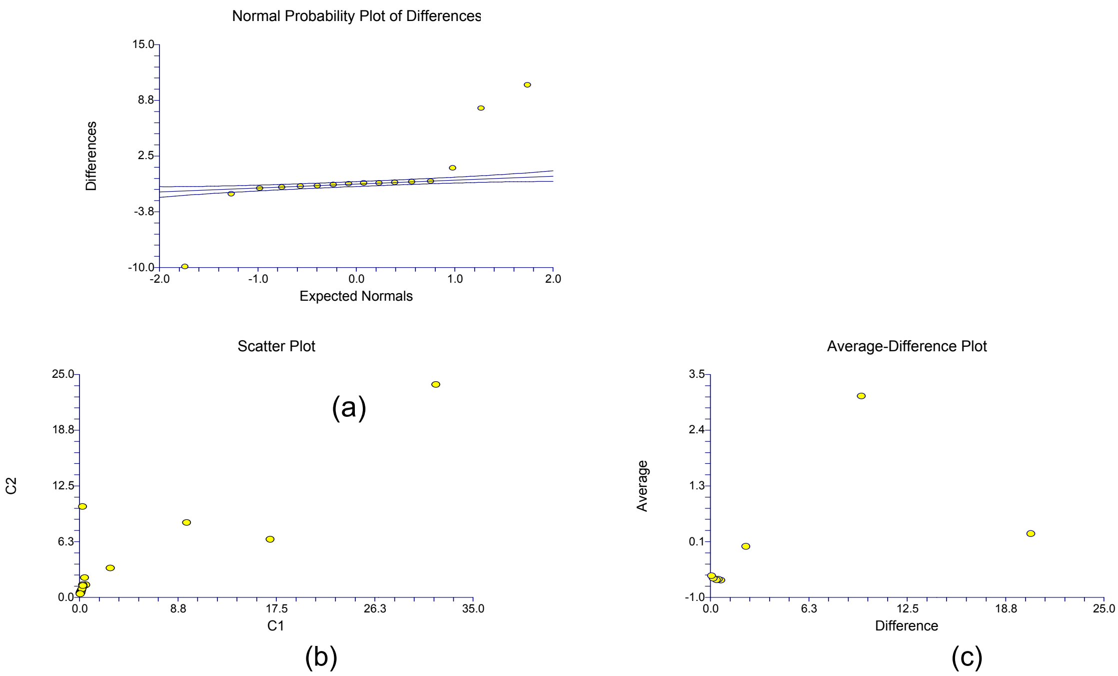

Fig 1a. Norm probability plot of difference b. Scatter plot of NRC 1994 against NF c.. Average-difference plot

Assumption	**Value**	**Probability**	**Decision (5%)**
Skewness Normality	1.0936	0.274152	Cannot reject normality
Kurtosis Normality	2.2865	0.022227	Reject normality
Omnibus Normality	6.4238	0.040280	Reject normality
Correlation Coefficient	0.888608		

Fig 2. Test of assumptions about differences

Alternative Hypothesis	**T-Value**	**Prob Level**	**Decision (5%)**	**Power (Alpha=.05)**	**Power (Alpha=.01)**
C1-C2<>0	0.0291	0.977177	Accept Ho	0.050085	0.010025
C1-C2<0	0.0291	0.511412	Accept Ho	0.047197	0.009312
C1-C2>0	0.0291	0.488588	Accept Ho	0.052934	0.010732

Fig 3. T-test for differencebetween means

			Standard	**Standard**	**95% LCL**	**95% UCL**
Variable	**Count**	**Mean**	**Deviation**	**Error**	**of Mean**	**of Mean**
C1	16	4.002384	8.705559	2.17639	-0.6364809	8.641249
C2	16	3.971	6.098962	1.524741	0.7210924	7.220908
Difference	16	3.138375E-02	4.315441	1.07886	-2.268152	2.33092

T for Confidence Limits = 2.1314

Fig 4. Descriptive statistics