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Where can we go with net energy in poultry?

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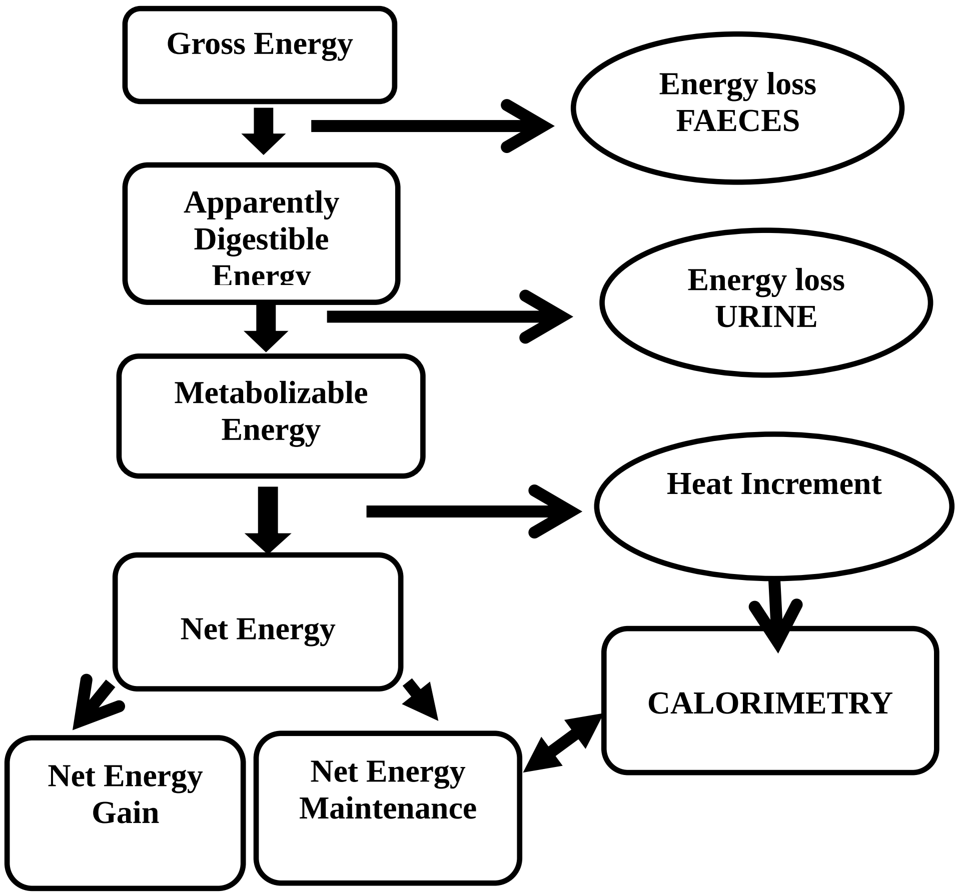
Overview

Metabolizable energy (**ME**) is the main system used globally in poultry industry for feed formulation and for evaluating feed ingredients and mixed feeds (de Boer and Bickel, 1988). ME is considered a reliable index of what is available to the bird for maintenance and production but is not a predictor of how efficiently the bird uses the available energy (MacLeod, 2000). The ME system developed by Hill and Anderson (1958) was reported to provide less variation in energy values for feed and ingredients than the Fraps PE system, but MacLeod (1994, 1997, 1999) suggest that the low variation of ME values is because the ME system ignores the metabolic responses to feed. A dietary net energy **(NE)** system is needed that is sensitive to daily rapid protein gain plus changing daily energy maintenance needs caused by the accretion of lean mass (Hilton et al, 2019).

History of energy and implementation in poultry production

In a bomb calorimeter, energy can be measured in the form of gross energy (GE). The amount of GE that the bird can utilize for growth and performance depends on how easily this feedstuff or diet is digested. Once GE is consumed the energy must go through multiple digestive metabolic processes to breakdown the large molecules of nutrients into smaller absorbable nutrients is termed digestible energy. Further in the digestive process energy is further lost in the excreta and once energy is corrected for these losses the energy is now in the form of metabolizable energy (ME). Again, energy is lost once more in the form of heat production and the energy finally reaches its final form of net energy (NE). NE is the form of energy that the bird utilizes for maintenance and production (figure 1).

Figure 1. Energy utilization in poultry. Adapted from Farrell, 1974



Net energy definitions

Armsby and Fries, in 1915, are the first to define net energy (NE) value as NE= ME – HI, was termed the 'Armsby net energy system (Emmans, 1994). This system was based on there being no relationship between amount of food consumed and the HI.

