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Short communication

UNEForm: a powerful feed formulation spreadsheet suitable for teaching or on-farm formulation

Evan Thomson*, John Nolan

Animal Science, School of Rural Science and Natural Resources, University of New England, Armidale 2351, Australia

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Abstract

Feed-formulation software using linear programming is commercially available and very capable. However, for teaching and small-users commercial software packages are expensive and have an element of the 'black box' about them — the calculation processes are not always readily apparent. The Excel© spreadsheet described is very flexible, easily modified to suit the needs of individual users, and uses the power of modern spreadsheet software to provide excellent least-cost diet formulation. It can also be used stochastically for practical and demonstration purposes.
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1. Introduction

The application of computers in feed formulation has been a boon to nutritionists. In teaching diet formulation the usual sequence of events includes an introduction to stochastic methods (successive 'guesses' to approach the desired result), Pearson squares and linear programming. Simple linear programs have been with us for many years, and most of the commercial feed-formulation software has such an engine at its heart. For teaching purposes such software has two drawbacks: cost, and the calculations are something of a 'black box' with only the inputs and the final results visible.

Previously developed software for teaching purposes includes UFFDA (Pesti and Miller, 1992), a purpose-designed program that was developed into a commercial product. Other Excel© templates have been developed (for example, LINEAR.xls and RANDB.xls, University of Georgia, available from their web-site).

* Corresponding author. Tel.: +61-2-6773-3024; fax: +61-2-6773-3275.
E-mail address: ethomson@metz.une.edu.au (E. Thomson).

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The capability and flexibility of modern spreadsheet programs induced us to develop a rudimentary database for use in stochastic formulation exercises. More recently, the model has been extended to make use of the linear programming capability of the 'solver' function in Excel©. The workbook as presented here has been a useful tool in our undergraduate teaching program. The inclusion of a graphical representation of the formulated versus desired nutrient supply has given users a greater appreciation of the degree to which any diet formulation deviates from the desired result.

2. Description

The Excel© workbook consists of one descriptive and four functional worksheets designated 'instructions', 'nutrients', 'ingredients', 'UNEForm' and 'output'. These worksheets are described in more detail below.

2.1. Instructions

This sheet contains brief but reasonably comprehensive instructions on the use of 'UNEForm', a brief bibliography and contact details. It is not an instruction manual for Excel© spreadsheets, but rather a concise operating manual for the specific feed formulation application.

2.2. Nutrients

The 'nutrients' sheet is divided into two sections, the current requirements box and the nutrient requirements lists. The desired nutrient list is copied from the nutrient requirement lists to the current requirements box, or entered directly. New lists can be entered or current ones edited quite simply. The current requirements box automatically appears in the 'UNEForm' sheet. For teaching purposes the 'nutrients' sheet is 'protected' to prevent accidental alteration of the lists. The current requirement is left unprotected and may be edited at any time (Fig. 1).

2.3. Ingredients

This sheet has two sections, the active ingredients box and the possible ingredients list. The active ingredients box holds up to 16 ingredients, with their nutrient breakdown (currently 19 nutrient parameters are used) and price. These are copied from the possible ingredients list (maximum number of ingredients in this list is virtually unlimited) and pasted into the active ingredients box as required (Fig. 2).

This arrangement makes it a simple matter to add new ingredients to the list. All ingredients in the active ingredients box automatically appear in the 'UNEForm' sheet. For teaching purposes the sheet is 'protected' to prevent accidental alteration, leaving only the active ingredients box alterable. The data set originally provided in the possible ingredients lists is a subset mostly selected from 'Nutrient composition of feedstuffs for pigs and poultry' (Evans, 1985).

