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METABOLIZABLE ENERGY IN FEEDING SYSTEMS FOR PIGS AND POULTRY

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Summary

The major consideration in this paper is the suitability of a metabolizable energy system for pigs. For poultry there is no practical alternative since urine and faeces are voided conjointly. The correction to digestible energy of a feedstuff for energy in urine is usually small, but there are circumstances when this may be large. Furthermore there are insufficient data on metabolizable energy requirements for pigs, and on values for feedstuffs. It is concluded that even if a metabolizable energy system were adopted for ruminants and for poultry, introduction of such a system for pigs would be premature. It is suggested that a net energy system will eventually be introduced to describe the nutritional worth of livestock feedstuffs, but this is unlikely to appear in the immediate future, and probably in the first instance only for poultry.

I. INTRODUCTION

If feedstuffs of known nutrient content are to be used with maximum efficiency, it is necessary to know both their energy content and the biological and economic performance expected from them. The ultimate solution is the use of a net energy system, since this takes into account the energy losses that occur when absorbed nutrients are transformed into product and used to-maintain the animal. Many of these energy transformations are not precisely defined and the immediate introduction of a net energy system for pigs and poultry would be unacceptable. Furthermore if feeding systems are to be widely adopted they should initially be reasonably simple and easily understood- Once adopted and tested, appropriate changes can be introduced to make them more accurate.

A major consideration in this paper is whether metabolizable energy (ME) is a more satisfactory basis for an energy system than digestible energy (DE) for pigs. For poultry there is no practical alternative to ME since urine and faeces are voided together and are therefore, conjointly, the first tax against a feedstuff.

II. SYSTEMS FOR PIGS

The digestible energy-of a feedstuff represents the energy content of that feed corrected for the energy lost in the corresponding faeces. Because no correction is made for energy of metabolic origin, which although independent of feed residue is intimately associated with it, the term "apparent digestible energy", in contrast to "true digestible energy", is the more correct description of feed energy. Since almost all values are reported as "apparent", these will be referred to simply as DE.

Under constant and well-defined conditions, DE can be measured with great precision and repeatability. Furthermore the range of DE values for grains that are normally used in pig diets is apparently small (E.S. Batterham, personal communications), and the mean value for each

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grain, within an acceptable bushel weight, can be used. For other ingredients, and more particularly protein and fat supplements, the situation is less clear. In Australia there is a bewildering array of protein feedstuffs available to the feed formulator, each having a wide variation in chemical composition. For example, today there are at least four different sources of fish meals and numerous sources of meat meals available. Many individual plant protein sources may vary in oil, fibre and protein content (Farrell 1976a), which leads to uncertainty in DE, particularly as very little local data are available for protein supplements. This is due largely to the specialized and time-consuming nature of determination of DE in pigs.

Fats and-oils require special consideration in assessing DE. Tallow compared with corn oil is less readily digested (Bayley & Lewis 1965), particularly in young pigs (Carlson & Bayley 1968). When unsaturated fatty acids and saturated fatty acids are fed in combination there is an associative effect resulting in a DE greater than would be calculated from'the individual values '(Freeman 1969). Improvement in the DE of tallow might therefore be expected when used in diets containing oil seed protein meals having residual oil.

Calculation of DE from Total Digestible Nutrients (TDN) of a . feedstuff (Agricultural Research Council 1967; National Research Council 1973) by using a constant factor of 18.4 MJ/kg TDN, or the prediction of DE from chemical composition (Morgan, Cole & Lewis 1975b), particularly from the fibrous components (Drennan & Maguire 1970; King & Taverner 1975) is problematical. There are several factors known to influence the DE of a diet. These include differences between individual animals (Morgan, Cole & Lewis 1975a), weight of pig (Ivan et al. 1974; Burlacu, Illiescu & Starvi 1976; Morgan, Cole & Lewis 1975a), stress (Ostrowski 1974), amino acid imbalance (Ostrowski 1975), environmental temperature (Fuller & Boyne 1972), processing of the feed (Lawrence 1972), including cubing (Vanschoubroek, Coucke & Van Spaendonck 1971), weather damage of grain (Taverner, Rayner & Biden 1975) and probably the source and amount of fibre in the diet (Whiting & Bezeau 1957a, b; Farrell 1973).

