Determining the NE Content of Diets and Ingredients

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SUMMARY

Producers and those in the feed industry have heard for several years that compared to either DE or ME, the NE system does a better job of estimating the available energy in ingredients and diets. However, there is still confusion regarding the derivation of values used in the NE system. Determining the NE content of either an ingredient or a diet is much more complex than either DE or ME. The comparative slaughter technique determines retained energy and requires an estimate of fasting heat production. Indirect calorimetry provides a direct estimate of heat loss while predictive equations have been developed using indirect calorimetry as a reference. Each technique has benefits and limitations which should be understood by anyone using these values.

INTRODUCTION

The hog industry is focused on producing a product with the greatest efficiency possible, and feed has the greatest impact on the ability to accomplish this goal. Feed cost accounts for over 65% of the total hog production cost. Within feedstuffs, the most expensive component is energy (90%). Therefore characterizing the available energy in a feed is required to estimate its overall feeding value.

MATERIALS AND METHODS

Net Energy Systems

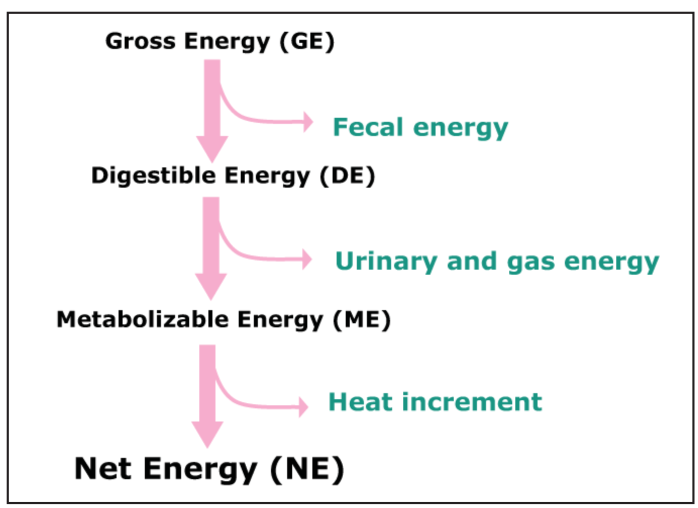
Historically, the swine industry in North America has used metabolizable (ME) or digestible energy (DE). However, we know that a NE system does a better job of characterizing the energy available for productive purposes. Moreover while the ME/DE ratio is relatively constant (example 0.95, 0.94, 0.91) for barley, wheat and canola meal, respectively, the NE to ME (or DE) ratio varies. For example the NE/ME ratio for barley, wheat and canola meal is 0.77, 0.74 and 0.57 respectively, meaning that we can't convert from ME to NE with the use of simple conversion factors.

Net energy (NE) is defined as the metabolizable energy (ME) minus the heat increment. Essentially it is the efficiency of the utilization of metabolizable energy. The heat increment is the heat produced during the digestion and metabolism of nutrients. After subtracting the heat increment from the metabolizable energy we are left with energy for maintenance and production. Maintenance energy is the amount of energy required for an animal to perform just the necessary functions to live. Energy used for production can be divided into energy for movement, lactation, growth, and gestation.

Theoretically, since NE is the energy available to the animal for productive functions it is the ideal energy system. However, the adoption of NE has been hindered, in part, because, relative to either DE or ME, it is difficult to measure. Direct calorimetry which measures the heat lost from an animal is difficult, requires extremely expensive equipment and is rarely done. At the Prairie Swine Centre, we often rely on nutrient tables (see references) for a listing of the NE values for feedstuffs, recognizing that they are estimates often derived from a limited number of experiments. When our research requires us to obtain our own estimates of the NE content of an ingredient or a diet we have 3 methods available to us.

