Corn nutritive value key to improved profitability

Corn is perceived as a highly digestible ingredient as well as a highly uniform source of energy and nutrients for poultry and pig diets, but published research and commercial experience suggest that this is far from true.

By **MILAN HRUBY***

ACHIEVING the maximum profitability from animal protein production has a lot to do with understanding the nutritive value variability of major feed ingredients such as corn.

Applying the most accurate corn nutritive values and, more specifically, energy values enables nutritionists to contribute to significant improvements in profitability of livestock operations. Even in today's market, where cheaper alternative ingredients are available for pig and poultry diets, corn is still the major component of diets in the U.S. and, consequently, the greatest contributor of dietary energy.

Compared to other grains such as wheat, barley or sorghum, corn is generally thought of as being a highly digestible ingredient. It does not contain significant levels of soluble non-starch polysaccharides, tannins or phenolic compounds that can compromise the nutrient and energy digestibility of poultry and pig feeds.

A relative absence of specific anti-nutrients in corn should not, however, be interpreted as indicating that corn has a highly digestible and uniform nutrient and energy content.

Insoluble non-starch polysaccharides, different types of starches and their quality — often affected by harvesting conditions and post-harvest handling — can strongly influence the nutritive value of corn.

Non-variable ingredient

A number of studies over the years have demonstrated that corn samples, even from the same region, can present a wide variability in energy values.

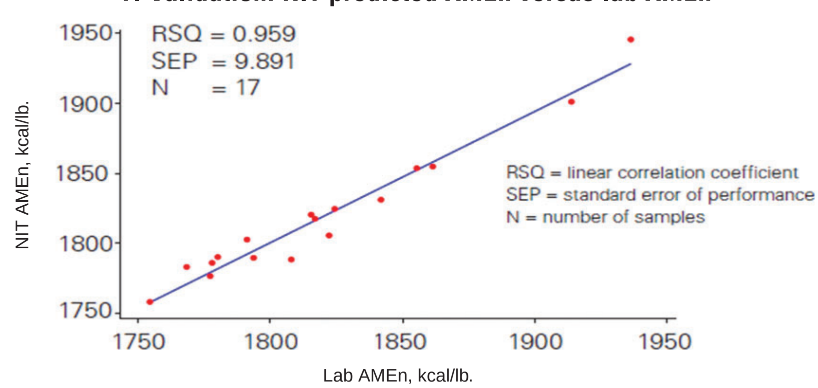
*Dr. Milan Hruby is senior regional technical services manager, U.S., for Danisco Animal Nutrition.

A study by Leeson et al. (1993) focusing on corn harvested during the same season and from a relatively small geographic area in Ontario noted that the average metabolizable energy (ME) of that corn was 3,218 kcal/kg (1,460 kcal/lb.), but the ME from the corn samples — collected during a rather wet harvest season — ranged from 2,926 kcal to 3,473 kcal/kg (1,328-1,576 kcal/lb.) on an as-received basis.

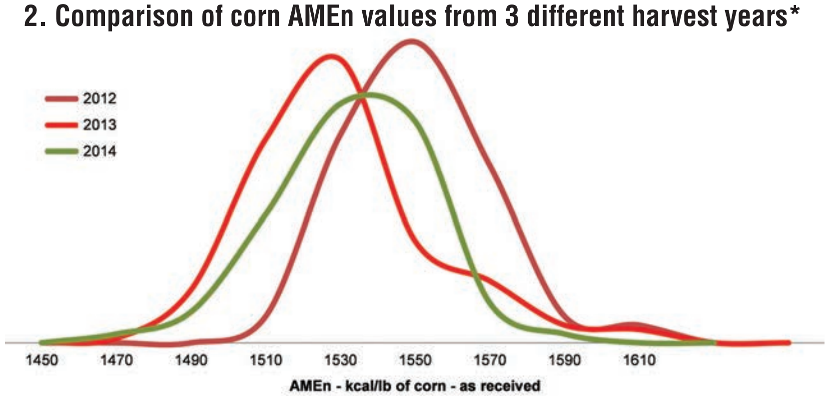
If a nutritionist is formulating a 55% corn-based diet using mean corn ME or the mean plus or minus one standard deviation based on the results of this research, the final energy contribution value from corn in a diet only could range between 1,681 kcal and 1,859 kcal/kg (763-844 kcal/lb.) of feed. This equates to a difference in dietary energy that would normally be associated with about 2.25% of added fat.

