Prediction of digestible and metabolizable energy of corn distillers dried grains with solubles for growing pigs using in vitro digestible nutrients

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ABSTRACT: The objective of this study was to develop prediction equations (EQS) that estimate DE and ME content of corn distillers dried grains with solubles (DDGS) using digestible (DIG) nutrients from in vitro or in vivo assays. Chemical composition data from 12 sources of corn DDGS were obtained using laboratory chemical analysis (LCA) and near infrared spectroscopy (NIRS). In vitro DM disappearance (IVDMD) from gastric and small intestine hydrolysis (IVDMD_h), large intestine fermentation (IVDMD_f), and total tract digestion (IVDMD_t) were also determined along with in vivo apparent total tract digestibility (ATTD) of DM, CP, ether extract (EE), NDF, and ADF, and energy values (GE, DE, and ME). Correlation analysis was used to compare chemical composition from LCA with NIRS, and a stepwise selection of variables was performed using linear regression to establish DE and ME prediction EQS. Composition determined by NIRS did not correlate with values from LCA. Consequently, significance and R^2 were poorer when using NIRS data as inputs to predict DE ($P = 0.11$; $R^2 = 0.23$) and ME ($P = 0.11$; $R^2 = 0.24$). However, when using LCA data, DE ($P = 0.04$; $R^2 = 0.35$) and ME ($P = 0.04$; $R^2 = 0.52$) estimates of corn DDGS obtained from prediction

EQS had significant P values, but low R^2 . Better prediction of DE ($P < 0.01$; $R^2 = 0.83$) and ME ($P < 0.01$; $R^2 = 0.76$) was observed when using in vivo DIG nutrients as inputs (DM basis) for DE, kcal/kg = $854.5 + (3.6 \times \text{DIG DM, g/kg}) + (3.7 \times \text{DIG EE, g/kg}) + (2.0 \times \text{DIG NDF, g/kg})$ and ME, kcal/kg = $704.5 + (3.3 \times \text{DIG DM, g/kg}) + (4.8 \times \text{DIG EE, g/kg}) + (2.6 \times \text{DIG NDF, g/kg})$. In vitro DIG DM, but not in vitro DIG NDF, was selected for use in EQS (7) DE, kcal/kg = $6,383.6 - (42.5 \times \text{in vitro DIG DM, g/kg}) + (35.4 \times \text{DIG EE, g/kg})$ and (8) ME, kcal/kg = $6,635.1 - (49.8 \times \text{in vitro DIG DM, g/kg}) + (41.3 \times \text{DIG EE, g/kg})$, but the significance and accuracy for both DE ($P = 0.07$; $R^2 = 0.45$) and ME ($P = 0.05$; $R^2 = 0.49$) predictions was less using in vitro DIG nutrient values than using in vivo DIG nutrient values. If chemical composition was used to replace in vivo EE, along with in vitro DIG NDF and DM, the prediction EQS only used the concentration of ADF and EE as predictors instead of in vitro DIG NDF and DM. In conclusion, in vivo DIG NDF, DM, and EE are the best predictors for DE and ME content of corn DDGS for swine. Using NIRS to determine chemical composition, in vitro DIG NDF, and in vitro DIG DM did not result in accurate predictions of DE and ME.

Key words: corn distillers dried grains with solubles, digestible energy, in vitro nutrient digestibility, in vivo nutrient digestibility, metabolizable energy, prediction equations

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INTRODUCTION

Energy is the most expensive component in swine diets, and accurate ME and NE estimates of feed ingredients are essential for optimizing caloric efficiency of pig production. In the United States,

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commercial swine diets containing corn, soybean meal, and corn distillers dried grains with solubles (DDGS) are often formulated based on the ME system because NE content of feed ingredients is more difficult and expensive to measure, and ME content of low fiber ingredients represents the utilizable energy reasonably well (Velayudhan et al., 2015). Corn DDGS is a commonly used major ingredient in U.S. swine diets because it is an economical alternative to corn and soybean meal, and it is produced and available in large quantities. However, variability in energy and nutrient content among DDGS sources has limited diet inclusion rates (Stein and Shurson, 2009; Kerr et al., 2013). Use of prediction equations (EQS) allows calculation of estimated DE and ME content in DDGS based on concentration of nutrients (Urriola et al., 2014).