"Net Energy system provides better characterization of the efficiency with which energy is used for growth and/or production"

1. **Comparative slaughter technique (CST).** In this method we measure the energy gained in the carcass over a specified period of time. Essentially we must euthanize a subset of animals at the beginning and at the end of an experiment, grind the entire carcass and take a sample, ensuring that this sample is representative of the entire carcass. In the lab we then measure the energy content of this subsample, which allows us to calculate the energy content in the entire carcass. By subtracting the energy in the carcass from the pigs slaughtered at the end of the experiment, from those at the beginning, we can calculate the energy gained over time or retained energy (RE). We also need a value for the fasting heat production (FHP) an estimate of the heat increment. This can be determined experimentally by measuring the RE in groups of pigs fed decreasing



amounts of their diet and then calculating the RE as if they had received no feed for a period of time (fasting). All production factors (i.e. genotype, sex, age, and diet) have to be exactly the same for this value to be used. It can be challenging to use this value from farm to farm because of confounding variables. Typically we estimate the FHP using an accepted value from the literature (ie. 110 kcal DE per kg $BW^{0.75}$.

NE is then calculated as: NE= RE – FHP

The advantage of CST is that animals are maintained in typical production conditions. The disadvantage is the cost, and the requirement to euthanize large numbers of animals. An estimation of FHP is required.

2. **Prediction equations.** Several researchers have developed equations which predict the NE content of a feed or diet. Depending on the equation chosen, these require knowledge of various nutrients or digestible nutrients in the feed as inputs. Most of these equations have been developed from experiments using indirect calorimetry (below). Examples of equations in common use are:

   NE, kcal/kg DM = 2.892 DCP + 0.8.365 DEE + 3.418 starch + 2.84 sugars + 2.055 Dres

   NE, kcal/kg DM = 0.703 DE + 1.58 EE + 0.48 starch – 0.98 CP – 0.98 CF

   (cited as NE2vand NE4 respectively in Noblet (1994) and Sauvant (2004). DCP = digestible crude protein, DEE= digestible ether extract, Dres = digestible organic matter – (DCP + DEE+starch +DCF), DE = digestible energy, EE = ether extract, CP = crude protein and CF = crude fibre

   Using these equations requires knowledge of digestible nutrient content of a feed. Moreover care has to be taken that characterization of the digestible nutrient content is conducted using similar methodology (lab analyses etc) that were used to develop the equation.

3. **Indirect calorimetry** is a measure of carbon dioxide (CO_2) and oxygen (O_2) exchange. Heat production is correlated to O_2 consumption and CO_2 production therefore indirect calorimetry allows an estimation of heat production. Pigs are maintained in chambers for several days and the air entering and leaving is sampled for CO_2, O_2 and methane (CH_4). Urine must also be collected and analyzed for nitrogen. The equipment required for indirect calorimetry is very expensive, to purchase and maintain. Typically the chambers can only accommodate one pig at a time. PSCI doesn't have calorimetry chambers, however we have collaborated with the University of Manitoba to use their chambers. This allows us to compare net energy values obtained from indirect calorimetry with the values we get using CST or regression equations.

Most of the equations today were established in Europe which has more experience with the NE system than Canada. They were developed using a series of digestibility and calorimetry experiments, primarily in France (INRA) or the Netherlands (CVB) during the 1990's and while the values obtained will vary depending on the system used, there is relatively good agreement between these two systems and selection of a specific equation will often depend primarily on the information available to the user. When we conducted experiments comparing the different systems we found that different equations gave similar values for the NE content of a diet, and these agreed better with indirect calorimetry than the numbers we obtained from the CST. This is to be expected as the development of the equations used indirect calorimetry as their reference. Most producers or feed formulators should select a system which is available to them, and not obtain values from different systems.

Regardless of the system chosen, there is general agreement that any NE system provides a better estimate of the energy available for production. This is especially important when formulating diets with by-product or non-traditional feedstuffs. It has well established that the ME and DE systems tend to overestimate the energy of fiber and protein and underestimate the energy value of oils, fats, and starch. These factors are vital when it comes to formulating a diet and can be used to lower feed cost.

SUMMARY AND CONCLUSIONS

Obtaining NE values for diets or feedstuffs is more complex than DE or ME values. However, the NE provides a better characterization of the efficiency with which energy is used for growth and/or production. Most feed tables now contain a value for the NE content. Commonly used and accessible tables are listed in the references. Most of the values are based on the INRA system. Unfortunately the values used by the CVB (Dutch) system are more difficult to obtain. It is important for producers and feed formulators to have a basic understanding of the derivation of these numbers and why these values may vary depending on the system used.

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