Putting metabolisable energy into context

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Feed represents more than 70% of the total cost of producing live broilers. In typical broiler feeds, more than 60% of the total cost is used to provide energy. Furthermore, it is generally agreed that broilers eat to satisfy energy requirement, therefore broiler feeds are normally formulated to provide all nutrients according to diet energy content.

Therefore, it is critically important to know the energy value of ingredients and feeds as accurately as possible.

This article will first briefly describe the energy systems used in poultry production. The importance of accurately knowing the energy content, and reasons why Ajinomoto Thailand has set up a metabolisable energy bioassay laboratory, are explained. The facilities and procedures used in this laboratory will be outlined. Finally, a preview of the assay results obtained so far and its implications for the poultry sector in Asia will be discussed.

The energy systems for poultry

The total energy, or Gross Energy (GE), of a feedstuff can be measured by burning the material completely and determining the heat given off. Not all GE is available to chickens for maintenance and growth, as losses occur during digestion and metabolism.

The most commonly used energy system in poultry is metabolisable energy (ME). This term, however, is rather generic. According to the definition and method of evaluation, poultry ME can be further categorised into apparent ME (AME), True ME (TME), nitrogen corrected AME (AMEn), and nitrogen corrected TME (TMEn).

Table 1. Calculations.

$$\text{AME (kcal/kg as is)} = \frac{(\text{GEfeed} \times \text{Feed consumed}) - (\text{GEexcreta} \times \text{Excreta})}{(\text{Feed consumed})}$$

$$\text{AMEn (kcal/kg as is)} = \frac{((\text{GEfeed} \times \text{Feed consumed}) - (\text{GEexcreta} \times \text{Excreta})) - (\text{NR} \times \text{K})}{(\text{Feed consumed})}$$

NR is the Nitrogen Retention, which is assumed to be (20% of body weight gain/loss)/6.25, and K is the constant which equals to 8.21 kcal/g nitrogen retention.

Ingredient	Bht/kg	C3200	C3100	S2230	S2130
Corn 8.1% (AMEn 3200)	5.00	51.50		51.50	50.66
Corn 8.1% (AMEn 3100)	5.00		48.98		
SBM 43.3% (AMEn 2230)	10.80	28.68	30.29	28.68	
SBM 43.3% (AMEn 2130)	10.80				28.84
Cassava 2.7%	2.80	5.00	5.00	5.00	5.00
Rice bran, full fat	4.00	5.00	5.00	5.00	5.00
Fish meal 62.6%	21.10	2.00	1.21	2.00	2.00
Palm oil	12.00	4.48	6.00	4.48	5.15
L-lysine HCl	85.00	0.17	0.17	0.17	0.17
DL-methionine	125.00	0.22	0.23	0.22	0.22
L-threonine	120.00	0.06	0.06	0.06	0.06
Biophos	25.00	0.80	0.89	0.80	0.80
Limestone 38.18%	1.00	1.25	1.32	1025	1.25
Salt	1.00	0.34	0.36	0.34	0.34
Premix	100.00	0.50	0.50	0.50	0.50
Total batch		100	100	100	100
Nutrients					
ME for poultry (Kcal/kg)		3000	3000	3000	3000
Crude fat (%)		7.87	9.23	7.87	8.51
Lysine (%)		1.16	1.16	1.16	1.16
MET + CYS (%)		0.86	0.86	0.86	0.86
Threonine (%)		0.78	0.78	0.78	0.78
Available phosphorus (%)		0.40	0.40	0.40	0.40
Sodium (%)		0.16	0.16	0.16	0.16
Feed cost Bht/kg		8.180	8.280	8.180	8.240
+/- Bht/ton			+100		+60
+/- $ton			+2.40		+1.45

Table 2. Impact of ME variation in corn and soybean meal (+/-100 kcal/kg) on cost of a typical broiler grower feed.

- **Apparent Metabolisable Energy (AME or ME):** Sometimes referred to as classic ME, AME is measured as the difference between the energy of the feed and the energy of the faeces plus urine which, in poultry, are combined as single excreta. The energy lost as gaseous products of digestion is insignificant and therefore can be ignored.
- **True Metabolisable Energy (TME):** An estimation of ME in which correction is made for metabolic faecal and endogenous urinary energy losses (Endogenous Energy Loss, EEL). Advocators of the TME system argue that EEL represents a maintenance cost, which should not be charged against the feed.
- **Nitrogen corrected AME (AMEn):** A correction is made on AME for nitrogen retention (NR) by the chickens during the test period. It is argued that body nitrogen, when catabolised, is excreted as energy containing products like uric acid. AME values are thus influenced by the amount of nitrogen retained during the test period. Because test diets are often imbalanced, nitrogen retention varies for different test diets. As a result, AME data are less likely to be additive.