Because of the economic implication of overfeeding or underfeeding dietary energy to poultry and pigs, it is not surprising that nutritionists typically employ various tools to evaluate the energy value of corn to help reduce large safety margins when using different batches of corn during feed production.

1. Validation: NIT predicted AMEn versus lab AMEn



2. Comparison of corn AMEn values from 3 different harvest years*



*U.S. harvest year 2012, 2013 and 2014 corn AMEn frequency distribution comparison. DuPont Pioneer NIT calibrations were utilized to provide the values in this Figure.

Ideally, predictions of corn energy value in monogastric diets would provide the closest estimation of the actual value of corn used by the producers of animal protein. The obvious limitations of this approach — such as a long turnaround time and the cost of such an evaluation — prevent its practical and widespread use.

Some research has focused on how simulated digestion systems can be used to evaluate ingredient energy value (Zhao et al., 2014; Yegani et al., 2013). However, these methods also have limitations related to maintaining specific timing and pH and temperature conditions and the use of certain liquids, including enzymes and buffers.

More typically, poultry and swine nutritionists will use evidence-based equations from nutritional guides that provide the ability to use relatively easily measurable factors such as moisture, protein, fiber, starch and oil to calculate the apparent metabolizable energy (AME) of corn.

This approach can be relatively fast and economical, especially if using non-destructive methods, such as near-infrared (NIR) technology. However, even the developers of these equations or models concede that because their development was based on a specific set of corn samples, the practical value of these equations might be limited to only that research corn data set.

Additionally, many of these models do not take into account nutrient digestibility since they tend to be based on total values only. Supporting this observation with the earlier Leeson et al. (1993) example, the authors also reported that, unfortunately, no correlation was found among analytical parameters such as moisture, fat, ash, fiber and ME.

Fast values

A rapid grading of corn grain at the receiving point is a key step in acquiring a real-time energy value that can be used for reliable least-cost optimization of the diet. This grading process also helps identify substandard grain at the point of delivery.

DuPont Pioneer has developed a robust *in vivo* procedure to evaluate corn energy value and a means of converting results from that process into a rapid, non-destructive method of analysis based on NIR spectroscopy. Two different measurements commonly performed in the NIR spectral range are:

1. Reflectance, which measures the ratio of the intensity of light reflected from the sample, and

2. Transmittance, which records the decrease in radiation intensity as a function of wavelength when radiation is passed through the sample.

To determine corn energy value, DuPont Pioneer uses transmittance measurements. NIR transmittance (NIT) technology has many advantages, including accuracy, repeatability, high speed, low cost and non-destructive analysis.

The calibrations for corn energy — nitrogen-corrected AME (AMEn) and digestible energy (DE) — are partial least-square models for analysis of whole corn grain. (Partial least-square is a technique used during calibration development to establish a mathematical relationship between customer scans and wet chemistry data for the same set of samples.) The models are robust and highly accurate, taking advantage of DuPont Pioneer's experience in understanding corn quality and the opportunity to choose specific corn samples from a large corn sample database to build reliable calibrations.

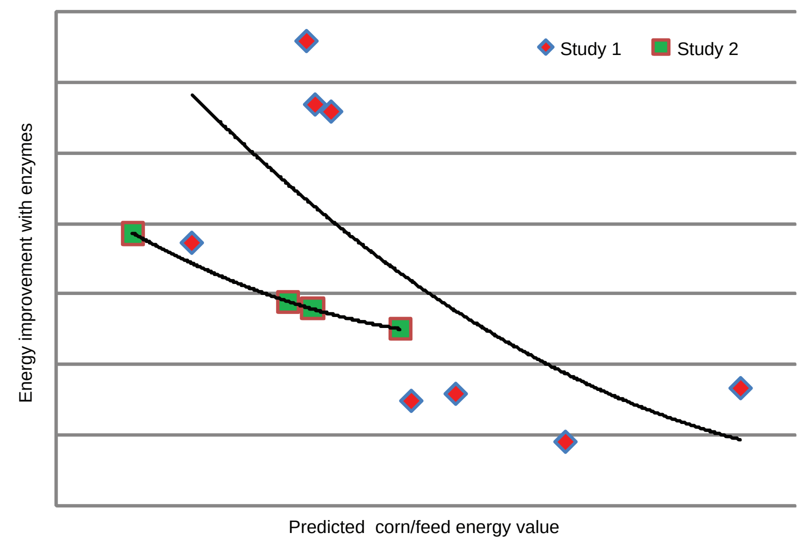
The current models report AMEn or DE in kilocalories per pound on a dry matter basis. In addition, calibrations for moisture, protein, oil, starch and gross energy are also provided. The models have been validated with an independent sample set and are highly predictive, as shown in Figure 1 for corn energy value.

