

Nigeria Oriented Poultry Feed Formulation Software Requirements

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Abstract: This paper describes a design requirement of feed formulation software for poultry industries in Nigerian. Nigeria based ingredients and United States Department of Agriculture (USDA) Nutrient Database – SR20 were recommended for special consideration. Factors like acceptability of the feed by the birds, palatability, digestibility and the cost of feed production and the presence of anti-nutritional factors which may tie down the nutrients contained in the feedstuff must be built in as the users are not going to be experts. Stochastic Method on Feed Formulation is recommended as great ingredient variability should be expected.

Key words: Ration, Ration Formulation, Least-Cost Ration Formulation, Linear Programming, Poultry

INTRODUCTION

Ration can be defined as the total amount of feed given to the animals on daily basis. While ration 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. Poultry are domesticated birds raised for meat or egg production examples are; Chickens, ducks, turkeys, guinea fowl, pigeon, ostrich e.t.c.

Poultry feeding is a major item of cost in poultry production in Nigeria, feed cost accounts for over 70% of the total cost of producing eggs and broiler production. Many commercial farms had collapse while a good number out of them witness slow growth due to sudden increases in the cost of poultry feeds[2]. In other to maintain a reasonable margin of profit despite the rising cost of raw materials and labour, there must be a design to reduce the cost of production and still maintain high level of performance in the birds. Otherwise the prices of poultry products (eggs and meat) will increase significantly. This is because of the facts that, increase in the prices of raw materials would definitely lead to increase in the prices of the finished feeds[2].

Furthermore an ideal ration must contain the required level of nutrients at minimum cost. This can be achieved with the aid of least cost ration formulation using computer. This method of ration formulation is greatly used in large scale compound feed formulation, because of its advantages in eliminating human errors in calculation and speed. The farmer is much more interested in the cost of the final mix (net profit). Hence, least cost ration formulation techniques have therefore, been employed to obtain diets that meet specific requirements from readily available ingredients at the lowest cost[2].

Efficient ration formulation requires; proper knowledge of the feedstuffs, nutrients contained in the feedstuff as well as the type of animal to be fed with such ration to ensure optimal production at a reasonable cost. The ration should be palatable enough to encourage adequate consumption by the animals, and efforts should be made to ensure that such ration will not cause any serious digestive disturbance or toxic effects on the animal[3-7,9,4].

Different Species, Strains or Classes of animals have different requirements for energy (Carbohydrate and fats), proteins, Minerals, and Vitamins in order to maintain its various functions like body maintenance, reproduction, egg production, milk production and meat production e.t.c. Formulation of poultry feed is a highly complex exercise. It involves selecting a combination of feed ingredients that adequately meet stated nutrients and other requirements of livestock. Achieving a technically satisfactory feed as cheaply as possible is referred to as “least cost” formulation and is the basic objective of both commercial and on-farm feed millers[3]. Formulation of Rations for poultry emphasizes the use of linear programming using a computer to derive the least-cost ration. Reasonable cost refers to least-cost technique. Ration formulation does not merely involve mathematical calculation to meet the requirement of the birds, since the result of the calculation may turn out to be impractical and not

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ideal for feeding the birds. Therefore there is the need to evaluate the feed formulation before it can be given to the birds\cite{9,4}.

**Important Considerations in Feed Formulation:**
Among such factors to be considered in making good feed formulation are:

- **Acceptability to the birds:** The ration being formulated has to be palatable enough to stimulate intake by the birds. Any feed refuse by the bird is worthless, since the feed has to be consumed by birds to serve its purpose.

- **Digestibility:** The nutrients in the feed have to be digested and released into the gastrointestinal tract to be utilized by the animals. For instance, rations with high fiber content cannot be tolerated by poultry.

- **Cost:** The requirement of the birds can be met through several combinations of feed ingredients. However, when the costs of these ingredients are considered, there can only be one least-cost formulation. The least cost ration should ensure that the requirements of the animal are met and the desired objectives are achieved.