It is thus desirable to bring AME data to a basis of zero-nitrogen retention. To correct nitrogen retention, a factor of 34.36kJ/g, or 8.21kcal/g, of nitrogen retained is often used. When the test

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diets are relatively balanced in protein and energy, nitrogen retention of bird could be assumed to be 20% of body weight gain divided by 6.25.

● **Nitrogen corrected TME (TMEn):** TMEn bears the same relationship to TME as does AMEn to AME.

AME and AMEn (or ME and MEn) are the most widely used energy systems for poultry in the world including Asia.

Importance of accurate ME values

It is known that ME contents vary greatly not only among different types of ingredients, but also among different batches of the same ingredient type. For instance, Leeson et al. (1993) showed that ME contents of 26 samples of corn from the same harvest year in Canada varied from 2940 to 3480kcal/kg (mean = 3218kcal/kg, Standard deviation (Std) = 162kca/kg). Kulcharoen (2001) studied the ME contents of 10 samples of solvent extracted rice bran from Thailand.

ME content varied from 1130 to 2160-kcal/kg (mean = 1652kcal/kg, Std = 381 kcal/kg).

This between batch variation in ME content of ingredients leads to variations in complete feeds. It is not difficult to imagine that the ME of typical broiler feeds formulated based on book values could easily vary by 50kcal/kg or more.

What is the impact of ME variation on feed cost? Our simulations with broiler feeds indicated that a change of only 50kcal/kg in ME specifications will change the feed cost by US$2.2 to US$2.9 per ton.

Thus, ME variation is very costly. In addition, ME variation reduces the level and uniformity of live performance and carcase quality, which further reduces profitability.

It is, therefore, very important for feed millers to accurately know the ME content of ingredients. Feed millers in Europe, Australia, and North America have ready access to ME testing facilities that are linked or supported by their governments.

For instance, there are two ME testing laboratories in Australia, each capable of testing more than 300 samples per year. Regression equations have also been developed in these countries to predict ME content based on chemical analyses.

Feed millers in Asia are not as fortunate. On one hand, the main energy ingredients used, such as corn, cassava chips, broken rice, and rice bran, are locally produced and have not been thoroughly tested for ME. On the other hand, there is no public or private laboratories to offer the ME test on a routine basis. As a result, feed millers in Asia have traditionally relied upon book values that are generated in Europe, North America, or Australia.

Some have used regression equations to predict ME based on chemical analyses. The accuracy of these prediction equations, however, is questionable and limited. Firstly, these equations are not derived from samples that are produced and used in Asia, so their validity is questionable.

Secondly, these equations are often based on proximate analysis plus analysis of starch and/or other carbohydrates. Accuracy of analysing these chemical parameters is often quite poor among laboratories in Asian countries. Thirdly, predictions by regression equations are always less accurate than the bioassay itself.

ME bioassay service

To help feed millers in Asia to accurately analyse poultry ME, Ajinomoto Co (Thailand) Ltd, has set up a metabolisable energy bioassay laboratory. The objective of this laboratory is to evaluate AME values of the commonly used feed ingredients in Asia on a routine basis. This facility has the capacity of testing more than 200 samples a year. We believe that our ME bioassay facility is the first laboratory in Asia to offer the ME test on a routine basis. We hope to build the most informative and diversified AME database for Asian feed ingredients. We hope that such information will bring significant values to our customers and to the feed and livestock sectors in Asia.

Laboratory facilities and location

The ME bioassay laboratory is set up at Bangkok Animal Research Center Co Ltd (BARC), a wholly owned subsidiary of Ajinomoto Thailand. This facility has its own feed mill, metabolic rooms, metabolic cages, rearing house, and basic laboratory equipment, such as a drying oven, grinder, and balances.

There are a total of 64 metabolic cages. Each cage is 600 x 450 x 375mm in dimension and houses five birds. Five or six cages are used for each test diet.

Procedure of ME bioassay

The procedures developed and used at the University of New England in Australia are followed:

- Day old male broiler chicks are raised in floor pens to 21 days of age. They are fed commercial broiler starter feeds.
- At the beginning of day 22, chickens are moved into metabolic cages in a room where temperature, air ventilation, and lighting are controlled. There are five birds per cage, and five to six cages per test diet. Water and feed are provided for ad libitum intake.
- Test ingredients are formulated into test feeds, and then dry pelleted to avoid selective feeding and wasting.
- The broilers are fed test diets for three days for adaptation.
- From day 25 to day 28, the test diets are fed. Body weight gain and feed consumption during these four days are recorded, and the excreta are collected every day.
- The excreta are dried in an oven at 80°C for 24 hours.
- Feed and excreta samples are ground, and analysed for dry matter (DM), and gross energy (GE).

