FEED ENERGY UTILISATION IN BEEF PRODUCTION SYSTEMS: A REVIEW

BEN GEORGE
BVetMed, MRCVS

identifies the information practitioners need to optimise beef growth rates and solve nutritional production issues faced by their clients

THIS article provides an overview for the general practitioner of energy requirements in beef production systems.

The objective is to enhance understanding of the principles behind ration formulation to specifically supply energy at different stages of growth. This will hopefully help practitioners solve production problems that have a nutritional aspect for their beef-producing clients. Aspects of efficiency will be covered briefly. There are many systems of beef production, so only the broad concepts will be covered and the article will focus on growing cattle only.

Energy

Energy is the biggest limiter to animal performance. The energy in the ration the beef animal can use for maintenance and growth is the metabolisable energy (ME) as shown in **Figure 1**.

Some ME will be retained by the animal for maintenance and tissue deposition, and some will be lost as heat (heat increment) due to the biochemical reactions required to absorb and release the energy.

The more energy the animal retains and turns into tissue, the more efficient is that animal. At best, recovery of ME from the diet in terms of the energy of the tissues laid down is about 40 per cent and much less if only edible tissues are considered (Lawrence and Fowler, 2002).

Therefore, the factors that impact on efficiency of energy utilisation are the diet and the animal itself. These two factors are interlinked.

Diet

The better the quality (q) of the diet, expressed as ME/gross energy (GE), the better is the efficiency with which the animal uses the retained ME (net energy) for maintenance and production.

This is partly because less energy is needed to absorb and release the energy from a higher quality diet and, therefore, the heat increment of the diet is less (shown in **Figure 1**), and so more energy is retained by the animal. The retained net energy is used for maintenance, with an efficiency factor given by K_m and for growth with an efficiency factor given by K_g.

However, at a greater level of ME intake, which would be found in beef cattle with large daily liveweight gains and eating high quality diets, the amount of feed ME available is reduced, due to an increased rumen outflow rate and, therefore, reduced fermentation time.

Thus, feeding high quality diets is a trade between efficiency of utilisation of the total ME in the feed by the animal and the efficiency of utilisation of the retained net energy by the animal. For this reason it is important to know how breed, age, sex and production level dictate energy requirements, so that energy is neither overfed nor underfed.

> "Feeding high quality diets is a trade between efficiency of utilisation of the total ME in the feed by the animal and the efficiency of utilisation of the retained net energy by the animal. For this reason it is important to know how breed, age, sex and production level dictate energy requirements."

The animal

Growth of production animals is incredibly complicated. A huge amount of work was carried out on the subject by Sir John Hammond at the University of Cambridge in the early part of the 20th century. From a production point of view, we are interested in the rate of tissue deposition, in particular, protein and fat, and how these differ between animals. Both an age and a genetic aspect must be considered.

From the age aspect, essentially protein is laid down at a decreasing rate and fat at an increasing rate.

The genetic aspect determines the rate of decrease of protein deposition and the rate of increase of fat deposition.

For example, heifers' rate of protein deposition falls far more quickly than that of castrates and males. The rate of protein deposition of an early maturing breed, such as the Aberdeen angus, will fall far more rapidly than that of a later maturing breed, such as the Limousin.

The implication is that energy requirements will differ at different stages of growth for the same liveweight gain, because far more energy is deposited in fat than in protein (Lawrence and Fowler, 2002).

For this reason, when determining energy requirements for beef animals we need to know:

- daily liveweight gain;
- age (usually given as a liveweight);
- sex; and
- breed (**Table 1**).

Calculating energy requirements

For greater depth in this area, the reader is referred to the Agricultural and Food Research Council (AFRC; 1993).

Consider a 400kg steer of a medium maturing breed, gaining 0.75kg per day, eating:

- **silage:**
- 25 per cent dry matter (DM) (250g/kg DM)
- ME 10.5MJ/kg DM
- q=ME/GE=10.5/19*=0.55
- **concentrate:**
- 86 per cent DM (860g/kg DM)
- ME 13MJ/Kg DM
- q=ME/GE=13/18.6=0.70

**ME available from silage analysis. GE from book values (McDonald et al, 2002).*

Every beef animal has a maintenance requirement for energy – that is, an amount of energy to keep its body composition constant and replace heat lost to the environment as a result of its basal metabolism. This energy can be quantified by the following equation:

$F=0.53\ (W/1.08)^{0.67}$

In this equation, **F** is fasting metabolism (MJ/day) and **W** is mass of animal. A small activity allowance can be added on as (0.0071 **W**).

