THE USE OF COMPUTERS IN ANIMAL NUTRITION

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ABSTRACT

The use of microcomputers in agricultural enterprises can save time and money. Time can be saved through quicker and more accurate record keeping. Money can be made through more detailed analysis of the agricultural or agri-related business that leads to sound management decisions. As farmers strive to maintain a competitive edge in world markets, the use of computers as a tool to generate timely information to aid in decision making is becoming more widespread. Livestock and feed producers have many possible uses for computers. Computerised linear programmed rations have been used extensively in the feed industry in order to minimise feed costs which are 60-70 % of animal production costs. Diet formulation using computers more efficiently matches diet requirements than do 'hand' methods. The latter methods are very time consuming and are likely to lead to an empirical rather than a 'least-cost' formulation. The former ones have contributed significantly to both the economics of animal nutrition and animal production because they are rapid and enable feed manufacturers to change their formulas frequently as the feed ingredient availability and costs change. Ration formulation using computers has intrigued animal nutritionists and economists in both developed and less developed countries (including some tropical countries), since the sophisticated mathematical linear programme was developed by Dantzig in 1947. Linear programming then began to be explored by animal nutritionists in the late 1950's. The practical application of linear programming for feed formulation for animal are briefly described.

Key Words: computer, linear programming, animal nutrition

INTRODUCTION

Feed still represents the major cost (60 - 70 %) of production for most classes of livestock (Pond and Pond, 2000). Because a great percentage of production cost is due to feed, diet formulation using computerised least-cost techniques has been used extensively in the feed industry in order to minimise the cost of the diet (Church and Varera-Alvarez, 1991; Pond *et al.*, 1995). This paper provides a review of the historical background to the development of electronic computers and linear programms, their uses and advantages in agricultural enterprises, their practical application in feed formulation for animal.

Historical background to the development of the microcomputer and linear programming

Historically, the first large-scale electronic computer in the world was designed and built at the University of Pennsylvania between 1939 and 1946 and was known as ENIAC (Electronic Numerical Integrator and Calculator). This early predecessor to today's microcomputer presented considerable problems for agricultural or home application. The first microcomputers to become commercially available were made in the early 1950's (Taylor and Newland, 1977; Legacy *et al.*, 1984). One of the most significant contributions of the microcomputer to the field of animal nutrition was the introduction of linear programming as a means of least-cost formulation of diets. This technique was the subject of research by agricultural economists for several years before it began to be explored by animal nutritionists in the late 1950's. This paralleled the introduction of intensive systems of animal production (Waldroup, 1984; Lowe, 1988). Pannell (1997) defined linear programming as "a mathematical technique for selecting the levels of decision variables which maximize or minimize an objective while satisfying a set of linear constraints" (p. 318). Linear programming was first developed by George B. Dantzig in 1947 to solve complex logistical problems of resource allocation in the USA Air Force (Dent and Casey, 1967).

Uses and advantages of computers in agricultural enterprises

It is well known that a large use of computers in agriculture sector is for management, providing the decision-maker with information and analysing facts (Lambert, 1985). Without question, the advent and utilisation of microcomputers appears to be another innovation which is greatly affecting agricultural productivity (Sonka, 1985). The author further explained that computers were formerly thought of as tools appropriate only for university researchers and managers of large agribusiness firms. Nowadays relatively inexpensive business computers are available for use by farmers and their advisors.

Thus, livestock and feed producers have many possible uses for computers (Shell, 1977; Legacy *et al.*, 1984; Sistler, 1984). Computerised economic animal nutrition techniques not only increase profits to farmers and agribusiness persons, but also improve the utilization of scarce nutrients (Cullison, 1975; Taylor and Newland, 1977; Mason, 1977; Perry *et al.*, 1999). According to Nesheim *et al.* (1979), computerised feed formulation enables a feed manufacturer to change formulas frequently as the feed ingredient costs change. Thus, the imposing problem of selecting the exact feed ingredients for livestock in the proper quantities to provide all nutritional elements for maximum results but at lowest cost is markedly aided by the use of computers (Scott *et al.*, 1982; Waldroup, 1984; Stadelman, 1995; Cheeke, 1999; Ernst, 2000).

