Characterizing and Manipulating Energy Content of Ingredients

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Executive Summary
Characterising the energy content of ingredients included into swine diets is important for accurate diet formulation. Methods to characterize the energy content of ingredients will be illustrated with data from a large collaborative study with barley. Potential use of characterizing information for manipulating the energy content will be discussed in the presentation.

Introduction
A good understanding of the nutritional value of ingredients included into swine diets is becoming increasingly important. Reasons include the improved definition of nutrient requirements across various environmental conditions, the increased attention on pork quality and the necessary reduction of nutrients excreted in swine manure. The presentation was based in part on a research project that explored a range of measurements to predict digestible energy (DE) of barley for pigs. The project was a collaborative effort between the Prairie Swine Centre (RTZ and JFP), Pacific Agri-Food Research Centre (Tom Scott), Canadian Grain Commission (Mike Edney), Agro Pacific Industries (MaryLou Swift), and the Crop Development Centre (Brian Rossnagel). The focus within nutritional value was DE, because the greatest cost pressure with least-cost diet formulation is against supply of available energy. The overall project had three objectives: (1) explore if a range in DE exists in western Canadian barley, (2) attempt to calculate the corresponding range in economic value, and (3) explore physical and chemical measurements, chicken available metabolisable energy (AME), and near-infrared spectroscopy (NIRS) to predict DE of barley for pigs.

Experimental Procedures
In total 40 barley samples were analysed for swine DE in 2 trials in grower pigs (30-40 kg) housed in metabolism crates that allowed collection of faeces. Trial 1 included 20 samples without damaged kernels (Fairbairn et al., 1999), whereas trial 2 included some “off-grade” (sprouted, frost-damaged) samples. Experimental diets included a specific barley sample (96%), vitamins, minerals, and chromium oxide as an indigestible marker. Dry matter, energy and chromium content were analysed in experimental diets and collected faeces to calculate DE content for each barley sample.

For the 20 barley samples from trial 1, the economic value for a typical diet for grower pigs was calculated using the feed formulation software Brill (Fairbairn et al., 1999). The economic value was calculated as follows: a diet was formulated for grower pigs using the average DE content (2940 kcal/kg) and price ($110/1000 kg) of barley, and with prices for other ingredients in July 1997. Then, this diet was reformulated using the actual DE content of each barley sample to reach the DE content of the original diet. Finally, the value of barley was adjusted to reach the cost price for the original diet. Each diet contained a minimum of 45% barley.
Results and Discussion

Overall, DE ranged from 2686 to 3163 kcal/kg (90% DM). Using the described calculations, value of the barley samples ranged from 78 to 139 $/1000 kg, a range of $61. Physical and chemical measurements, chicken AME, and NIRS were analysed to predict DE of barley for pigs.

Physical measurements. Density, described as test weight or bushel weight, remains in use throughout the grain and livestock industry as an indicator of “quality.” Some studies suggest a positive relationship between density and nutritional value of barley (Beames et al., 1996). However, a large body of scientific literature indicates that the prediction of DE with physical measurements should be treated with great scepticism. Likewise, density ranged from 47.9 to 71.5 kg/hL or 38 to 57 lb/bushel in the present study (Figure 1) and was not related to DE \( (R^2 = 0.14) \), indicating that physical measurements can not predict DE accurately.

Chemical measurements. A wide range of chemical components was analysed in the barley samples from trial 1 (Fairbairn et al, 1999), including components of standard proximate analyses and non-starch polysaccharides (NSP). Starch was positively correlated to DE \( (r = 0.64; P < 0.01) \), whereas crude fibre, neutral detergent fibre, and acid detergent fibre (ADF) were negatively correlated to DE \( (r = -0.83, -0.82, -0.92, \text{ respectively}; P < 0.01) \). Of the chemical components, ADF concentration was the best single predictor for DE in trial 1 \( \text{DE}=3526 – 92.8 \times \text{ADF (90% DM)}; R^2 = 0.85; P < 0.01 \), indicating that chemical parameters can predict DE accurately.

Chicken AME. Barley samples were analysed by a modified AME-bioassay in broiler chicks (Scott et al., 1998), in diets with and without supplemental enzymes. Without enzymes, AME and DE were not related \( (R^2 = 0.03; \text{Figure 2}) \), but the relation improved greatly by enzyme supplementation \( (R^2 = 0.56; \text{Figure 3}) \). These results indicate clearly that chicken AME can currently not be used to predict swine DE in barley. Chicken AME might be considered a worthy approach to study swine DE, but only after enzyme supplementation is modified to further increase the relation between swine DE and chicken AME \( (e.g., R^2 > 0.90) \). Recent research at PARC indicates that feed intake and subsequent performance of chickens differs greatly among barley samples, an interesting observation that needs to be verified in swine.

NIRS. So far, the best calibration for swine DE content in cereal grains has been developed in Australia (Van Barneveld, 1998). With a sample set of 156 samples, DE in whole grain cereals could be predicted to an accuracy of 90 kcal/kg. In the present study, ground kernel barley samples were analysed by NIRS \( (400-2500 \text{ nm}, 2 \text{ nm intervals}) \). A good calibration was developed using 27 ground samples \( (R^2 = 0.96; \text{SE of prediction (SEP)} = 30.47) \) to predict DE in 12 other ground samples \( (R^2 = 0.98; \text{SEP} = 24.0) \). A similar calibration was developed with whole kernel samples \( (R^2 = 0.94; \text{SE of cross validation (SECV)} = 87 \text{ kcal/kg}) \), indicating that NIRS can predict DE content of barley fairly accurately. Apart from NIRS calibrations for nutritional value per kg of cereal grains, successful calibrations for feed intake and subsequent performance in chickens indicate further benefits of NIRS (Swift et al., 1998).

Potential use of characterizing information for manipulating the energy content will be discussed in the presentation. The information can be used to re-formulate diets to reach an pre-planned diet DE content or to make decision whether to use processing methods to increase the energy content.

Conclusions

A significant range in DE content exists in western Canadian barley, which results in a large range in economic value. Physical parameters can not be used to estimate the DE content in
barley. Equations based on chemical characteristics can predict DE content accurately. Broiler AME and swine DE are not correlated; however, addition of enzymes to broiler diets improved the correlation between AME (+ enzyme) and DE greatly. The results indicate that barley DE can be predicted accurately by NIRS; however, a larger sample set is required to increase robustness of calibration.

Implications

The results indicate that in order to characterize the energy content of feed ingredients accurately, prediction equations based on chemical characteristics or NIRS-technology can be used. The results further suggest that a larger sample set will be required to increase robustness of calibration to predict barley DE by NIRS.

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References


Figure 1. Density and DE Content

Figure 2. AME and DE Content

Figure 3. AME + Enzyme & DE Content