Requirements for bulls are 15 per cent higher, so the equation becomes:

$F=1.15\ (0.53\ (W/1.08)^{0.67}+0.0071\ W)$

TABLE 1. Classifications based on AFRC (1993)

Early maturing	Medium maturing	Late maturing
Aberdeen Angus	Hereford	Charolais
North Devon	Lincoln red	Limousin
Friesian	Sussex	Simmental
		South Devon

TABLE 2. Correction factors for C2 in equation, from AFRC (1993)

Maturity type	Bulls	Castrates	Heifers
Early	1.0	1.15	1.30
Medium	0.85	1.00	1.15
Late	0.70	0.85	1.00

TABLE 3. Values for correction factors B and K in equation, from AFRC (1993)

The values essentially allow for the fact that although efficiency of energy utilisation will be greater for greater dietary quality, the increase in feeding of ME will lead to greater rumen outflow rates and, therefore, less time to release the ME from the food.

Diet quality	B	K
0.4	1.98	0.453
0.5	2.40	0.365
0.6	2.98	0.291
0.7	3.82	0.227
0.8	5.12	0.170

For our steer: $0.53\ (400/1.08)^{0.67}+(0.0071\times400)=$ **30.7 MJ**

We then need to calculate the energy of the liveweight gain. This will be different for individuals of different age, sex and breed.

Correction factors have been calculated for this and are shown in **Table 2** for use in the following equation:

MJ/Kg of gain= $C2(4.1+0.0332W-0.000009W^2)/(1-C3\times0.1475\ \Delta W)$

Where:

C2 is correction factor for maturity group and sex.

C3 is a correction factor for level of feeding above maintenance; it is equal to 1 when level of feeding is above maintenance and is 0 if feeding is below maintenance.

For our steer, energy value of gain= $1(4.1+0.0332\times400-0.000009\times400^2)/(1-1\times0.1475\times0.75)=$ **17.9MJ/Kg gain**

Therefore, the net energy required for maintenance and production per day at current rate of production is **30.7+17.9 MJ=48.6 MJ/day**

The next step is to work out if the efficiency with which the animal can extract the ME from the diet will be sufficient to meet its energy demands. The efficiency with which ruminants can extract energy from the diet depends on the quality (q) of the diet and the feeding level, as explained earlier.

Consider each diet component separately:

- **The silage:**

The ME from silage will be utilised for maintenance with an efficiency K_m of:

$0.35\times q+0.503$
$=0.35\times0.55+0.503=0.69$

The ME from silage will be utilised for growth with an efficiency K_g of:

$0.78\times q+0.006$
$=0.78\times0.55+0.006=0.43$

Thus, as (q) increases so does efficiency of utilisation of ME by the animal.

We need to take into account diet quality and feeding level, which are given by the correction factors B and K in the following equation:

Net energy that can be retained from silage

Of q=0.5 for maintenance and production=(maintenance energy/K) ln (B/(B-R-1))

Where:

- **R** is the scaled energy retention, given by energy required for gain/energy required for maintenance.
- Correction factors **B** and **K** have been calculated by previous workers, for different levels of dietary (q) and are shown in tabulated form in AFRC (1993; **Table 3**).

Running this calculation for our steer tells us **90.32 MJ** of ME would be retained from the silage. Thus, the net energy that is retained from the silage is:

48.6MJ/90.32MJ=0.54

10.5MJ kg DM of ME×0.54 =**5.64 MJ Kg/DM**

Running through the same calculation for the concentrate tells us that **9.10MJ/Kg DM** of net energy is retained from the concentrate, due to its higher quality (q=0.7).

The next stage is to calculate the dry matter intake of the steer and use this to calculate the freshweight amounts of silage and concentrate that would need to be fed. Several equations can be used to predict dry matter intakes.

Since grass silage makes up a large proportion of most cattle diets, the equation used in AFRC (1993) to predict grass silage intakes is complex and takes into account its digestibility and total nitrogen. For the purposes of this exercise a less complex and, therefore, less accurate predictor of intakes will be used:

DM intake=2 per cent body mass=0.02×400= **8Kg DM**

From this we can calculate what the net energy density of the ration must be:

48.6 MJ/ day+5 per cent safety factor=51.03MJ day/8kg DM=**6.37 MJ/Kg DM**

As there are only two components to the ration, proportions can be calculated using

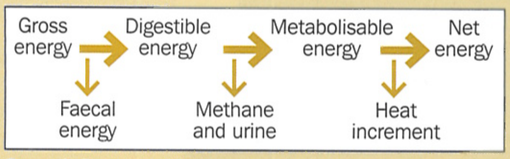
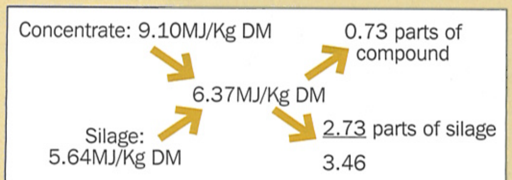


Figure 1. Partition of feed energy.