Given these areas of uncertainty regarding DE the question is whether further refinement would be worth while by allowing for energy losses in urine and combustible gases. With pigs, the latter are normally less than 1% of the gross energy of a feed (Verstegen 1971) and can be ignored. The energy of urine is largely a function of the quality and quantity of protein in the diet (May & Bell 1971, . Morgan, Cole & Lewis 1975a), environmental temperature (Holmes 1973) and the physiological status of the pig. This means that the ratio of DE to ME is not constant. The loss of energy in urine is especially large for protein concentrates. Of particular local interest is the large loss of energy in urine of pigs consuming meat and bone meal. In one instance, this reduced ME to 83% of DE compared with an expected value of 95% (Morgan, Cole & Lewis 1975a). Although ME of protein sources are not strictly additive most practical diets are formulated to optimise utilization of dietary protein and energy and the range of dietary protein concentrations is normally small. Consequently May and Bell (1971) proposed that the ME of a complete diet can be obtained by applying the factor 0.98 to DE. Slightly lower factors have been suggested (National Research Council 1973; Agricultural Research Council 1967) and 0.95 was found by Morgan, Cole and Lewis (1975a). If diets are formulated with crude protein (CP) contents outside the usual range, a correction should be applied to the ME/DE ratio. The equation of May and Bell (1971) may be used where

$$100 \times ME/DE = 101.2 - 0.19 \times \% \ CP \qquad (1)$$

The physiological status of the pig is an important consideration because the ME of a protein source is greater if incorporated into protein tissue than if used for oxidative metabolism, and only in the latter case is chemical energy lost as uric acid or urea. For pigs the energyloss in urine (kJ/g N) can vary by as much as 35% (Diggs et al.. 1965; Morgan, Cole & Lewis 1975a). Because N retention can therefore influence the energy of urine, ME values for pigs (Morgan, Cole & Lewis. 1975a) and poultry (Hill & Anderson 1958) are often corrected to either zero or 30% retention of dietary N. Kleiber (1961) argued that such a correction to ME was unwarranted for the sake of a reduction in variability of ME values.. His argument is supported by the data of Morgan, Cole & Lewis (1975a) who found that the standard error of ME values so corrected was no less than that of uncorrected values. A further objection stems from the knowledge that the loss of urinary ammonia-N can account for from 5 to 8% of the N balance of pigs (Verstegen 1971); thus the true N retention is overestimated unless ammonia-N is collected quantitatively.

On balance there seems to be no scientific or practical advantage in using a ME rather than a DE system for pigs. The additional energy of urine is normally so small relative to the large loss of energy of faeces that such a refinement is almost pedantic. Of more importance is the recognition that there are circumstances, as mentioned above, when urinary energy losses can be substantial. An appropriate correction to DE could be made to meet these circumstances.

It is important to recognise that ME, or DE for that matter, does not represent the biological value of a feedstuff. There is evidence to suggest that as the crude fibre and the crude protein content of the diet increase, the energy deposited in carcass gain of pigs, expressed as a per cent of ME, declines (Just, Rasmussen & Hansen 1976). Furthermore Ewan (1976) found a range of net energy values for different feed ingredients when included in practical diets. The availability of ME of conventional diets, measured with pigs during' the meat production phase of growth and cited by Thorbek (1975), ranged from 66 to 72%. . It should be made clear that because of differences in energetic efficiency associated with fat and protein deposition, maximum efficiency of utilization of ME does not necessarily coincide with maximum lean meat in the final product.

III. SYSTEMS FOR POULTRY

Broiler chickens require specified ME concentration-in the diet in order to allow maximum economic performance. Laying hens require a minimum ME concentration of about 11 MJ/kg of feed, and in the case of broiler-breeding stock and growing pullets it is common practice to. restrict energy intake in order to reduce the tendency to deposit large amounts of fat in body tissue in the former case, and to increase initial egg size and overall production in the latter. Consequently it is important to formulate diets, to a known ME.