A preview of the ME bioassay results

In operation since October 2002, the Ajinomoto Thailand ME bioassay laboratory has received and tested more than 150 samples, most of them were sent by feed mills in Thailand. These samples included corn, soybean meal, fishmeal, full fat soy, rice bran, cassava chips, and feather meal.

While we are still compiling and analysing the data, some of the results obtained so far are briefly presented here.

Corn

A total of 28 corn samples from Thailand, Pakistan, China, and Indonesia have been tested so far and the results are shown in Fig. 2. The AME values ranged from 2,925 to 3,379kcal/kg with a mean of 3,154kcal/kg and coefficient of variation (CV) of 3.9% (all values presented are on as fed basis). The AMEn values ranged from 2,847 to 3,288 kcal/kg with a mean value of 3,080 kcal/kg, and CV of 3.7%.

Our test results showed that corn produced and used in Asian countries varied greatly in ME content. As most of these samples (samples one to 17) were from Thailand and collected during October 2002 to March 2003, we conclude that even for corn produced in the same country within the same harvest season, ME content differed significantly from sample to sample. Similar variation among samples from the same harvest season was also reported by Leeson et al. (1993) for corn produced in Canada in 1992.

Secondly, we noticed that the mean

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AMEn value of the corn tested (about 3,080kcal/kg) was significantly lower than the NRC listed value of 3,350kcal/kg. On the other hand, our value is close to the value of 3,130kcal/kg listed by INRA in its latest ingredient database. The INRA value was based on a total of 2,634 samples.

Rice bran

A total of 13 full fat and seven solvent extracted rice bran samples have been tested so far. All samples were from Thailand. AMEn of full-fat rice bran varied from 985 to 2,951kcal/kg, with a mean value of 2,453kcal/kg and a CV of 13.0% (Fig. 3).

The solvent extracted rice bran had AMEn ranged from 1,457 to 2,173kcal/kg, with a mean of 1,850kcal/kg and a CV of 15.17% (Fig. 4).

Our results showed that ME of rice bran, particularly solvent extracted rice bran, varied tremendously even among samples from the same country.

Cassava chips

Thailand is a major cassava producing and exporting country. Cassava chips are widely used in Southeast Asia and Europe in poultry and swine feeds. We have so far tested four cassava chip samples from Thailand.

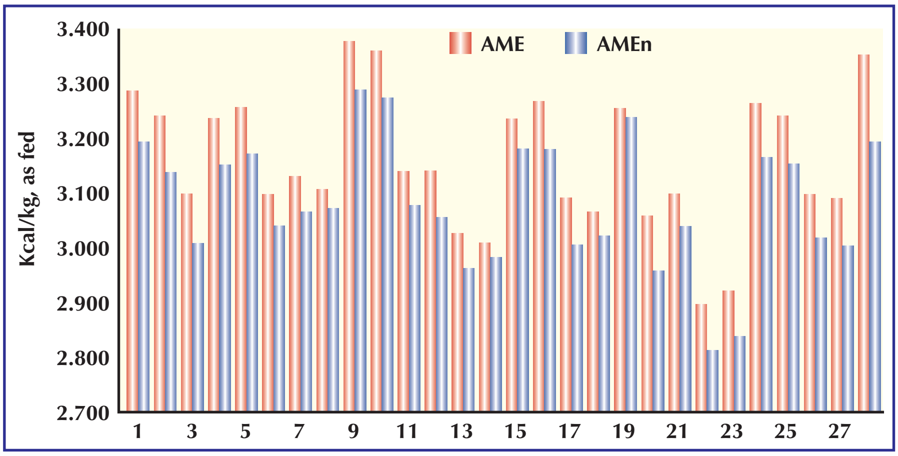

Fig. 1. AME and AMEn of 28 corn samples from Thailand, Pakistan, China and Indonesia.

As shown in Fig. 5, AMEn of cassava chips varied from 2,170 to 2,925kcal/kg, with a mean of 2,548kcal/kg, and CV of 13.2%. Our value is significantly lower than the value of 3,000kcal/kglisted in INRA (2002).

Soybean meals (SBM)

A total of 36 soybean meal samples had been tested so far. The origin of these samples includes USA, Argentina, Brazil, India, Thailand, China, Pakistan, and Japan.

