

Putting An Energy Value On Feed



The photograph shows a bomb calorimeter being used in experiments to determine the metabolizable energy of poultry feeds. Samples of test feedingstuff are placed in the 'bomb' and burned. The heat (energy) produced is measured. The test feedingstuff is fed to experimental birds and the faeces produced are subjected to the same process. The difference between the two gives the energy from the feed which has been used by the bird. This figure must be

Energy content of feed is one of the most important things about which a poultry producer must make a decision. Once the system of production has been fixed, feed efficiency is almost entirely determined by this one factor. The producer who buys the feed however is faced with the dilemma that this essential feed characteristic is invisible to him and is not easily measured. He can only make an assessment on the basis of animal performance and his experience with a feed over a period of time. Hence, there is a growing interest in energy declarations; a statement being made at the time of sale about the energy content of a feed.

This entirely laudable objective raises many scientific problems and since legislation is required, at least in Europe, to support any scheme of declarations, these must be answered in clear, unambiguous terms. There is therefore a lot of discussion, about issues on which the scientific community has found it difficult to agree.

Many of the problems are concerned with the definition of energy values, which energy valuation systems to use, whether different types of stock need to be considered separately and with smaller issues such as nitrogen correction and even units. However, even if these are resolved it is the problem of verification that looms largest over the implementation of an energy declaration scheme. Given a sample of feed, how is the producer to know what it conforms with the energy value on the sales ticket, how is the compounder to monitor his production and on what basis can any disagreements be resolved?

It must be recognised from the outset, that there is no single correct answer to this problem. It is not possible to say "the energy value of this feed is . . .", but rather "given the assumptions of this verification scheme, the energy value of this feed sample has, with given probability, an energy value within the range . . .". Even with such

corrected, for what is known as the endogenous energy loss (eg cell debris, unused enzymes etc) to give the true metabolizable energy (TME) of the feedingstuff. This technique is carried out many times and the data are combined with those obtained by chemical analyses of the feedingstuffs to derive prediction equations which the compounder could apply to his own products. (Photos kindly supplied by IE, ARC Poultry Research Centre).

qualifications it will still be possible for feeds to occur in which the realised energy value deviates widely from that which is predicted. Any scheme will also cost money and it is a political and commercial question, not a scientific one, as to how the value of increasing accuracy and confidence in a scheme should be balanced against the costs.

Three possible approaches can be envisaged; a direct biological test, an *in vitro* laboratory test which simulates biological digestion or a chemical prediction equation. Of these, the last seems most likely to be adopted, at least in the short term. Biological tests, although greatly simplified in recent years by the development of quick bioassays, are too costly and complex for routine use. Suitable *in vitro* methods remain to be developed although preliminary work in this area has been encouraging. It is to be hoped that the implementation of legal schemes based on chemical prediction equations will not reduce the impetus of research into

Table.

Some equations developed for the prediction of metabolisable energy values. All equations predict apparent ME corrected to zero N-retention, MJ/kg

	R ² %	s MJ/kg	v MJ/kg
1. $y = 7.417 + 0.262\% \text{ FAT} + 0.079\% \text{ CPR} + 0.098\% \text{ STC} - 0.093\% \text{ NDF} + 0.069 \text{ USR}$	98.5	0.24	0.19
2. $y = 8.328 + 0.257\% \text{ FAT} + 0.072\% \text{ CPR} + 0.090\% \text{ STC} - 0.106\% \text{ NDF}$	98.3	0.26	0.19
3. $y = 18.10 + \% \text{ FAT} (0.346-0.0083\% \text{ FAT}) + 0.012\% \text{ CPR} - 0.262\% \text{ FIB} - 0.661\% \text{ ASH}$	95.6	0.42	0.20
4. $y = 20.11 + \% \text{ FAT} (0.542-0.0178\% \text{ FIB}) + \% \text{ CPR} (0.398-0.0202\% \text{ FIB}) + \% \text{ NFE} (0.380-0.0188\% \text{ FIB}) + 1.47\% \text{ FIB}$	98.0	0.29	0.32
5. $y = 0.343\% \text{ FAT} + 0.167\% \text{ CPR} + 0.179\% \text{ STC} + 0.185\% \text{ SUG}$	97.5	0.31	0.31

Notes. FAT—ether extract; CPR—crude protein; STC—starch; NDF—neutral detergent fibre; USR—ratio unsaturated to saturated fatty acids; FIB—crude fibre; ASH—inorganic matter; NFE—nitrogen free extractives; SUG—free sugar

R²—proportion of variation in ME values explained by equation

s—residual standard deviation

v—addition standard deviation associated with variation in analytical methods

improved and more simple methods.

