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Transitioning to net energy: A swine story

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Net energy **(NE)** is one member of the sequence of energy systems which also includes gross energy **(GE)**, digestible energy **(DE)**, and metabolizable energy **(ME)**. It is perhaps the most sophisticated because it attempts to consider more components of the ingredient or diet which normally cannot be used by the pig for maintenance and/or productive purposes. Gross energy makes no such adjustment and therefore has little direct value in diet formulation. Digestible energy corrects for energy which is lost in the feces, and metabolizable energy also adjusts for energy lost in the urine. The data in Table 1 reveal that heat increment averages 22% of gross energy, and ranges from 17 to 28%, across an array of ingredients that are frequently used in commercial pig diets. Interestingly, the range in NE is about 81%, much greater than the range in ME at 55%. At a very crude level, this suggests that NE accounts for more variation among ingredients than does ME; looked at another way, using ME to formulate diets essentially assumes that HI is similar across ingredients and does not need to be considered. Of course, this is not true.

Reasons for adopting the NE system

Nutritionists adopted NE for two reasons. The first is to achieve more predictable animal performance, especially as it relates to feed efficiency. In my experience, this advantage is real but the magnitude of benefit is quite small, perhaps in the range of 1 to 2%, so quite difficult to measure. The second reason, which I believe is the most meaningful economically, is to assign relative economic value to ingredients. Using the NE system, high protein and higher fiber ingredients will tend to be discounted as compared to the ME system; conversely, high fat ingredients, and fat itself, are valued more highly. The benefit to the producer in this regard is highly market dependent, but can range from nil to more than $1 per pig sold; it is very rare to see no financial advantage to adopting NE but the ingredient market is highly volatile, so the actual benefit to an individual producer is difficult to predict. So, the motivation to adopt the NE system is driven primarily by a desire to improve financial returns. Because the NE system tends to select diets with lower levels of protein, it may provide benefits in terms of environmental sustainability as well.

Sources of ingredient NE values

An obvious prerequisite of implementing an NE system is finding a source of energy values in which you have confidence. There are 4 approaches to achieving this, although only two are truly practical for most producers. One option is the serial slaughter method, which quantifies the amount of energy accumulated in the body over a given period of time. This method is very labor intensive and also results in the greatest variation in net energy values, so it is not normally used. Another approach is indirect calorimetry, in which gaseous exchange (O_2 and CO_2) is measured, from which NE values can be derived. This method is usually the method of choice because of its precision and speed of determination; however, indirect calorimeters are very expensive to purchase and to operate. Consequently, there is currently only one such unit working with swine in all of the US. The third approach is to use published values such as those available from (NRC, 2012), INRA (French system) and CVB (Dutch system). This method is commonly used due to its simplicity but fails in one important way – there is no mechanism to adjust NE values as the composition of the ingredient changes. The fourth and final method, and the one which I recommend, involves the adoption of prediction equations that allow for the calculation of net energy based on the chemical components of the diets. The equations are derived from data generated by indirect calorimetry. Such equations have been developed in a number of countries; the most commonly used for swine came from France (INRA) and The Netherlands (CVB). The NRC (2012) provides some of the INRA equations. Whichever method is used, they must not be mixed with another; the results of doing so can be catastrophic. Therefore, before converting to the NE system, significant time must be spent determining which method is to be adopted – and then stick with it.

Implementation of the NE system

The approach we have used to assist nutritionists to convert to the NE system is logical and methodical; it is designed to minimize the risk of unexpected consequences while at the same time ensuring that the full benefits of NE are realized in a very timely manner. The first step was mentioned in the previous section and involves the adoption of NE values for all ingredients in the nutritionist's matrix. One cannot adopt a new energy system unless all ingredients can be included. Once the source is chosen, these values are included in the ingredient matrix. At this point, the path to adoption splits into two activities. The first activity is to continue to formulate diets according to the current system (we'll assume ME) and tracking how NE values of the diet change; are there major fluctuations in diet NE values, for example. This affords the nutritionist a chance to develop a sense of the magnitude of the impact if diets were being formulated using the NE system. This is done over the course of 4 to 6 months – sufficient time for the nutritionist to develop a good feel for NE. While this is going on, the nutritionist or formulator should be formulating actual diets using either the ME or the NE system; this will provide direct information on the magnitude of differences between NE-based diets and ME-based diets. This activity should embrace a broad combination of ingredient prices because it is changes in the relationship of ingredient prices – not just the absolute prices - that will impact diet composition using either ME or NE the most. At the end of this period of evaluation, during which the actual manufactured diets are still based on the ME system, the nutritionist should have developed a pretty good sense of how things might change once diets are switched over to NE. The next step is crucial, and will demand extra time on the part of the nutritionist or their designate – the formulation program is switched to NE and is now going "live" meaning that diets are based on NE and not ME. Most importantly, the energy values of the previous system remain in the matrix and for a period of a few months, someone is assigned to review all diets very, very carefully to ensure there are no hiccups. For example, if an NE value is incorrectly entered into the matrix, some very strange diets could be the result with possibly catastrophic consequences in the field. The person assigned to the diets should be reviewing diet NEs as well as diet MEs, to see if there are large deviations. At the end of this period, the conversion should be complete.