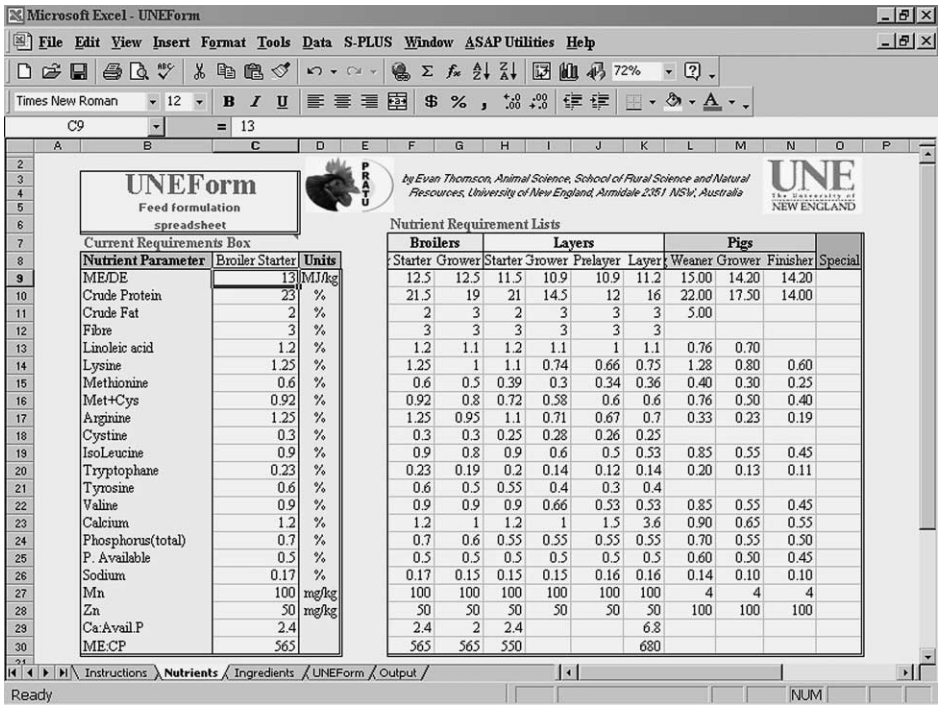

Fig. 1. 'Nutrients' sheet.

2.4. UNEform

This sheet is the area of most interest where diet composition can be altered and the consequences evaluated. The main view contains two tables, the feed formulation box and the feed composition (Fig. 3). The use of 'conditional formatting' options permits the flagging of unusual or out of range values, which greatly facilitates the 'debugging' of formulations. The amount column of the feed formulation box may be completed manually (stochastic method). The total must equal 100 or it will flag brilliant red. The cost and feed composition tables are displayed. The supplied values are also displayed in bold red whenever they fall outside an acceptable preset range from the requirement values. The preset ranges may be adjusted by any competent spreadsheet user if necessary.

A useful feature of the sheet is the column graphs representing the supplied nutrient values as a percentage of the required nutrient value. The percentages are calculated in cells linked to the feed composition table and the resulting graphs reflect the current state of the formulation at all times (Fig. 4). The graphs are seen by scrolling down one page with the 'page down' button or by use of the mouse. The calculations involved in generating the feed composition table are displayed in the calculation table, found by scrolling to the right in the 'UNEForm' sheet.