Chemical prediction equations combine a number of analytical variables into a calculated figure which correlates with the actual energy value. They have been familiar to poultry nutritionists for many years although most attention has been given to their use for individual ingredients. It is unlikely that an equation of conceivable complexity can be devised which will accurately predict the nutritive value of all possible feeds; the occasional possibility of toxic or anti-nutritive

factors seems to rule out complete robustness. However for a normal range of mixed feeds, which can be sold against all the other constraints acting in the marketing place, our recent experience suggests that high levels of accuracy can be achieved in the prediction of metabolisable energy (ME) values.

In recent experimental work, we have made 56 observations of the relationship between ME values of feeds and their chemical composition. Twenty eight formulations were used, each

being tested as a meal and in pellet form. Pelleting had no significant effect so all the data were combined. ME values were determined with adult cockerels, using tube feeding methods devised by Dr Ian Sibbald for the determination of true metabolisable energy (TME) values, but in this work the data were used to calculate the apparent ME (AME) for an intake of 80g per day. Endogenous energy losses were determined in birds given glucose and ME values were corrected to zero nitrogen-balance. This procedure gives



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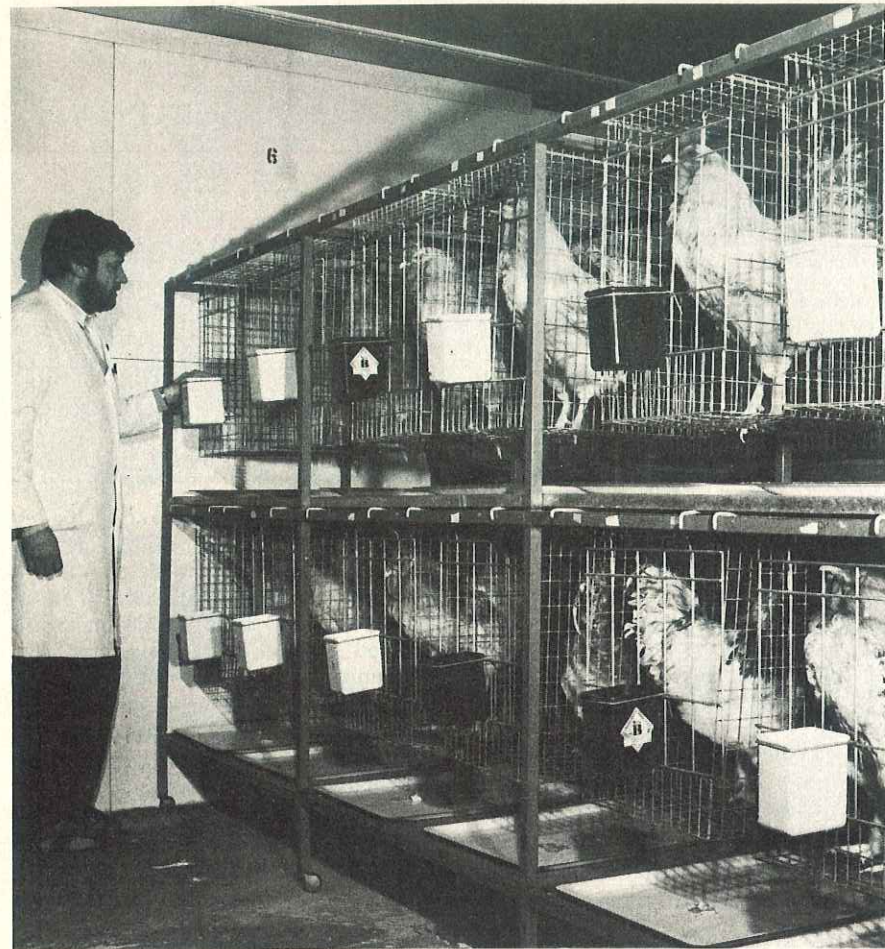
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AME values which agree closely with those in general use but which are not biased by differences in food intake. This is an important consideration in the development of prediction equations. A total of 14 chemical analyses were done on each feed, each in three laboratories to provide an estimate of the reproducibility of each test.