- **Presence of Anti-nutritional Factors and Toxins:** This affects the digestion of some nutrients by making them unavailable to the birds. e.g. anti-trypsin factor in soybeans, meal. Some feed ingredients may also contain toxic substances which may be detrimental to the animal when given in excessive amounts. The inclusion of these ingredients should be limited or eliminated from the formulation\cite{9,4}.

**Methods of Formulating Feed:** There are several methods of in formulating rations; all of them have the same objectives of providing the required balanced nutrients at the least possible cost. Some of these methods are:

**Pearson Square Method:** Some of the merits of this method of feed formulation include:

- It is relatively simple direct and easy to follow
- It is useful in balancing for the protein requirements

Some of the limitations of this method are:

- It uses only two feed ingredients
- Less consideration is given to other nutritive requirements, vitamins and minerals\cite{9,4}.

**Simultaneous Equation Method:** This is an alternative method for the Pearson Square method using a simple algebraic equation.

The advantages of this one over the Pearson Square method is that

- One can balance for both the protein and the energy.
- It is also useful in considering more than two feed ingredients at once when balancing more complex rations

**Trial-and-error Method:** This is the most popular method of formulating rations for poultry. As the name implies, the formulation is manipulated until the nutrient requirements of the birds arrived at. Trial-and-error method can be done manually on paper or with the aid of a computer using programme like spreadsheet e.g. Excel, Lotus123, and Quattro pro.

This method makes possible the formulation of a ration that meets all the nutrient requirements of the birds\cite{9,4}.

The limitation of this method is that; it is laborious and takes more time before one will arrive at a fairly satisfactory result.

**Two –By-two Matrix Method:** This method solves two nutrient requirements using two different feed ingredients. A 2 x 2 matrix is set and a series of equations are done to come up with the solution to the problem\cite{9}.

**Linear - Programming (LP)**\cite{9}: This is the common method of Least Cost Feed Formulation. This method was first developed in 1947 by G.B. Dantzig to solve some U.S. Air Force planning problems but now it is widely used in all types of fields.

This is a method of determining the least-cost combination of ingredients using a series of mathematical equations. A standard linear programming model, in matrix form, may be stated as follows.

\[
\text{Minimise } \sum_{j=1}^{n} c_j x_j \quad (j = 1, 2, \ldots, n)
\]

\[
\sum_{j=1}^{n} a_{ij} x_j \geq b_i \quad \sum_{j=1}^{n} a_{ij} x_j \leq b_i \quad \sum_{j=1}^{n} x_j = 1 \quad x_j \geq 0
\]

where

- \( c_j \) = Cost per unit for jth ingredient
- \( x_j \) = Quantity of jth ingredient
- \( a_{ij} \) = Quantity of ith nutrient per unit of jth ingredient
- \( b_i \) = Requirement for ith nutrient in the diet
There are many possible solutions to the equations, but when the factor of cost is applied, there can only be one least cost combination\(^4\).\(^9\)

According to the Free Online Dictionary of Computing\(^3\), Linear Programming is defined as a procedure for finding the maximum or minimum of a linear function where the arguments are subjects to linear constraints.

As earlier indicated, LP is preferred for poultry feed formulation. Almost all the references consulted use LP technique, the reason being that variant (feed ingredient) are not expected to change property because of mixing, i.e. every unit of a least cost feed formulated ration has the same productivity regardless of ingredients sources\(^{10}\).

**Stochastic Method**\(^9\): Simple diets can be formulated using either Pearson’s Square or simultaneous equations methods. Both of these methods are unable to handle inequalities or ranges and both are independent of price. An alternative to this method is Stochastic Method. In real life nutrient composition is highly variable. This variation is associated with variety of factors which include variation of nutrient content of ingredients coming from different batches and sources and variation attributed to the laboratory procedure and human error. For example if same sample of soybean is analyzed multiple times for protein content, it is very likely that every time a slightly different value will be obtained. In Linear Programming method a mean value of these analytical values is used for formulation. Statistically, these mean values are associated with only 50% confidence of meeting the requirements in prepared formula. Most feed manufacturers want to minimize the risk of not meeting the nutrient requirements of the animal. The following two methods have been proposed to minimize this risk.

