

Energy and amino acid systems for formulating poultry feeds.

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Abstract

Proposals are made for controlling energy and amino levels in feedstuffs used for poultry feeding. Alternative information is briefly and partially reviewed.

Introduction

Energy and amino acids account for most of the cost of poultry feeds and are also the main determinants of successful production. Formulating feeds both accurately and efficiently for these nutrients is therefore a central tenet of poultry nutrition.

The general purposes of feedstuffs evaluation systems can be summarised as follows;

- a) To measure the replacement values of feedstuffs, i.e. a relative ranking.
- b) To relate animal performance to feed attributes.
- c) To facilitate the prediction and/or control of animal performance through nutrition.

Systems of evaluation are required which describe feedstuffs in a way that can effectively predict animal performance. Variability of feedstuffs is an important problem. As feed mixtures are mostly designed by linear programming, additivity of scales with respect to animal performance is also important. Some non-additivity can be dealt with but the general requirement for additivity in nutritional scales remains a strong one. Insofar as different systems incur different costs then a cost-benefit ratio needs to be determined in the context of each business.

It is quite frequently argued that sophisticated methods of describing feedstuffs (i.e. precise methods) are not worthwhile because the system as a whole cannot be closely controlled (i.e. accuracy is a problem). For example it might be held that the availability of lysine in a cereal is of no importance because batch-to-batch variation in crude protein content cannot be controlled. This is proposed as a false dichotomy. Subject to consideration of cost-benefit the most precise nutritional scales and tools should be used in feed formulation. Accuracy of application will always be a problem and the management aim is always to improve accuracy in a cost-effective way. Formal methods of incorporating the risk from inaccuracy into feed formulation were discussed by Fawcett et al., (1992).

Ideally the systems used for describing feed ingredients should involve measurements only on the ingredients themselves i.e. chemical, physical, microbiological measurements etc. However, measurements of digestibility or availability are, at least in part, a function of the animal and this raises additional complexity into the choice of evaluation systems. For energy, involvement of animal factors is unavoidable since energy cannot be measured on the feed itself in a meaningful way.

Energy systems

A range of energy systems might be considered for the formulation of poultry feeds;

- a) Digestible energy
- b) Metabolisable energy; apparent ME (AME) or true ME (TME)

- c) Net energy; which can be predicted from nutrients or from digestible nutrients, can be predicted from ATP yield or by modelling ATP flows or calculated from heat increment as effective energy.

Digestible energy as a practical scale is usually ruled out because of the difficulties of measuring it in birds. However it is worth noting that much of the variability in energy yield of feedstuffs is founded at the level of digestibility and also that the measurement of digestible nutrients is a component of most net energy systems.

Metabolisable energy (ME) has been the practical scale of choice for many years. In comparison with pig and ruminant nutrition global uniformity in practical poultry nutrition is very striking. The apparent ME scale (AME) corrected to zero N-balance (AME_n) is most widely used.

Over the past 20-30 years the issue of methodology for determining ME of feed ingredients has received a lot of attention and has been discussed at these meetings (McNab and Fisher, 1981). In particular the use of methods requiring very low (but precisely measured) inputs of test feed has been debated together with the resultant need to correct for variations in endogenous energy losses (EEL). This debate has led to proposals to use fully-corrected "true" ME values (TME) by Sibbald (1976); to the correction of AME values to a fixed level of intake (e.g. $AME_n(80)$), as discussed by Fisher (1983) and to alternative ideas of ensuring high intakes and ignoring the issue of relative EEL (Farrell, 1981). The nearest we have got to a standardized method in Europe was based on high feed intakes (close to *ad libitum*) and on a conventional feeding system (Bourdillon et al., 1990).

From the point of view of practical feed formulation the debate about AME and TME has been rather inconclusive and might be seen as being unhelpful, since more important topics, such as variation in ME values, have been less fully investigated. The question of alternative approaches to ME assays raises issues of the speed, cost and convenience of energy determinations on feed ingredients but the resulting data are all essentially similar in application.

The prediction of ME is an important topic when variations in energy values are considered. The original WPSA tables provided equations for individual feedstuffs based on the proximate analysis. Carré (1990) considered chemical prediction equations for individual feedstuffs and also proposed a general method using cell wall content as a predictor which seems to be very valuable for plant derived products.

The possibility of moving from Metabolisable to Net Energy systems was debated at this meeting in 1999. The debate was rather inconclusive and since then the only significant development has been the formal publication of the Rostock Feed Evaluation System (Beyer et al., 2003) including NER (net energy retention) values for poultry. Net energy data for poultry feedstuffs are now available from the old PE studies of Fraps (1946), from De Groote's (1974) system of calculation, by calculation from Emmans' (1994) and from the Rostock tables. New tables from France and from the CVB in The Netherlands are sometimes anticipated. Table 1 compares the different available sources of information for NE for a few feed ingredients and also compares relative NE with ME. There is obviously a lot of variation between different systems and it is not clear that much progress is being made.