Average AME and AMEn values were 2,618 and 2,335kcal/kg, respectively, with CV of 9.7 and 10.7% (Fig. 6). ME value of these SBM samples varied considerably, with variations much greater than that of corn. This is not surprising because, as a byproduct of soy oil production, the nutrient content of SBM is affected not only by the quality of soybeans, but also by processing conditions.

We had proximate analysis data on 23 of these SBM samples. No apparent relationships were found between ME and crude protein or either extract contents, but there was a tendency showing that the higher the crude fibre (CF) content, the lower the ME content (Fig. 7).

Full fat soy samples

Seven full fat soy samples were collected from Thailand. Mean AME and AMEn of these samples were 3,590 and 3,299 kcal/kg, with CV of 7.4 and 8.0%, res-

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Fig. 2. ME of full fat rice bran.

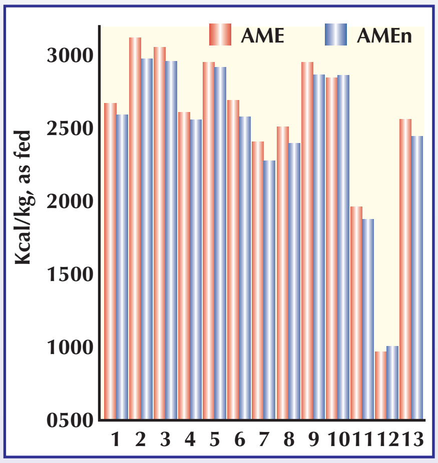


Fig. 3. ME of solvent extracted rice bran.

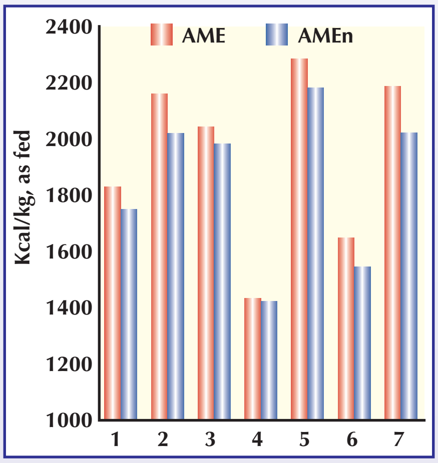
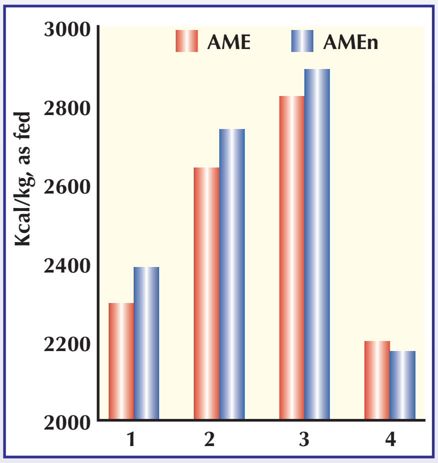


Fig. 4. AME and AMEn of cassava chips.



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pectively. Our value is identical to the MEn value of 3,300kcal/kg listed in NRC (1994), and is very close to the INRA (2002) value of 3,350kcal/kg. Still, the range of variation is surprisingly large.

Fish meal

A total of 11 fishmeal samples have been tested. All samples were collected from Thailand. Most of these fishmeal samples originated from Thailand, and these samples varied widely in protein (46 to 63%) and ether extract (5.8 to 15.6%) content. Three of these samples originated from Peru (Fig. 9). The mean AME and AMEn values of all samples were 2,761 and 2,423kcal/kg, respectively, with CV of 14.8 and 15.2%. Excluding three samples from Peru, the mean AME and AMEn of fish meal samples produced in Thailand are 2,588 and 2,262kcal/kg, respectively. Therefore, fishmeal samples produced in Thailand can be extremely variable in energy content, and have lower AMEn than those imported from Peru.

Implications of the results

Two remarks can be made based on the ME results obtained so far.

Firstly, the ME content of some major ingredients produced and used in Asia countries differed significantly from book values listed in well known databases such as NRC (1994) and INRA (2002).

For instance, AMEn of corn (3,080kcal/kg) is significantly lower than the value listed in NRC. Fish meals produced in Thailand had a mean MEn of 2,262kcal/kg. Secondly, we noticed that ME content varied greatly in all ingredients we tested, and particularly among ingredients that are produced as byproducts, such as full fat and solvent extracted rice bran, fish meal, and soybean meal. Their coefficients of variation (CVs) often exceed 10%.