- Application of safety margin in linear formulation
- Use of Stochastic Programming

In the first solution diets are formulated at 5-10% higher than requirement. This is an unsatisfactory solution from quality control and economic points of view because it does not account for variation level. Nutrient variation could be higher enough to exceed safety margin level. In case where variation level is low, the formulated diet will be unnecessarily expensive. This will result in economical loss of the Feed manufacturer or livestock farmer. The second solution Stochastic Programming has been widely recommended for feed formulation. The term Stochastic comes from the Greek word meaning skillful at aiming. In modern terms, stochastic has become a statistical word referring to variables that are random or uncertain.

The standard form of constraints in linear programming is as follows.

\[
\text{Minimise } \sum_{j=1}^{n} c_j x_j \rightarrow (j=1, 2, 3, \ldots, n)
\]

subject to

\[
\sum_{j=1}^{n} a_{ij} x_j \geq b_i, \quad \sum_{j=1}^{n} a_{ij} x_j \geq b_i
\]

If a user wishes to increase the success rate of meeting the \(i^{th}\) nutrient in the diet up to or to fall below the level \(b_i\), to a probability of \(P > 0\), then both constraints will be modified as follows

\[
P\left(\sum_{j=1}^{n} a_{ij} x_j \leq b_i\right) \geq q_i, \quad P\left(\sum_{j=1}^{n} a_{ij} x_j \geq b_i\right) \geq q_i
\]

Because the above constraints are nonlinear so they could not be solved using software that formulates least cost diets by linear programming. This form of constraint is solved by stochastic programming. Thus Stochastic Programming provides assurance of meeting the requirement of animals to a greater probability – statistically at a value greater than 90%.

Win Feed (http://www.winfeed.com) is the only commercial software with this capability till date as afar as the authors know. WinFeed uses standard deviation of variability to meet required degree of assurance.

**Merits of Formulated Rations - Using Computer:**

- Least cost minimizes the cost of ration, given a certain set of ingredients and their nutritional content which is done in real time using a computer\(^\[1\]\).
- It is convenient and saves manpower.
- It is a choice for the commercial feed Millers who handles large no of ingredients\(^\[1,14\]\).
- It allows ‘least cost’ diet formulation using the specific information fed into them.
- It eliminates human error both in calculation and in speed\(^\[2\]\).

**Examples of Software That Use Linear Programming for Feed Formulation:**

- Winfeed\(^\[15\]\)
- MIXIT (various version exist)\(^\[14\]\)
- Winpas\(^\[16\]\)
- Feedlive\(^\[17\]\)
- EGGPRO Version 2.0\(^\[14\]\)
- Feed Mania\(^\[14\]\)
Examples of Software That Use Stochastic Method in Feed Formulation: Winfeeds\textsuperscript{[13]} is the only commercial feed formulation software that uses stochastic method known to the authors.

Design Criteria for Nigeria Oriented Feed Formulation Software:

Simplified Interface: Quite a number of the reviewed feed formulation software has a rather cryptic interface from the angle of a non nutritionist. Nigeria farming system is mostly small scale and the farmers are usually non-expert in that field. A simplified Nigeria oriented model is required to take away the formidable work of formulating feeds to ones heart content using (especially) raw material in one locality. Issues like Nutrient percentages, Ingredient ratios and other expatriates terminology will not be appealing to ‘plain old farmer’ though educated (in another fields).

The Desired Interface Should Have These Steps as Shown in Figure 1:

Select Animal Kind: Select the animals you want to formulate feed for. This will make the software to determine which routine to follow in its analysis. This is needed as the software could be switched over to work for other farm animals. At this juncture, we need to realize that Nigerian farmer is most likely to rear other animals. Therefore, a universal approach should be used in implementing its design.