With 14 analytical variables a theoretical total of 16 383 equations can be calculated. Some selection is therefore necessary and in the report of this work (see footnote to this article) 17 equations were finally selected for practical consideration. Five of these are shown in the table.

Equation 1 in the table is the 'best' equation found to describe ME in our feeds. It explained 98.5% of the variation in the determined energy values and the residual standard deviation (or error) was 0.24 MJ/kg (57 kcal/kg) or 1.6% of the mean. The residual standard deviation is a quantitative measure of the differences in ME values which cannot be explained by the variables in the equation. In addition to this residual error there is a further variability associated with the use of this equation, of 0.19 MJ/kg (45 kcal/kg), which arises from the lack of exact reproducibility in the chemical analyses. Both of these errors should be considered in choosing an equation.

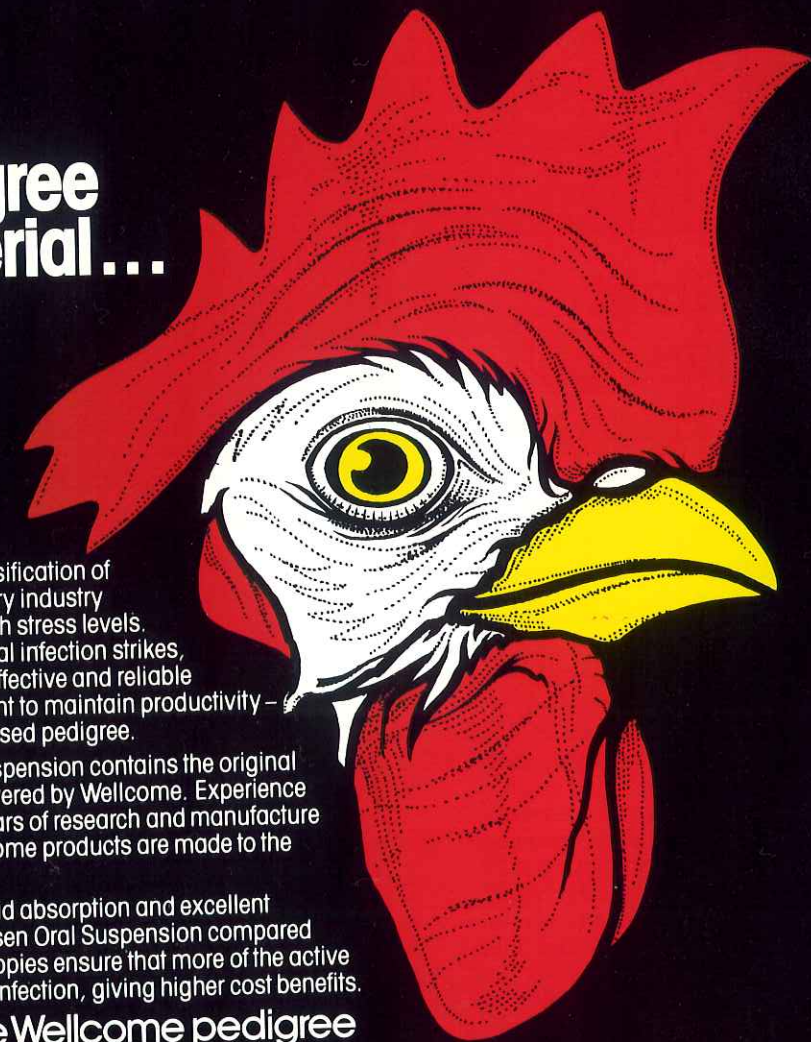
This 'best' equation contains 5 chemical variables, fat, crude protein and starch, the main energy sources, neutral detergent fibre, acting presumably as an index of digestibility and the ratio of unsaturated to saturated fatty acids. This last measure is one of several variables potentially related to the digestibility of the fat. This is an expensive collection of analyses, and equation 2 shows that omission of the fatty acid analyses and thereby reducing costs, has little overall effect on the accuracy of prediction.