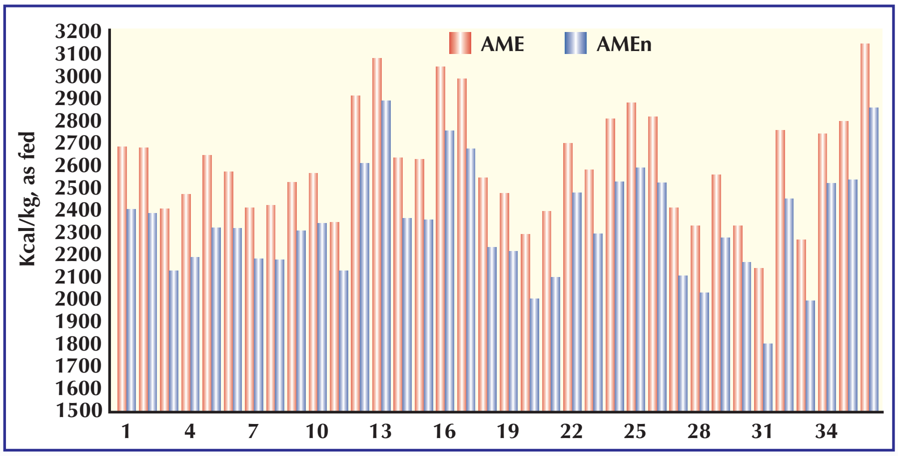

Fig. 5. AME and AMEn of soybean meal samples.

What would be the impact of such variation in ingredient ME on feed cost? As shown in Fig. 2 and Fig. 6, it is quite common that different batches of corn and soybean meal can differ in MEn by more than 100kcal/kg.

Table 2 shows the simulation results of a broiler grower feed, assuming that MEn of corn or soybean meal varied by 100 kcal/kg. Our simulation indicated that for corn and soybean meal 44%, a reduction of 100kcal/kg in MEn content would increase feed cost by $2.40 and $1.45 per ton of feed, respectively.

Therefore, the cost of wrongly estimating the ME content of ingredients could be extremely high. ■

References are available from the author on request.

Summary

Energy is the most costly component in poultry feeds. To help the feed and poultry industry in Asia to better handle this most important nutrient, Ajinomoto (Thailand) has set up a poultry ME bioassay laboratory. The ME bioassay laboratory uses growing broilers and follows the total collection method. It has the capacity of testing more than 200 samples per year.

Results so far showed that some major ingredients produced and used in Asia had significantly different ME content from the book values published by NRC or INRA. In addition, large variations were found among different samples of corn, full fat and solvent extracted rice bran, soybean meal, and fish meal.

Such variations would significantly increase feed cost. If not detected and remedied, such variations would lead to significant variation in ME of complete feeds, which would in turn contribute to variations in live performance, uniformity, and carcase quality, and reduce profitability. We continue to test other ingredients produced and used in Asia. While the ME bioassay is accurate, it is expensive and time consuming. Ajinomoto (Thailand) is currently exploring and developing in vitro and NIR techniques for quick and accurate estimation of poultry ME.

Fig. 6. AMEn versus crude fibre (CF) of 23 soybean meal samples.

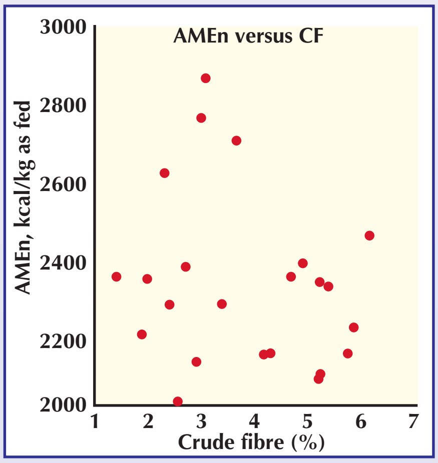

Fig. 7. AME and AMEn of full fat soy beans.

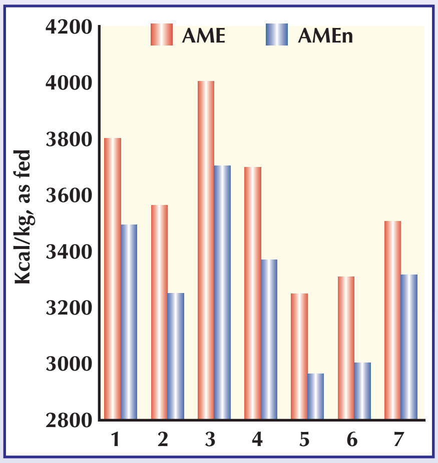

Fig. 8. AME and AMEn of fishmeal samples collected from Thailand.