Next, productive energy (PE) measures the net energy value of a feed. Frapps at Texas A&M did extensive work in this area in the 1940's (Leeson and Summers, 2001; McNab and Boorman, 2002). This is the amount of energy the bird uses toward maintenance and production.

The basic principal behind productive energy is to collect data that can be utilized in the following equation:

WM + G = FX

W= Average chick weight for experimental period (usually 14 d)

M: Maintenance requirement

G: Gain in carcass energy during feeding period

F: Feed intake

X: Productive energy value of diet per unit weight

Additionally, Blaxter & Wainman (1961) decided to relate energy retention to feed intake. In their NE system two slopes were calculated that intersected at zero; one line is below maintenance and the other above.

In 1965, Keilanowski presented one important principal that energy definition should include retained energy in the NE value, one must separate out energy from protein verse energy from fat. However, these energetic values for protein and fat are not equal and therefore indicated that Blaxter & Wainman, although on the right track, in fact could consider the retained energy as a single variable. Kielanowski (1965) proposes there should be three variables in animals' performance that must be included; maintenance (now zero fat and protein retention), positive retention of fat and protein. Additionally, if all three of these could be calculated and rations appear to be similar then only a single number would work (Kielanowski, 1965).

Now in the 90's, Emmans attempted to account for the variability in HI and labeled his system effective energy (Emmans, 1994). This presented two problems; the first was to compare fed and fasting of diets that resulted in positive energy retention and the second was to put a value on the "extra" HP when the retentions were positive. Again, there is no distinction between energy retained as protein versus fat.

Lastly, indirect calorimetry utilized respiratory exchange to measure metabolism. The use of indirect calorimetry is useful in evaluating the patterns of metabolism. Understanding the different rates in which fat and carbohydrates are oxidized gives insight into the availability of energy in the form of ATP (Livesey and Elia, 1988). In the last decade, most of the NE research has been done through different teams in France; Noblet, and in Australia; Swick and Choct. Much of these research teams focus on the classical definition of net energy. This method is to subtract HI from AMEn (Noblet et al., 1994, 2010, 2015; Swick et al., 2013; Wu et al., 2018). A disadvantage of using indirect calorimetry is the expense of the chamber itself and it is labor intensive, giving reasoning to why other methodologies are utilized.

NE for Ingredients, diet formulation and economic potential

The classic way to calculate NE of feed is to determine ME and subtract the HI. To test formulation with the classic NE, swine NRC (1998) numbers to put on corn, soybean meal and poultry fat (Table 1). Additionally applying previous research done by Hilton et. al (unpublished data) linear regression using digestible lysine as the predictor and classic NE was conducted to get diet NE values (Table 2).

Table 1. NE of ingredients used in formulation

		ME (NRC '98)	NE
Ingredient	**DM,%**	**kcal/lb**	
Corn, grain 7.86% CP	**88.9**	**1525**	**1210**
Soybean 47.5% CP	**90**	**1536**	**907**
Poultry Fat	**99.6**	**3718**	**3346**

Table 2. Cost of diets formulated on ME basis verse Classic NE basis

Diet	dLys %	ME Kcal/lb	Classic NE Kcal/lb	Diet Cost-ME	Diet Cost NE	Cost savings
Starter	1.25	1,370		$379.19		$26.03
Starter	1.25		1,065		$353.16	
Finisher	1.15	1,410		$360.69		$32.26
Finisher	1.15		1,070		$328.43	
WD1	1.02	1,450		$386.66		$58.28
WD1	1.02		1,076		$328.38	

Although classic NE shows some economic benefit (Table 2),The modern broiler is growing at a rapid rate generating tremendous amounts of heat; consequently, a sensitive NE energy system is needed to measure body heat production primarily caused by maintenance and accretion of myofibrillar and sarcoplasmic protein by optimizing intake of digestible amino acids and energy.

Classic NE method only assesses the value of HI which accounts for a small portion (Farrell, 1974) of dietary energy that is lost from ME and can be misleading as more calorie efficiency (NE/ME) is given to fat deposition than lean mass deposition. Classic NE does not take into consideration the type of production or gain that is occurring in the animal and mainly penalizes protein accretion because of HI generated from nitrogen and carbon loss through uric acid production. Due to genetic selection to promote lean muscle accretion, lessened emphasis should be placed on fat and more on protein calories and will be considered in the overall NE equation for predictive calorie value of ingredients.

Final Considerations

Formulation on NE values will allow nutritionists to take advantage of protein metabolism, genetics and even environmental conditions. However, continuous research needs to occur for ingredients and diets. In addition to ingredient and complete diet NE, looking into the effect these adjustments will have on body composition will be key in making the NE system work for the poultry industry. Lastly, standardization of the system needs to happen so all nutritionists can take advantage of NE formulation.

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