The most widely used analyses in the feed industry are moisture, fat, crude protein, crude fibre and ash, the components of the proximate or Weende system of analysis. These could be introduced as the basis of an energy declaration system at little additional cost. Equation 3 shows an effective combination of these variables in our data, giving a residual standard deviation of 0.42 MJ/kg (100 kcal/kg). This equation contains a non-linear term for fat level which reflects the fact that fat digestibility tends to decrease at higher levels of inclusion. However, equation 4 is more useful, since, although based on the Weende components, it has a residual error of only 0.29 MJ/kg (69 kcal/kg). This

(Continued on page 67)

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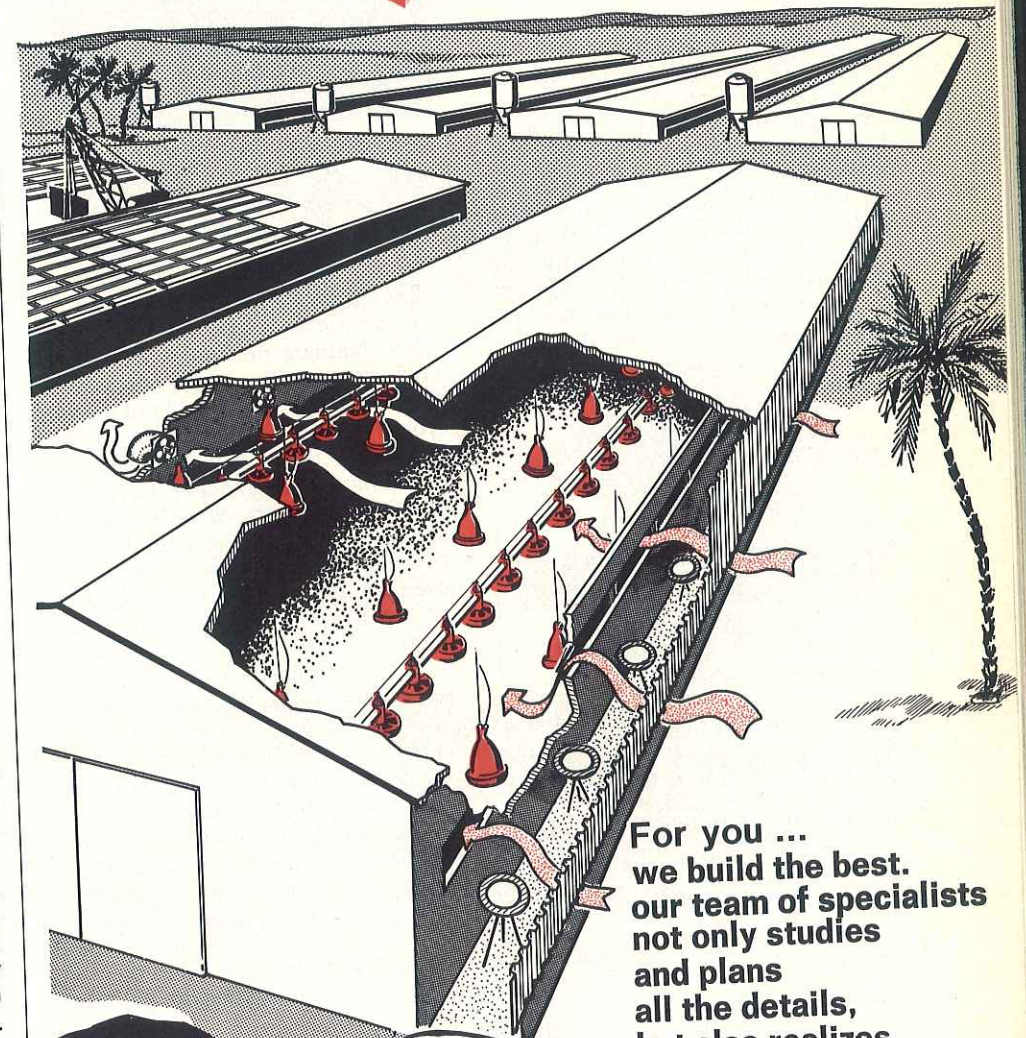
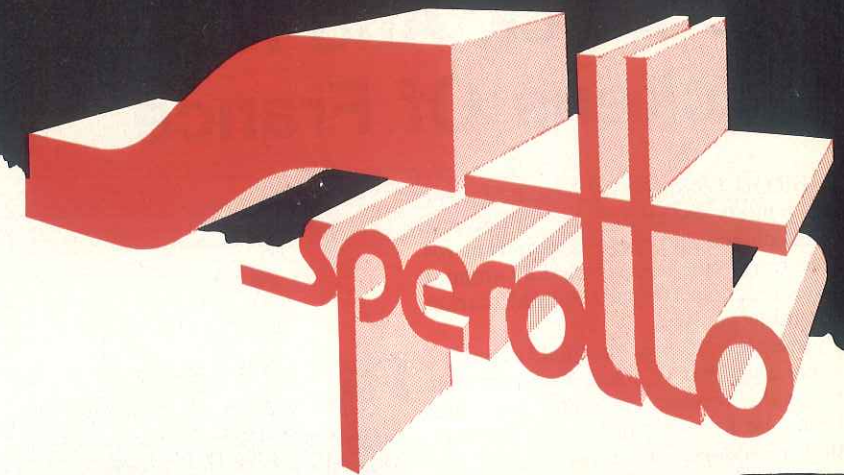
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equation has terms representing the interaction between fibre and other nutrients; thus fat is predicted to yield 30.6 KJ/g in a feed with 2% crude fibre, falling to 25.2kJ/g if fibre is raised to 5%. This type of equation, which has not been demonstrated previously, will be of particular value when analytical facilities are limited.