Select (Available) Ingredients: The next logical step is to allow the end user to select what he/she has to offer the animals. This requires extensive database of available feed stock in Nigeria. Fortunately, the USDA SR20 has a major coverage of these ingredients and should be adopted. Also this Hand book on Energy Value of Foods (Basis and Derivation)\textsuperscript{[12]} will be useful in establishing the data for a new localized ingredient.

Specify (Output) Quantity: This is the quantity that is to be formulated for. A universal unit is kilogram, gram, pounds and ounces. But a rough estimation is that of the use of Bournvita, Milk and Tomato tins (those that have standardized volume). A built in conversion mechanism will be needed as user may have very poor understanding of the metric system.

View (Formulated) Output: This output should be in the form easily understood. For example – a Table of number of tin of maize, number of tomato tin of salt, number of tea spoon of Methionine.

Additionally, the following facility should be inclusive so as to handle all ranges of people or users;

- The Advance Mode is meant for advance user – the nutritionist and knowledgeable individuals. This will allow them to fine tune processes as they like – like choosing between formulation method to follow, ingredient ratio, custom palatability index etc.

Language Switch: A notable local implementation is the language switch. This will allow the software to use any Nigeria language. The language interface (very advance) will allow each graphical element description or label to be given local language spellings and name. Also, the output should be in the local language.

Time Zone: Serious automation is needed if the software will be universal and successful. The time and zone will allow the software to determine what period of time or rather the season the formulation is meant for. It has being established that season has significant influence on performance of poultry\textsuperscript{[11]} and perhaps other animals.

Further more, theses addition will make it user friendly:

- Ability to choose between formulating for best performance or cheapest cost. There are situation in which the animals are raised for home consumption, cost may not be very important in this case. A typical case are Geese force feed to make them have oversized liver.

Ingredient Mixing Order: Commonly, shovel or drum mixer are used, but the order the feeds are added matters. A concentration of pre-mix can spell danger for the animal – such as Salt poisoning\textsuperscript{[13]}.

Finally an interface to update ingredient list. The interface at this point may have an internet link to download updated ingredient data or upload a new ingredient request for analysis by the developer or agency. A simple SMS may be very useful for the uploading as well.

Other Design Factors:

Local Ingredients and USDA Ingredients: The USDA SR20 has 7519 distinct food list including things like ‘Cassava - 11134’ with 46 analysis of the food content for each of these foods. There are other information within this free database that can be profitably harnessed for the feed formulation software being described here. The unfortunate thing is that the locally processed form like ‘dried fufu’ will not be found there. This is where the local content has to come in – remembering that we are designing software for all kind of ingredients available to the farmers in NIGERIA. As described under the Simplified Interface section, a means of seamlessly updating the built in database is required bearing in mind that the end user are likely not very literate in information technology.
A simple solution is a regular publication in the National Newspaper and provision of interface to enter the information (as minimum as possible).

**Extensibility - Link to Spreadsheet and ASCII files:** Information for updating and exchange should be in a popular format. Spreadsheet and ASCII editor are common. The Farmer especially the startup will likely be using used computers that may not be able to run modern program at optimum or in real time.

**Data File Update:** The ingredient (and nutrient) data update can be made available in simple text form and send by sms, email and other electronic messaging system cheaply. The selection of plain text is to simplify transmission and readability. At this point a data crunching mechanism will have to be employed to crunch much information into the 160 maximum character of a single sms (worst case of very poor farmer assumed – i.e. many farmers should not be expected to have internet access).