Economically, the use of microcomputers in agricultural enterprises can save time and money. Time can be saved through quicker and more accurate record keeping. Money can be made through more detailed analysis of the agricultural or agri-related business that leads to sound management decisions (Legacy *et al.*, 1984). Currently, as farmers strive to maintain a competitive edge in world markets, the use of computers as a tool to generate timely information to aid in decision making is becoming more widespread (Reynolds, 1999).

In practice, there are six basic prerequisites necessary for the computer formulation of least-cost rations for animal. They are: (1) working computer facilities, (2) personnel trained in the use of computer facilities, (3) information on nutritional

requirements, (4) information on feed suitability, (5) information on feed nutrient composition and (6) information on prevailing prices of available feeds (Cullison, 1975; Perry *et al.*, 1999).

The practical application of linear programming in feed formulation for animal

The increased application of linear programming techniques in feed formulation has enhanced the need for more detailed information about the nutrient levels in feedstuffs (El Boushy and van der Poel, 2000). In general, information on the feeding standards for different classes of livestock is available in publications (Payne and Wilson, 1999). In addition to finding the least-cost combination of feedstuffs to meet specific nutrient requirements, it is also possible by linear programming to determine: (1) the acceptance or rejection of ingredients based on their cost and nutritive value; (2) the effect of variations in nutrient content of feedstuffs on their economic value; (3) the final cost of a diet and the cost contributed by each ingredient; (4) the relationship between requirements for any specific nutrient and the cost of the feed formulation; (5) the optimum nutrient density of a diet for maximum economic return to the feed formulator and (6) the cost of replacing any ingredient not in the solution and hence assistance in determining a suitable purchase price for feed ingredients (Perry, 1975; Cheeke, 1999). In addition, parametric programming is an advanced form of linear programming which allows the feedmiller to study and consider any or all of the hundreds of possible solutions which may offer advantages other than just the cheapest or optimal solution (Lowe, 1988).

Without doubt, computerised least-cost diets have intrigued animal nutritionists and economists since the introduction of sophisticated mathematical computer linear programming techniques (Allison and Baird, 1977).

Scott *et al.* (1982) emphasised that most computer manufacturers have developed ready-made programs that instruct the computer how to carry out the mathematical computations necessary for solving linear programming problems. Hirshfeld (1990) has also observed that desktop computing is bringing a new class of analyst to the linear programming community. These people are familiar with linear programming but they do not wish to become experts. New users include business managers, farmers, consultants, social scientists, government planners and applied economists. In order to make use of the computer packages these users do not need to understand the mathematics used to solve a linear programming model: the simplex algorithm (or one of its relatives). They only need to know how to prepare input, how to interpret output and how to deal with a number of problems that can arise.

Linear programming is now widely used in ration formulation in both analogue and digital computers (Alderman, 1977). It proved to be the most suitable tool for diet formulation for animals (Walker, 1977; Bickel, 1988) and specification of least-cost animal rations with linear programming is now standard practice in both developed and less developed countries (Musser *et al.*, 1977; Nino and Hughes, 1977; Rasyaf, 1984; Lowe, 1988). Payne and Wilson (1999) also reported that in some tropical countries an animal-feed industry has developed and commercial animal rations are sometimes available that have been formulated using least-cost methods based on linear programming.

From a market viewpoint, there are many companies and institutions which sell computer software for least-cost ration formulation. The selection of the best one to use

is based upon the computer available and the particular objectives desired (Sistler, 1984; Cheeke, 1999).

In the simple category, the User-Friendly Feed Formulation Program (UFFF) software package (Pesti and Miller, 1988), which was used by the second author and his colleague to formulate experimental diets for laying hens (e.g., Henuk and Dingle, 2001a; 2001b), is an interactive linear programming adapted specifically for feed formulation. It was designed to communicate to the average user what the data needs are, and how and when to supply them to the computer. Results are presented that can easily be interpreted, stored and reused at a later date.