The final equation shown, no. 5, is a summation of the four main energy-yielding components, fat, protein, starch and free-sugars. This is an almost complete description of the potential energy sources and therefore no constant is required in such an equation. However it is slightly less accurate than equations containing a measure of fibre as an index of digestibility. This final equation is of a type which has wide support in Europe and will probably be adopted in EEC regulations on this subject. A final point from the results of this work is that neutral detergent fibre, a measure of cell wall material, was consistently found to be a better predictor of energy content than crude fibre.

The final choice of any equation for a system of energy declarations must balance many considerations, only some of which are of a technical nature. However, these experiments have shown that chemical prediction equations can predict ME values in typical mixed feeds with errors of 0.25-0.3 MJ/kg (52-72 kcal/kg) if the chemical composition is exactly known. By way of comparison, the error of a biological test, using six replicates, will be about 0.15-0.20 MJ/kg. An additional error, of roughly similar magnitude, arises in the case of prediction equations because chemical analyses are not exact, giving an overall standard accuracy of predicting ME value of $\pm 0.35-0.45$ MJ/kg (84-108 kcal/kg). The average accuracy for a whole population of feeds will be about 70% of this standard accuracy of 0.25-0.32 MJ/kg (60-76 kcal/kg) whilst a range of twice the standard accuracy 0.70-0.90 MJ/kg (167-216 kcal/kg) will include 95% of all probable errors. Whether this is sufficiently accurate for a practical system of energy declarations must now be decided.—Dr Colin Fisher, Head of the Department of Nutritional and Environmental Studies of the Agricultural Research Council's Poultry Research Centre, Roslin, Midlothian, Scotland.

(The experimental work discussed here is published in Occasional Publication No. 2, Poultry Research Centre available from the Librarian, ARC Poultry Research Centre, Roslin, Midlothian EH25 9PS, Scotland. Price £5.00.—Ed)



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