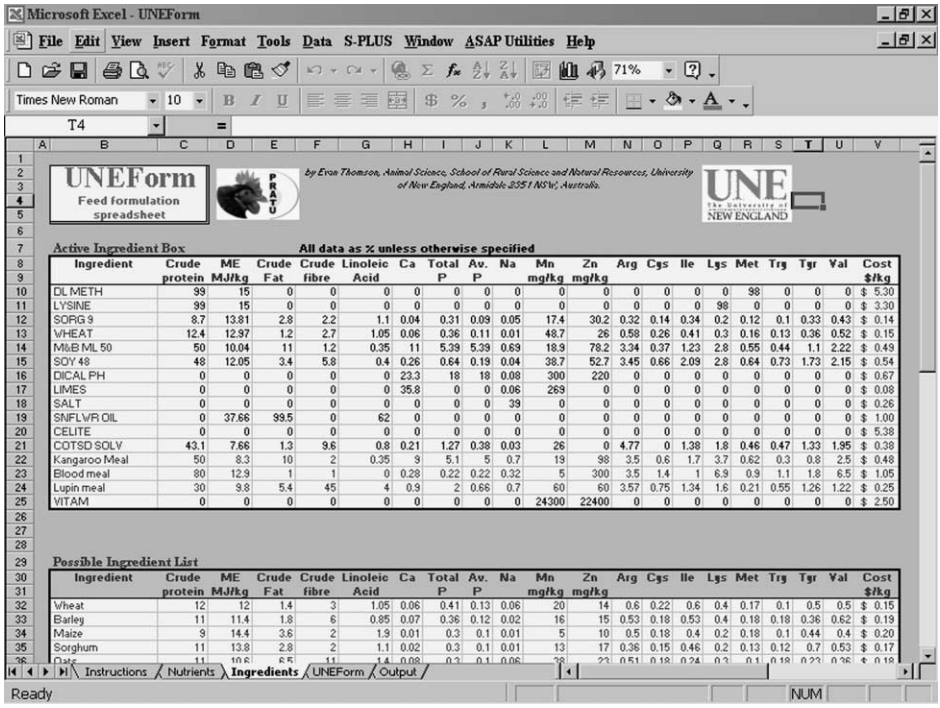

Fig. 2. 'Ingredients' sheet.

2.5. Linear programming

Users of Excel© need to ensure that the solver function has been implemented. In most installations the user will need to go through tools, add-ins to activate the solver before proceeding. The 'UNEForm' sheet must also be unprotected before using the solver function. The cells in the amount column of the feed formulation box are best set to zero before starting. The solver parameters dialog box has an 'Options' button, which allows access to a submenu, where the assume linear model option should be selected. Returning to the previous menu allows completion of the formulation (Fig. 5).

The cost/tonne is selected as the target cell and is set to seek minimum value. The cells in the amount column of the feed formulation box are selected as the cells to change. Finally, the constraints are set in the subject to the constraints window. setting the constraints, along with the setting of nutrient requirements is, for many users, the most significant educational experience in learning to formulate diets for animals.

Upon choosing the 'solve' button in the solver parameters dialog box, the optimum diet will be produced, and the options to save the new values and to view ancillary sensitivity reports will appear. These reports, if invoked, give useful information, such as the price changes necessary for unused ingredients to be included, and other aspects of the formulation (Pesti and Seila, 1999).

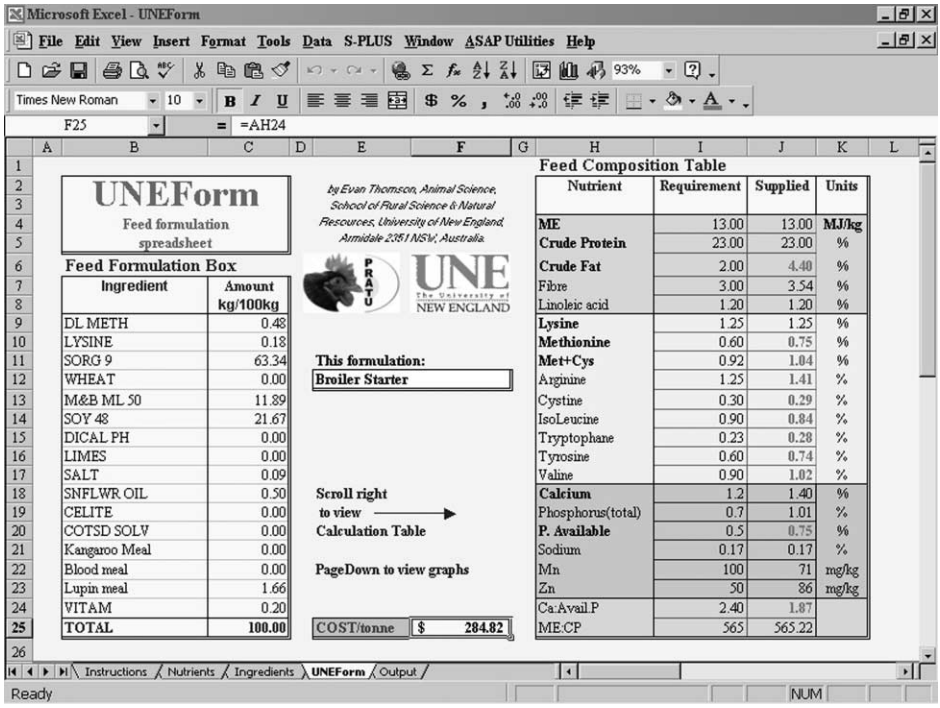

Fig. 3. 'UNEform' sheet.

2.6. Output

The 'output' sheet is formatted to give a single A4 page printout of the formulated diet, with costs, nutrients and the two graphs included (Fig. 6).

