Nutritional Value of Ingredients

There are different methodologies for assigning nutritional values to feed ingredients. However, consistently using the same methodology across the feed ingredients used in diet formulation is key. A common approach is to use nutritional composition databases from the National Research Council (NRC), the French National Institute for Agricultural Research (INRA), or the Brazilian Tables for Poultry and Swine. Additionally, nutritional values may be provided by the ingredient supplier. However, there are practical approaches that can be used to assign nutritional values to feed ingredients when values are not available or not similar to the reference ingredient in the databases. The approaches to practically assign values of energy, amino acids, and phosphorus to feed ingredients are discussed in this fact sheet.

Assigning energy values

Dietary energy is the most expensive component of swine diets. Precision in assigning the energy value of a feed ingredient is crucial to achieve the predicted performance and optimal feed cost.

Energy can be expressed as digestible (DE), metabolizable (ME), or net energy (NE). The DE and ME energy systems are the most widely used for evaluating ingredients because energy values are relatively easy to measure. However, the NE system is recognized as the closest ingredient energy value estimate because it takes the heat increment from digestive process and metabolism of feeds into account. Importantly, the same energy system must be consistently used across the feed ingredients used in diet formulation.

Practical approaches can be used to assign energy values to feed ingredients (Gonçalves et al., 2016).

Prediction equations

Prediction equations generally require chemical analysis input for dry matter (DM), crude protein (CP), ether extract (EE), neutral detergent fiber (NDF) or acid detergent fiber (ADF), ash, and starch to yield a predicted energy value. For an accurate ingredient analysis, following a standardized sampling procedure is key.

The NRC and the Brazilian Tables present equations for predicting NE developed by Noblet (Noblet et al., 1994). EvaPig® is a software developed by INRA in partnership with the French Association for Animal Production (AFZ) and Ajinomoto Eurolysine S.A.S. that presents equations for predicting NE based on databases from these organizations. The prediction equations for NE from INRA and the Brazilian Tables account for difference in energy digestibility between growing pigs and sows, while the NRC equations do not.

Validation experiments

Validation experiments are conducted to confirm energy values for feed ingredients (Li et al., 2017). In these experiments, the ingredient is included in increasing amounts in the diet while other nutrients are maintained at a constant level among dietary treatments. This is based on the fact that pigs tend to consume feed to meet the energy requirements, thus if the other nutrients such as lysine are maintained constant, similar growth performance is expected (Li et al., 2018).

Initially, an estimated energy value is assigned to the ingredient to formulate experimental diets, which is most often derived from nutritional tables. Then, feed efficiency or caloric efficiency are used to determine whether the energy value of the ingredient was accurately estimated. Caloric efficiency is the most commonly used criteria and is determined by estimating the amount of daily energy intake per pound of gain (kcal of NE per lb of gain).

Caloric efficiency

Caloric efficiency, kcal NE per lb gain =

(ADFI, lb × Dietary energy, kcal NE per lb) ÷ ADG, lb

If the energy value of the ingredient was accurately estimated, a similar caloric efficiency is observed among the dietary treatments with increasing amounts of the ingredient. If the caloric efficiency is not similar, the energy level for the ingredient is likely underestimated if caloric efficiency improves with increasing amounts of the ingredient, or overestimated if caloric efficiency worsens (Li et al., 2017). The NE values of corn, distillers dried grains with solubles, canola meal, wheat middlings, soybean oil, tallow, among other ingredients have been validated through this method (Hastad et al., 2005; Wu et al., 2007; Adeola et al., 2013; De Jong et al., 2014; Graham et al., 2014; Nitikanchana et al., 2015; Li et al., 2017).

Relative values

The use of relative values can be used if 1) the feed ingredient contains a similar composition (CP, NDF, EE, ash, starch) to the reference ingredient and 2) the reference ingredient energy value is reliable (Gonçalves et al., 2016). In this method, both the new ingredient and the reference ingredient are submitted to the same approach to be assigned an energy value, which can be any of the approaches described above. The estimated energy value for the reference ingredient is then compared to its original reliable energy value. If there is a difference between estimated and original energy values, an adjustment is applied to the estimated energy value of the ingredient of interest.