CONCLUSION

1) Computerised linear programmed rations have been used extensively in the feed industry in order to minimise feed costs which are 60-70 % of livestock production costs.
2) The sophisticated mathematical computer linear programming was first developed by Dantzig in 1947 and it began to be explored by animal nutritionists in the late 1950's.
3) There are many companies and institutions which provide computer software for least-cost ration formulation for animal. The selection of the best one to use is based upon the computer available and the particular objectives desired.

REFERENCE

Alderman, G. 1977. Extension of feed analyses and computer services to farm managers. In: *Proceedings of the First International Symposium: Feed Composition, Animal Nutrient Requirements, and Computerization of Diets*, pp. 722-729. Coedited by P.V. Fonnesbeck, L.E. Harris and L.C. Kearl. International Feedstuffs Institute, USA.

Allison, J.R. and D.M. Baird. 1977. Formulating least-cost swine production diets. In: *Proceedings of the First International Symposium: Feed Composition, Animal Nutrient Requirements, and Computerization of Diets*, pp. 613-618. Coedited by P.V. Fonnesbeck, L.E. Harris and L.C. Kearl. International Feedstuffs Institute, USA.

Bickel, H. (1988). Feed evaluation and nutritional requirements. *Livestock Production Science*, **19**: 211-216.

Chandler, P.T. and C.A. Brown. 1977. Mathematical equations for calculating maximum profit dairy diets on the computer. In: *Proceedings of the First International Symposium: Feed Composition, Animal Nutrient Requirements, and Computerization of Diets*, pp. 588-596. Coedited by P.V. Fonnesbeck, L.E. Harris and L.C. Kearl. International Feedstuffs Institute, USA.

Cheeke, P.R. (1999). *Applied Animal Nutrition: Feed and Feeding*. 2nd Edition. Prentice Hall, New Jersey, USA.

Church, D.C. and H. Varela-Alvarez. 1991. Ration formulation. In: *Livestock Feeds and Feeding*, pp. 218-243. 3rd Edition. Edited by D.C. Church. Prentice Hall, New Jersey, USA.

Cullison, A.E. 1975. *Feeds and Feeding*. Reston Publishing Company, Inc., Reston, USA.

Dent, J.B. and H. Casey, 1967. *Linear Programming and Animal Nutrition.* J.B. Lippincott Company, Philadelphia, USA.

El Boushy, A.R.Y. and van der Poel, A.F.B. 2000. *Handbook of Poultry Feed from Waste: Processing and Use.* 2nd Edition. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Ernst, R.A. 2000. Poultry and egg production. In: *Introduction to Animal Science*, pp. 393-399. Edited by W.G. Pond and K.R. Pond. John Wiley & Sons, Inc., New York, USA.

Henuk, Y.L. and J.G. Dingle. 2001a. Brown egg layers fed low density diets perform better in barn than in cages. In: *Recent Advances in Animal Nutrition*, **13**: 26A. Edited by J.L. Corbett. The University of New England, Armidale, NSW, Australia.

Henuk, Y.L. and J.G. Dingle, 2001b. Brown egg layers fed high density diets do not perform better in barn than in cages. In: *Recent Advances in Animal Nutrition*, **13**: 27A. Edited by J.L. Corbett. The University of New England, Armidale, NSW, Australia.

Hirshfeld, D.S. 1990. Some thoughts on math programming practice in the '90s. *Interfaces,* **20**(4): 158-165.

Lambert, J.L. 1985. Silicon, silicon, everywhere and not a chip to think. *Computers and Electronics in Agriculture*, **1**: 1- 4.

Legacy, J., Stitt, T. and Reneau, F. 1984. *Microcomputing in Agriculture.* Reston Publishing Company, Inc., Reston, USA.

Lowe, R.A. 1988. Trends in feed formulation technology. In: *Progress in Poultry Production - 1988 European Poultry Fair International Conference*, 7: 71-80. Royal Agricultural Society of England, Warwickshire, UK.

Mason, T.R. 1977. Formulation of diets by hand. In: *Proceedings of the First International Symposium: Feed Composition, Animal Nutrient Requirements, and Computerization of Diets*, pp. 743-748. Coedited by P.V. Fonnesbeck, L.E. Harris and L.C. Kearl. International Feedstuffs Institute, USA.