The DuPont Pioneer model was developed by directly linking AMEn results obtained with various corn samples fed to 21-day-old broiler chicks in one research facility to reduce the variability of measurements. Furthermore, the model is continuously updated with data from digestibility studies using specific corn samples to further improve the model's strength and accuracy.

All the parameters for corn energy and other analytes can be provided to DuPont customers, either directly for their specific batches of corn or as an overview of the U.S. corn market for a particular harvest year. The Table provides an example of corn harvested in the U.S., and Figure 2 shows a comparison of AMEn values in three different harvest years.

For U.S. corn harvested during 2014 and sampled at commercial feed mills, the average AMEn and DE values on an as-received basis were determined to be 3,359 kcal/kg (1,524 kcal/lb.) and

3. Relationship between starting corn energy value and response to xylanase, amylase and protease



2014 U.S. corn NIT results*

All as is	Avg.	Min.	Max.	Std. dev.	CV, %
Moisture, %	14.0	10.9	16.5	1.05	7.51
Protein, %	7.2	6.1	8.6	0.46	6.38
Starch, %	60.4	57.9	63.0	0.88	1.46
Oil, %	3.4	2.9	3.9	0.19	5.53
AMEn, kcal/lb.	1,524	1,469	1,577	20.0	1.3
AMEn, kcal/kg	3,359	3,237	3,476	44.1	1.3
DE, kcal/lb.	1,564	1,510	1,619	20.25	1.30
DE, kcal/kg	3,447	3,328	3,567	45.0	1.30
Gross energy, kcal/lb.	1,738	1,686	1,799	22.49	1.29

*DuPont Pioneer NIT calibrations were utilized to provide the values in this Table.

3,447 kcal/kg (1,564 kcal/lb.) of corn, respectively. For AMEn, the range between the lowest and the highest determined corn energy value was 239 kcal/kg (108 kcal/lb.).

While this is less than half of the spread observed in the Leeson et al. (1993) research, its value is still very interesting commercially. Considering that the 2014 U.S. corn harvest, in general, produced high-quality corn, one can only imagine what the outcome will be during less-favorable harvest season conditions.

Reducing safety margins

Kaczmarek et al. (2007) demonstrated that post-harvest treatment of corn can have a profound effect on its nutritional value.

In their study, the performance of broilers fed diets based on high-moisture corn dried at 176°F, 248°F or 284°F was adversely affected in a linear fashion. The authors reported that average daily gain and feed conversions at 35 days of age were 1,878, 1,838 and 1,523 g and 1.51, 1.56 and 1.67, respectively, for broilers fed diets based on three corn samples dried under the different temperatures to the same corn moisture content.

It was suggested that the harshness of the drying process may result in reduced solubility of starch and protein. The authors have also shown that the use of feed enzymes — in this case, xylanase, amylase and protease — could improve both feed conversion and, specifically, weight gain of 35-day-old broilers.

Furthermore, they observed that the response to xylanase, amylase and protease was more apparent in corn that had been dried at the higher temperature, suggesting that exogenous enzymes can play a role in improving the nutrient digestibility and uniformity of various corn samples and ameliorating some negative effects of harvest and post-harvest handling.

More recently, research using corn samples of different quality harvested in the U.S. and China showed that there was a relationship between a starting corn energy value and the magnitude of corn/dietary energy improvement due to the addition of enzymes (Figure 3).

In both types of studies presented, a combination of xylanase, amylase and protease exogenous enzymes was used to evaluate the response directly in broilers. Lower-energy corn or diets based on different corn samples provided a better opportunity for the enzyme combination to improve dietary energy value.

Simply not simple

There may be a perception in the market that corn is a highly digestible ingredient as well as a highly uniform source of energy and other nutrients for poultry and pig diets, but published research and commercial experience suggest that this is far from true. Recent technology improvements have afforded opportunities to quickly, reliably and cost-effectively predict corn energy value through NIT technology application.

In addition, the feed industry has used exogenous or feed enzymes to improve nutrient digestibility and uniformity of feeds based on various ingredients, including corn, for some time. Combining the knowledge of starting corn energy value with the prediction of an enzyme response could allow nutritionists to better target specific batches of corn with feed enzymes. It will also enable them to adjust their safety margins for corn energy to deal more economically with batch-to-batch corn energy value variation.

References

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