The need in Australia is not so much for a system that defines 'energy requirements since in some instances these have been established

(National Research Council 1971; Agricultural Research Council 1975), particularly for broilers (Farrell, Cumming & Hardaker 1973; Farrell, et al. 1976; Farrell, et al. 1977), rather the need is to provide accurate energy values for locally available feedstuffs. For a single ingredient there is often a range of ME values (Guirguis 1976), and this has led to confusion in the industry. Variation in ME of a feedstuff may be due to differences in moisture content, in intake, in chemical composition as in the case of meat and bone meal and some plant proteins and cereals, inclusion of grit in the diet, and also to method of determination which may provide biased estimates (Miller 1974). Variation has also been attributed to both sex of bird and inclusion level of the test ingredient (Guirguis 1976). To overcome some of these differences, standardized procedures of determination of ME have been developed (Sibbald 1976; Farrell 1978).

A problem arises with fat because ME underestimates its true biological value. Fat is used with a high efficiency for lipogenesis (Annison 1974) indicating that a net energy system (Nehring & Hanelein 1973; De Groote 1974) may be more appropriate to describe the nutritional worth of poultry feedstuffs. De Groote (1974) found an economic advantage of a net energy compared with a ME system in a broiler experiment. However there is insufficient knowledge of the influence of dietary components, other than fat, on net availability of ME. Guillaume et al. (1976) found an apparent negative effect of crude fibre on net availability of ME of poultry diets.

IV. PRACTICAL CONSIDERATIONS

In practice, feed manufacturers tend to have a conservative approach to diet formulation by maintaining energy concentrations reasonably constant. This is understandable as their principal aim is to provide a diet that in general optimises biological performance and is consistent. The manufacturer , although recognizing the possibility of formulating more economical diets by allowing changes in energy concentration, does not tend to do so. The manufacturer usually considers that he can best present the image of his product and meet his customers' demands by having this product consistent in composition and giving a high feed conversion ratio even when a cheaper formulation would be possible through manipulation of energy concentration.

An exception to this is the feed company that is vertically integrated, either through direct ownership of production facilities, or through contract growing of livestock. This is most common in the broiler industry, where there is opportunity to manipulate the energy concentration of the diet with the subsequent consequences of altering biological performance. This allows adjustment to be made to the amount of feed offered, in the case of restricted feeding of livestock, and to anticipate a change in the amount of feed required to achieve a specific productive process, usually with a concomitant economic gain. For example, I have successfully used the formula, digestible energy (MJ/d) = 1.36 $W^{0.75}$ to adjust the daily feed allowance of experimental pig diets with a range of DE concentrations, over the liveweight (W) range 29 to 40 kg (Farrell 1976b).

It is important to recognize that broiler breeder hens are extremely sensitive to dietary ingredient changes that may be independent of energy concentration. There is therefore reluctance to interfere with the initial formulation in case a reduction in egg mass occurs.

V. CONCLUSIONS

The requirement in Australia today is largely for a simple feed evaluation system that will provide energy values that are sufficiently precise for feed manufacturers to formulate a diet which will achieve a consistent, predetermined biological performance. It seems that for pigs, DE is the most acceptable system, and for poultry, ME. However there may well be a need in the near future for a more sophisticated feed evaluation system particularly for the broiler industry. Because the chemical composition of the final poultry product, whether it be egg mass or meat, is reasonably constant it is likely that such a system will be introduced sooner for poultry than for pigs, particularly as the latter are frequently restricted-fed through some of the production phase, which may result in a marked change in the net energy of the feedstuff.

Even if a ME system were widely adopted in Australia for ruminant livestock and for poultry, it would still seem that there is little justification for using the same system for pigs, particularly if ME is in fact estimated from DE.

A ME system can only be used when both feed and energy requirements have been determined in terms of ME. This has been done in some countries, but not to any extent in Australia. Considering differences in environment, management and the genetic differences in stock, the use of overseas ME data has not been adequately tested here and cannot therefore be justified. This conclusion is supported by the statement of the Ministry of Agriculture, Fisheries and Food (1975) that "a rationing system based on metabolizable energy involves a knowledge of the energy requirements of the animal, and the ability of the food to satisfy those requirements, in terms of metabolizable energy."

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