3. Discussion

The development of this spreadsheet has been a sporadic process over 3 years. Our goal has been to develop a robust and functional feed formulation facility that would allow the production of practical diets while allowing easy inspection of all parts of the process. It was also desirable to make the program as logical and intuitive to use as possible.

In our teaching of the principles of least-cost diet formulation to undergraduate students, we have a preliminary period of instruction in stochastic principles. We ask the students to formulate a simple least-cost diet for laying hens from maize, soybean meal, limestone chips and mineral mix. Small groups of students compete to see which group can arrive at the best least-cost diet that meets our preset conditions. This exercise allows the students to understand the calculations that are generated in the calculation table when ingredients of different composition and price are combined to give single values for outputs, such as ME content, crude protein content and price of the formulated mix.

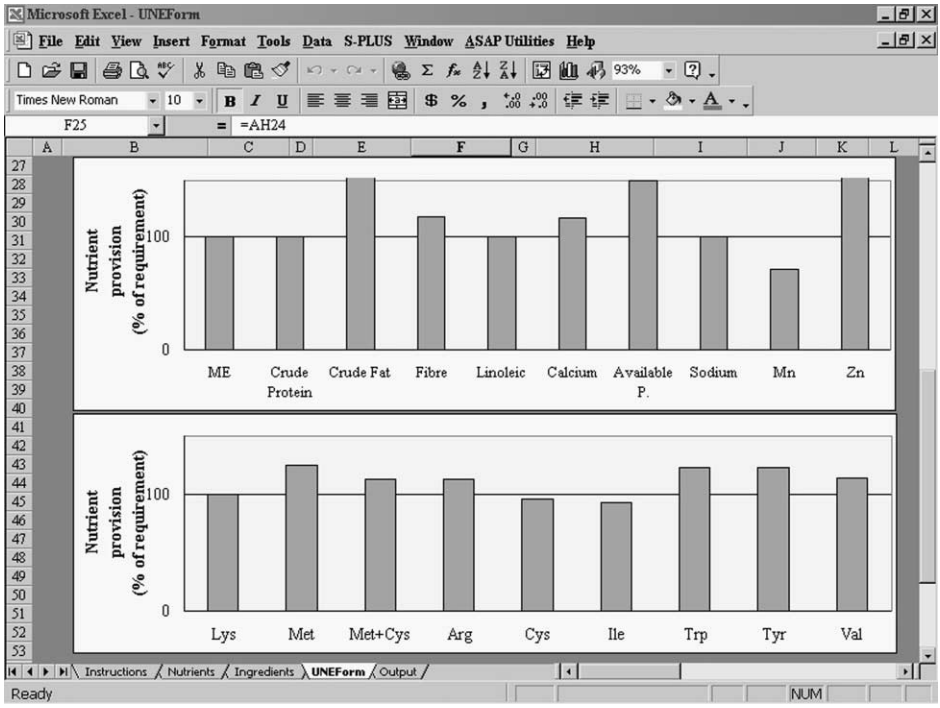

Fig. 4. Graphical representation of supplied nutrients as a percentage of requirement.

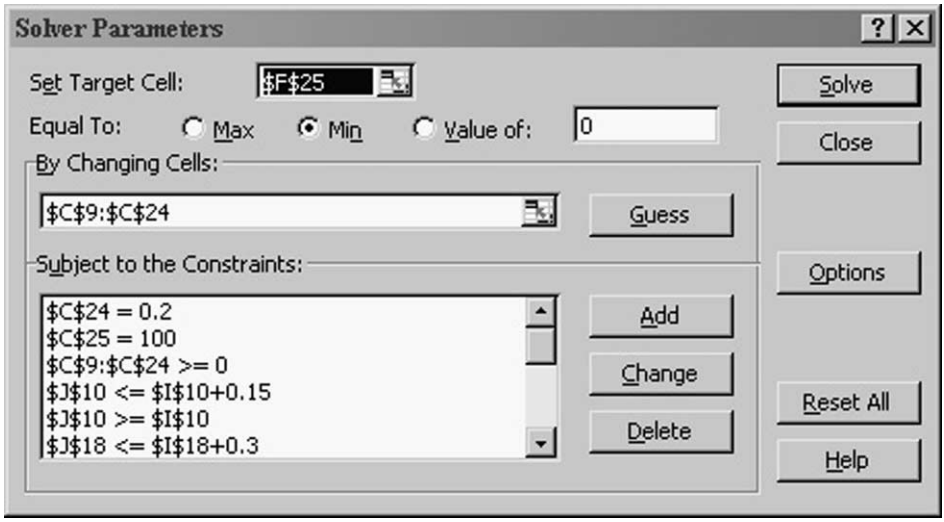

Fig. 5. Solver parameters dialog box.