	Information type				
	AME _n (CVB, 1999)	PE Fraps (1946)	NE _{broil} De Groote, (1975)	Eff. Energy Emmans (1994)	NER _f Rostock tables
<i>Maize (MJ/kJ)</i>	13.66	10.28	11.75	13.06	10.84
Maize (rel)	100	100	100	100	100
Wheat	94.5	91.8	92.8	92.8	93.1
Wheatfeed	56.3	64.6	85.2	43.6	73.5
Full Fat soya	105.2	NA	110.1	96.5	103.2
Soya meal	67.2	60.4	73.6	47.2	72.9
Fish meal	99.6	80.5	74.9	83.2	76.5

The argument in favour of using a net energy system was very well summarised by De Groote (1999) at the time of the last debate. In simple terms it derives from the fact that the utilization of ME differs for different metabolic functions. The difficulties of moving from this important principle to a system of numbers applying to individual feedstuffs are many. They derive essentially from the fact that a NE value can only be ascribed to a complete feed given to a particular animal. To move from this position to additive NE values for individual feedstuffs given to a class of birds requires some approximations to be made. This places an emphasis on the 'system' of evaluation as a whole (a uniform set of approximations) and we get stuck in a rather rigid, and unproductive, competition between 'systems'. This state of affairs can be clearly seen in ruminant and pig nutrition and also in the futile 'competition' between AME and TME, and contributes very little to the improvement of feed formulation in the industry as a whole. These complexities have also led to the development of computer models to predict 'net' energy yields for complete feeds (MacLeod, 2001; Birkett and de Lange, 2001). This approach will undoubtedly lead to a better prediction of animal performance but methods of incorporating such methods into routine feed formulation remain to be developed.

It is difficult to make a single suggestion for an 'ideal' energy value system but the following issues might be considered.

- a) The system should continue to be based on ME corrected to zero N-balance.
- b) Use apparent ME; if controlled (tube) feeding experiments are used for local quality control then convert the data to AME at a suitable level of feed intake.
- c) Probably use two scales for young and adult poultry.
- d) The position regarding turkeys remains unclear.
- e) Calculate De Groote net energy (NE_{broil}) and effective energy.
- f) Net energy ideas should be introduced by modelling value of complete feed and feeding back into feed formulation.

Control of variation in ME;

- a) Proper and careful classification of ingredients will assist with the control of variation in energy levels.
- b) Adjustment for dry matter (and OM content?)

- c) Use of equations based on proximate analysis (e.g. WPSA table)
- d) Analyse the cost:benefit ratio of using prediction equations which require special analyses e.g. WICW, NSP, viscosity etc.
- e) Continue development of NIR

Amino acid systems

Compared to energy the problem of defining a suitable system for controlling amino acid levels is much simpler and fairly strong recommendations can be made. The main technical problems seem to have been resolved and, thanks largely to the effort of companies selling crystalline amino acids, are well applied. Two limitations can however be noted;

1. The analytical methods are quite expensive and therefore difficult to justify at the point of application. We still have to depend heavily on tables. With vegetable products this is of less concern than with animal protein products. This is an area where application of NIR appears to have great potential.
2. Variation in digestibility and availability within feed ingredients remains as a largely unresolved problem in the practical sense. Again this is more important for animal products.

The following suggestions are made for control of amino acid levels.

- a) Ideally the levels all essential amino acids should be controlled. Control of crude protein is then unnecessary. As a minimum list control of seven amino acids is suggested; LYS, MET, TSAA, THR, ARG, *i*-LEU, TRY and VAL.
- b) The need to control non-essential amino acids remains unclear. It is useful to monitor TNEAA and the ratio of TEAA to TNEAA. Similarly it is unclear whether it is worth spending money on the control of amino acid balance in feeds made from the usual range of ingredients and crystalline amino acids. Under some conditions variation in litter conditions and hock-burn might justify control of these elements of protein nutrition.
- c) Digestible amino acids should be controlled. The data on digestibility are far from perfect, and probably always will be, but there is no justification for controlling only total amino acids levels. Data sources for amino acid digestibility are based on apparent fecal digestibility (CVB, 1999), true fecal digestibility (many sources including the Degussa tables (Degussa, 2000) or on ileal digestibility (Ravindran et al., 1998). The proposal to use standardized ileal digestibility data, discussed at this meeting by Ravindran (2003), looks like the proper resolution of this problem.

Control of variation in amino acid levels

- a) Again proper classification of ingredients will help with effective control. For example, with animal proteins, and even with some by-product vegetable proteins, control by different manufacturing plants can be highly effective.
- b) Adjustment for crude protein levels, using either equations or protein composition, is essential. Suitable equations are published by the amino acid companies.

Discussion

The control of data used to describe feed ingredients at the feed mill is an essential and important part of successful poultry nutrition. Many methods and approaches are available and the challenge for the nutritionist is to implement high quality but cost-effective systems but also to keep new possibilities under review.

In the past the emphasis has been on national 'systems' of feed control and on large databases as a source of data. These continue to be important sources of information but the emphasis is increasingly on local control of variation in feedstuffs and on better description of the feed ingredients actually in use. It is unlikely that a perfect system can be achieved but continuous improvement should be sought.

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