Limitations of NE

Net energy does a better job that DE or ME in accounting for unused portions of ingredients (losses via feces, urine and heat increment). While it is an improvement over ME, it is not perfect. For example, if animals are chilled, some of the heat increment is actually beneficial to the pig because it helps to keep it warm, thus preserving a higher portion of the available NE for growth. Also, the NE is not able to account for the variation in the efficiency with which dietary components are used for maintenance and growth (Figure 1). Finally, NE cannot be measured directly in the same way as DE and ME; this could lead to errors and certainly does not help create confidence in the NE values available for use in diet formulation.

Conclusion

The NE system offers numerous potential advantages which can improve financial returns and achieve environmental benefits as well. However, it is a more demanding energy system as well, so its adoption needs to be carried out in a carefully planned and methodical manner. In my experience in the pig industry, I have not worked with any nutritionist who switched back to an older system after having adopted NE.

Figure 1. Increasing the proportion of corn DDGS at constant dietary energy alters the relative contribution of energy from starch, fat, protein and fiber.

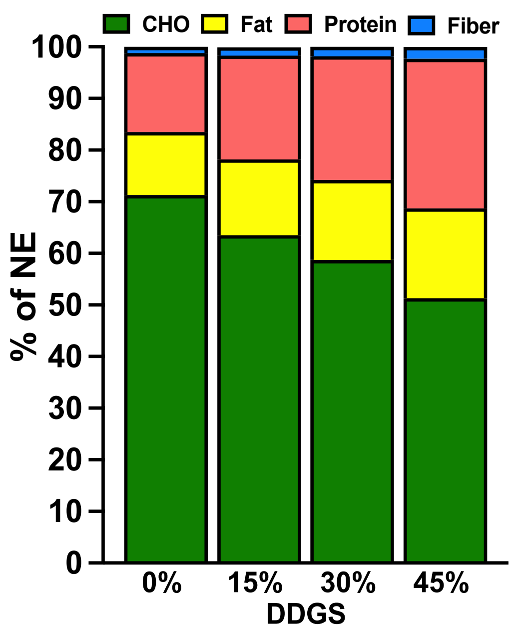

Table 1. Losses of energy via the feces, urine and heat increment for common ingredients used in swine diets

Ingredient	GE[1], Mcal/kg	FE[2], % of GE	DE[1], Mcal/kg	UE[2], % of GE	ME[1], Mcal/kg	HI[2], % of GE	NE[1], Mcal/kg	NE, % of ME	NE, % of GE
Barley	3.94	20	3.15	2	3.07	24	2.13	69	54
Canola meal	4.33	24	3.27	6	3.01	26	1.89	63	44
Corn	3.93	12	3.45	1	3.40	19	2.67	79	68
Corn DDGS[3]	4.71	24	3.58	4	3.40	23	2.34	69	50
Corn germ meal[4]	4.18	28	2.99	4	2.83	22	1.89	56	45
Oat groats	4.58	19	3.69	2	3.60	19	2.72	76	59
Soybean hulls	4.21	52	2.01	2	1.94	23	0.99	51	24
Soybean meal[5]	4.26	15	3.62	8	3.29	28	2.09	64	49
Wheat, HR	3.79	13	3.31	2	3.22	20	2.47	77	65
Wheat bran	4.01	40	2.42	2	2.32	17	1.65	71	41
Wheat midds	3.90	21	3.08	3	2.97	22	2.11	71	54
Whey permeate[6]	3.43	7	3.18	1	3.15	17	2.58	82	75
Mean	***4.11***	***23***	***3.14***	***3***	***3.02***	***22***	***2.13***	***69***	***52***
Minimum	***3.43***	***7***	***2.01***	***1***	***1.94***	***17***	***0.99***	***51***	***24***
Maximum	***4.71***	***52***	***3.69***	***8***	***3.60***	***28***	***2.72***	***82***	***75***
Range	***1.28***	***45***	***1.68***	***7***	***1.66***	***11***	***1.73***	***31***	***51***
Range, % of mean	***31***	***196***	***54***	***233***	***55***	***50***	***81***	***45***	***98***

Source: NRC, 2012

[1] GE: Gross energy; DE: Digestible energy; ME: Metabolizable energy; NE: Net energy

[2] FE: Fecal energy; UE: Urinary energy; HE: Heat increment

[3] 6 to 9% total fat

[4] 2% fat

[5] 47% crude protein

[6] 80% lactose