For example, the estimated energy value of the ingredient of interest is 910 kcal NE/lb and the estimated energy value of corn is 1,210 kcal NE/lb, therefore the ratio is 910 ÷ 1,210 = 0.75. The adjustment is then applied on the original energy value of the reference ingredient to generate a relative energy value for the ingredient of interest. For example, if the original reliable energy value of corn is 1190 kcal NE/lb, the relative value of the ingredient of interest is 1,190 × 0.75 = 892 kcal NE/lb.

Relative value

Adjustment = Estimated energy of ingredient, kcal/lb ÷ Estimated energy of reference ingredient, kcal/lb

Relative value, kcal/lb = Adjustment × Original energy value of reference ingredient, kcal/lb

Assigning amino acid values

Protein is essential for growth and development of swine. Accurate determination of digestible amino acids in a feed ingredient is important to achieve optimum performance and because protein sources are expensive components of the diet.

Amino acid digestibility is expressed as total tract digestibility or ileal digestibility. The ileal digestibility is more accurate than total tract digestibility because amino acids are exclusively absorbed in the small intestine and microbial fermentation in the large intestine affects the recovery of amino acids. The ileal digestibility is expressed as apparent (AID), standardized (SID), or true (TID) ileal digestibility, depending on how endogenous amino acid losses are considered in the measure of digestibility. The most widely used method to formulate diets and estimate amino acid digestibility is SID.

There are two steps to practically assign SID amino acid values to feed ingredients (Boisen, 1998):

- **Amino acid analysis**: The first step is to submit the feed ingredient to analysis of crude protein and amino acids.
- **Digestibility value**: The second step is to assign SID values to the crude protein and amino acids level in the feed ingredient. The most common approach is to use digestibility values from nutritional tables (NRC, INRA, or the Brazilian Tables), scientific literature, or university databases. Ideally, the digestibility of the same ingredient is used, but ingredients with similar characteristics can also serve as a reference for digestibility.

Assigning phosphorus values

Phosphorus is an inorganic element important for development and maintenance of the skeletal system of swine. Preciseness on assigning the phosphorus value of a feed ingredient is important because supplemental sources of phosphorus are expensive and excess phosphorus increases its excretion in swine waste which imposes a negative effect on the environment.

Phosphorus can be expressed as total, digestible, or available. Available phosphorus represents the amount of phosphorus that is digested, absorbed, and available for utilization according to the slope-ratio method. Total phosphorus represents all phosphorus contained in the ingredient, including non-available phosphorus that is mostly bound to phytate. Digestible phosphorus represents the amount of phosphorus that is digested and absorbed, which is expressed as apparent (ATTD) or standardized (STTD) total tract digestible phosphorus. The basal endogenous losses of phosphorus are accounted for on STTD basis, but not on ATTD basis. The most commonly used method to formulate diets and estimate phosphorus digestibility is STTD.

Similar to the approach used for amino acids, there are two steps to practically assign STTD phosphorus values to feed ingredients (Gonçalves et al., 2017):

- **Phosphorus analysis**: The first step is to submit the feed ingredient to analysis of total phosphorus.
- **Digestibility value**: The second step is to assign STTD value to the phosphorus level in the feed ingredient. The most common approach is to use digestibility values from nutritional tables (NRC, INRA, or the Brazilian Tables), scientific literature, or university databases. Ideally, the digestibility of the same ingredient is used, but ingredients with similar characteristics can also serve as a reference for digestibility. In this case, it is important to pay attention to processing method, amount of phytate, and level of naturally occurring phytase, as these factors influence phosphorus digestibility in feed ingredients. EvaPig® accounts for processing methods and naturally occurring phytase on phosphorus digestibility of feed ingredients, while the NRC does not.

More information about traditional or alternative methods for assigning energy and nutrient values to feed ingredients for swine is found in recent and thorough reviews of literature by Święch (2017), Zhang and Adeola (2017), and Li et al. (2018).

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