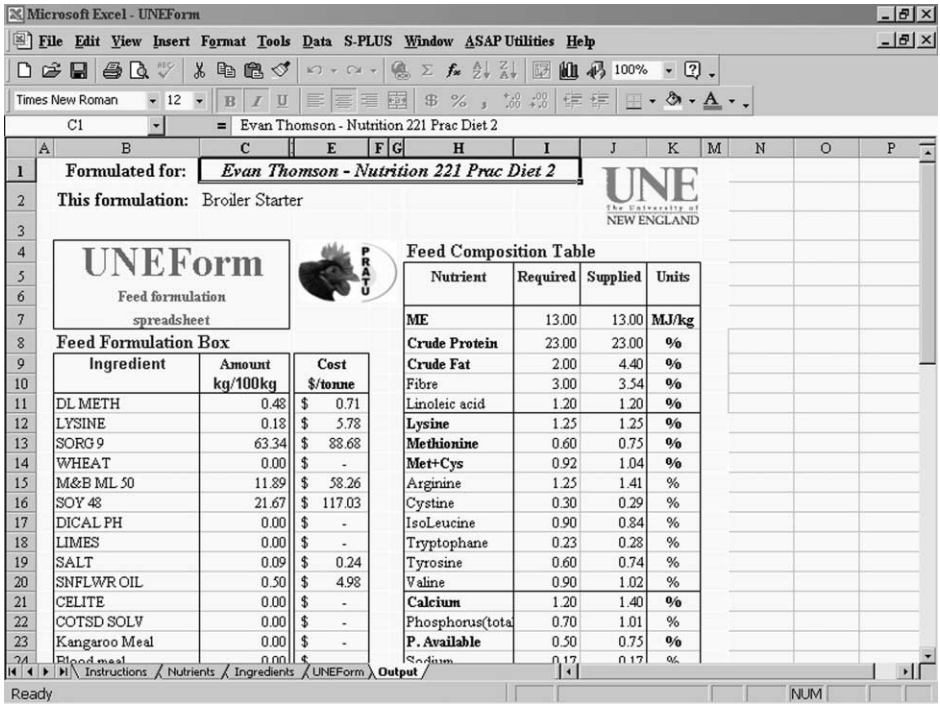

Fig. 6. View of the 'output' sheet.

The development of an appropriate requirement is of course crucial to the formulation of a suitable diet, and forms the first point of application of nutritional knowledge to any practical feeding problem. A basic set of guidelines for poultry and pigs is provided, largely taken from McDonald et al. (1995). These can easily be modified to allow for changing circumstances or better knowledge of the requirements of the target animals. This also facilitates discussion of requirements, the level of growth desired and formulation for profit versus maximum growth.

The process of selection of ingredients has the advantage of having the user observe the nutrient supply matrix. Discussion at this point may include analysis methods, variability of nutrient composition, availability of nutrients, digestible versus total amino acids, effect of storage, and anti-nutritional factors.

Setting the solver constraints, along with the setting of nutrient requirements, is for many users, the most valuable experience in learning to formulate diets.

Graphical representations facilitate discussion of concepts, such as limiting amino acids, nutrient balance, total versus available nutrients and nutrient ratios (such as ME:CP, calcium:phosphorous and lysine:arginine). They also demonstrate the relationship (or lack of it) between crude protein and amino acid balance.

Finally, the use of the answer report and sensitivity report are effective ways of both teaching and understanding shadow prices and opportunity costs in least-cost feed formulation.

4. Software

Excel© version 6.0 or later is required to run this spreadsheet. Copies of the UNEForm Spreadsheet are available from the authors or from the following web page: http://ansc.une.edu.au/poultry/. Excel© is a copyright product of Microsoft Corporation, One Microsoft Way, Redmond, WA 98052, USA.

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