**Cost/ Economy:** One common problem with the reviewed feed formulation software and all other foreign software is that they are very expensive and that is even if you are able to lay hand on them without some form of restriction. We are neither talking about warez here nor encouraging its use, software development is a profession on its own; it cost fortune to acquire the knowledge to write commercial code with it. The development of the Feed formulation Software being described will have cost in its basis for its design. The cost issue could be tackled in this manner;

- A sponsoring agent will pay for its development and distribution
- Exotic add-on should be omitted to give attention to functionality
- GNU free code snippet should be used to make development faster
- Public domain database such as USAD SR20 should be used
- Third party freelance individual should be encouraged to provide information such as ingredient database. This effort will be rewarded by stamping (crediting) their names everywhere their information is used.
- Undergraduate and post graduate student could also contribute to coding.

**Visual Interpretation – Charts:** Visual clue helps to visualize the result of the formulation. Simple bar chart or pie chart is sufficient.

**Palatability Index and available Nutrient:** Just like for human being, not all good looking foods are sweet to the mouth. Palatability is an indication of the
willingness of the animal to go for the food. Another problem is nutrient availability, some ingredient may show an analysis of being high in a particular nutrient but when eating, they are unchanged or un-extracted - kind of ‘garbage-in-garbage-out’. An uninformed farmer/user can be helped out by programming this into the ration being formulated. All the reviewed software claim that the end user guides in the final decision and selection. This will not work for our Nigeria environment as said earlier.

**Design Algorithm:**

**Database Structure:** A relational database with the following schema could be employed with projected fields (for future reference and expansion and backward compatibility):

- The main database
- The ingredient Description Database
- House keeping Records

**The main database Schema:** This contains a record for each ingredient in the following manner:

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Data type</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index field</td>
<td>Integer</td>
<td></td>
</tr>
<tr>
<td>Link field</td>
<td>Double</td>
<td></td>
</tr>
<tr>
<td>Food code (USDA code)</td>
<td>Text</td>
<td>Compatibility with USDA R20</td>
</tr>
<tr>
<td>Food category code (USDA based)</td>
<td>Text</td>
<td>Levels in appropriate units</td>
</tr>
<tr>
<td>Nutrient a</td>
<td>Double</td>
<td></td>
</tr>
<tr>
<td>Nutrient b</td>
<td>Double</td>
<td></td>
</tr>
<tr>
<td>Nutrient c</td>
<td>Double</td>
<td></td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>Nutrient n</td>
<td>Double</td>
<td></td>
</tr>
<tr>
<td>Palatability Index</td>
<td>Double</td>
<td></td>
</tr>
<tr>
<td>Availability Index</td>
<td>Double</td>
<td></td>
</tr>
<tr>
<td>Nutrient a)</td>
<td>Double</td>
<td></td>
</tr>
<tr>
<td>Availability Index (Nutrient b)</td>
<td>Double</td>
<td></td>
</tr>
<tr>
<td>Availability Index (Nutrient c)</td>
<td>Double</td>
<td></td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>Availability Index (Nutrient n)</td>
<td>Double</td>
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</tr>
</tbody>
</table>

**The Ingredient Description Database:**

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Data type</th>
<th>Remark</th>
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</thead>
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<tr>
<td>Index field</td>
<td>Integer</td>
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</tr>
<tr>
<td>Link field</td>
<td>Double</td>
<td></td>
</tr>
<tr>
<td>Food Description</td>
<td>Text</td>
<td>USDA R20 and Local content</td>
</tr>
<tr>
<td>Local name 1</td>
<td>Local Language description</td>
<td></td>
</tr>
<tr>
<td>Local name 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local name n</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**House Keeping:**

These include:

- Temporary file to keep formulated feed information
- Import and Export manager for advance user
- Database integrity monitor
- User monitor and Audit Trail Records
- Password Access control list – ACL

**Conclusion:** Importing finished product has never helped us to be independent; we need to develop our own software with Nigeria as a focus. Our need is not the other country need, our weather differs, our resources differs as well. Nigeria has a lot of man power to implement this software and it is suggested that a team programmer be encouraged to work on this as “nothing goes in if food has not entered first”.

**REFERENCES**

3. FOLDOC (Free Online Dictionary of Computing.) http://www.foldoc.org


17. http://www.liveinformatics.com