Proportion of DM each component must contribute:
Concentrate:
0.73/3.46 × 8Kg DM intake=1.68Kg of DM
Silage: 2.73/3.46×8Kg DM intake=6.31Kg of DM
Proportion of fresh weight:
Concentrate: 1.68Kg DM/0.86=1.95 Kg/day
Grass silage: 6.31Kg DM/0.25=25.2 Kg/day
Total ME fed:
1.68Kg/DM×13MJ/Kg DM+6.31Kg/DM×10.5MJ/Kg DM=88MJ

Figure 2. Pearson square method of calculating feed requirements.

Figure 3. From left: early, medium and late maturing breeds – Aberdeen Angus, Hereford, and Limousin.

a Pearson square method as shown in **Figure 2**.

Summary

The above calculation with grass silage substituted for maize silage will result in a higher quality diet being fed and, because of the increased efficiency of utilisation of net energy from higher quality diets, less total ME needs to be fed.

Due to the increased expense of forage maize over grass silage, the economics would not be very favourable for this level of production, which can be sustained adequately with grass silage as the main source of energy.

However, for higher rates of production in later maturing breeds being fed to their growth potential, a higher quality forage would be necessary as DM intakes would begin to limit production on a lower quality forage.

Running the same formula to calculate energy requirements for castrates of early and late maturing breeds, with the same live weights and liveweight gains, gives the following answers:

- **Early maturing breeds:**
- Total ME required= **91.9 MJ/day**
- Fresh weight of concentrate to achieve this requirement over and above what silage can supply within the dry matter intake capacity of the animal= **3.9kg/day**
- **Late maturing breeds:**
- Total ME required= **84.7 MJ/day**
- Fresh weight of concentrate to achieve this requirement over and above what silage can supply within the dry matter intake capacity of the animal = **0.32kg**

More energy is required by the early maturing breeds than the late maturing breeds at the same level of liveweight and production. This is because the genetic programme of growth for the early maturing breed at this liveweight is depositing fat at a faster rate than protein. Fat contains more energy than protein and so more energy is required per day. Less energy is required per day for later maturing breeds at the same level of production because they are depositing more protein than fat.

The implications for producers are that buyers pay on the basis of the EUROP system and therefore pay more for the saleable tissue – the protein and penalise for too much fat, which has to be trimmed off. It would be incredibly wasteful to push early maturing breeds and their crosses to the same finish weight as late maturing breeds, because a large proportion of the energy content in the carcase would be trimmed off as fat and binned.

To supply current wholesaler requirements with most efficiency, producers need to be utilising later maturing breeds and their crosses and feeding them to their production potential using a least cost ration. This requires regular weighing of animals and good management.

In suckled beef systems, producers need to be optimising efficiency by selecting sires with the best estimated breeding values (EBVs) for 200-day and 400-day weights. Further efficiency gains can be made if records are also kept of dams.

The ultimate goal is a healthy animal that converts supplied energy into tissue (protein and fat) with maximum efficiency and reaches slaughter weight in as short a time as possible.

BEN GEORGE qualified in 2009 from the RVC and joined St Boniface Veterinary Clinic in Crediton, Devon, carrying out mixed practice, but mainly dairy work. He also has a degree in animal science from the University of Reading. Ben has a particular interest in dairy cattle health and productivity.

References

AFRC (1993). *Energy and Protein Requirements of Ruminants*. Advisory manual prepared by the AFRC Technical Committee on Responses to Nutrients, Wallingford, Oxford, CAB International.

Lawrence T L J and Fowler V R (2002). *Growth of Farm Animals* (2nd edn), Wallingford, Oxford, CABI Publishing.

McDonald P, Edwards R A, Greenhalgh J F D and Morgan C A (2002). *Animal Nutrition* (6th edn), Essex, Pearson Education.

Wilkinson J M (2004). Nutrition. In A H Andrews, R W Blowey, H Boyd and R G Eddy (eds). *Bovine Medicine Diseases and Husbandry of Cattle* (2nd edn), Oxford, Blackwell: 95-122.