Musser, W.N., T.C. Chao, B.R. Miller, A.P. Rahn, and H.L. Fuller. 1977. Toward economically efficient animal rations: The Farrell analysis approach. In: *Proceedings of the First International Symposium: Feed Composition, Animal Nutrient Requirements, and Computerization of Diets*, pp. 566-573. Coedited by P.V. Fonnesbeck, L.E. Harris and L.C. Kearl. International Feedstuffs Institute, USA.

Nesheim, M.C., R.E. Austic, and L.E. Card, 1979. *Poultry Nutrition.* 12th Edition. Lea & Febiger, Philadelphia, USA.

Nino, E.J.A. and H.G. Hughes 1977. Formulating least-cost ad-libitum rations for growing beef cattle. In: *Proceedings of the First International Symposium: Feed Composition, Animal Nutrient Requirements, and Computerization of Diets*, pp. 625-630. Coedited by P.V. Fonnesbeck, L.E. Harris and L.C. Kearl. International Feedstuffs Institute, USA.

Pannell, D.J. (1997). *Introduction to Practical Linear Programming.* John Wiley & Sons, Inc., New York, USA.

Payne, W.J.A. and R.T. Wilson, 1999. *An Introduction to Animal Husbandry in the Tropics.* 5th Edition. Blackwell Science Ltd., Oxford, UK.

Pesti, G.M. and B.R. Miller, 1988. *Least-Cost Poultry Feed Formulation: Principles, Practices and A New Microcomputer Program.* Research Bulletin 354 -

Software Series 2. The Georgia Agricultural Experiment Stations, College of Agriculture, The University of Georgia, Athens, USA.

Perry, T.W. 1975. *Feed Formulations*. 2nd Edition. The Interstate Printers & Publishers, Inc., Danville, Illinois, USA.

Perry, T.W., A.E. Cullison, and R.S. Lowrey, 1999. *Feeds and Feeding*. 5th Edition. Prentice Hall, New Jersey, USA.

Pond, W.G., D.C. Church, and K.R. Pond, 1995. *Basic Animal Nutrition and Feeding*. 4th Edition. John Wiley & Sons, New York, USA.

Pond, W.G. and Pond, K.R. 2000. *Introduction to Animal Science*. John Wiley & Sons, Inc., New York, USA.

Rasyaf, M. (1984). *Program Linier untuk Industri Makanan Ternak*. Kanisius, Yogyakarta, Indonesia.

Reynolds, J. 1999. *Computer Software for Agriculture*. 11th Edition. NSW Agriculture, East Maitland, NSW, Australia.

Scott, M.L., Nesheim, M.C. and Young, R.J. (1982). *Nutrition of the Chicken*. 3rd Edition. M.L. Scott & Associates, Ithaca, USA.

Shell, G. 1977. Time shared data management services. In: *Proceedings of the First International Symposium: Feed Composition, Animal Nutrient Requirements, and Computerization of Diets*, pp. 586-693. Coedited by P.V. Fonnesbeck, L.E. Harris and L.C. Kearl. International Feedstuffs Institute, USA.

Sistler, F.E. 1984. *The Farm Computer*. Reston Publishing Co., Inc., Reston, USA.

Sonka, S.T. 1985. Information management in farm production. *Computers and Electronic in Agriculture*, 1: 75-85.

Taylor, R.D. and Newland, H.W. 1977. Computers and economic animal nutrition. In: *Proceedings of the First International Symposium: Feed Composition, Animal Nutrient Requirements, and Computerization of Diets*, pp. 7-14. Coedited by P.V. Fonnesbeck, L.E. Harris and L.C. Kearl. International Feedstuffs Institute, USA.

Waldroup, P.W. 1984. Microcomputers -- practical and fundamental applications. In: *Monsanto Technical Symposium*, pp. 13-16. Sheraton Motor Inn, Syracuse, New York, USA.

Walker, H.W. 1977. Development of a computerized system for formulating animal diets. In: *Proceedings of the First International Symposium: Feed Composition, Animal Nutrient Requirements, and Computerization of Diets*, pp. 532-539. Coedited by P.V. Fonnesbeck, L.E. Harris and L.C. Kearl. International Feedstuffs Institute, USA.