A 3-step procedure has been used to predict DE and NE content of feed ingredients used in swine diets based on in vitro OM digestibility and chemical composition (Noblet and Jaguelin-Peyraud, 2007). A modified 3-step procedure with the addition of measuring gas production has also been used to predict in vivo DM, OM, and digestibility of NDF (Chen et al., 2014) or TDF (Huang et al., 2017). However, the use of the modified 3-step procedure and measurement of gas production has not been evaluated for accuracy in predicting DE and ME content among sources of DDGS. Near infrared spectroscopy (NIRS) is another technology that has been used to predict chemical composition of DDGS (Zhou et al., 2012). As a result, it may be possible to obtain reliable estimates of DE and ME content from NIRS determined chemical composition in combination with in vitro digestible (DIG) nutrient data. Therefore, the objective of this study was to develop DE and ME prediction EQS using either in vivo or in vitro DIG nutrients among sources of corn DDGS.

MATERIALS AND METHODS

Sample Collection

A total of 12 samples of corn DDGS from our previous experiments (Kerr et al., 2013; Huang et al., 2017), that had values for in vivo apparent total tract digestibility (ATTD) of nutrients, as well as in vivo determined DE and ME content for growing pigs, were used in this study (Kerr et al., 2013). These sources were obtained from different ethanol plants and represented diverse geographical locations of U.S. corn production and different coproduct processing technologies, to represent the

variability in chemical composition among sources of corn DDGS available in the U.S. market.

Total and DIG Nutrient and Energy Determinations

Laboratory chemical analysis (LCA) of all corn DDGS samples was determined using the following methods: DM (AOAC International, 2005; official method 934.01), EE (AOAC International, 2005; official method 920.39 (A)), NDF (Holst, 1973), ADF (AOAC International, 2005; official method 973.18), CP (AOAC International, 2005; official method 992.23). In addition, NIRS was used to estimate chemical composition (i.e., DM, CP, EE, starch, ADF, and NDF) of all samples by scanning using an NIRS analyzer (DA 7250, Perten, Hägersten, Sweden) at the Crops Research Unit of the University of Minnesota (St. Paul, MN). In vitro DM digestibility (IVDMD) of corn DDGS was determined to simulate gastric and small intestine hydrolysis (IVDMD_g), large intestine fermentation (IVDMD_l), and total tract digestibility (IVDMD_t) as described by Huang et al. (2017). The ATTD of nutrients, as well as DE and ME content (Table 1) of the 12 corn DDGS samples fed to growing gilts (BW 83.7 to 105.6 kg) were determined in previous in vivo experiments (Kerr et al., 2013). Digestible nutrient content and in vitro DIG nutrient content were calculated as:

$$\text{DIG nutrients, \%} = \text{nutrients, \%} \times \text{ATTD of nutrients} \quad (1)$$

$$\begin{aligned} \text{In vitro DIG nutrients, \%} \\ = \text{nutrients, \%} \times \text{in vitro nutrient digestibility} \quad (2) \end{aligned}$$

Statistical Analyses

The PROC CORR of SAS (Version 9.3; SAS Inst. Inc., Cary, NC) was used to analyze the association between the chemical composition of corn DDGS samples based on LCA and NIRS determined values. A value of $P < 0.05$ was considered to represent a significant correlation. The PROC REG STEPWISE of SAS was used to select input variables for EQS to predict DE and ME content of corn DDGS. Prediction EQS were divided into groups based on origin of composition data: 1) LCA data, 2) NIRS estimates of chemical composition, 3) in vivo DIG nutrients, 4) in vitro DIG nutrients in combination with in vivo DIG nutrients, and 5) in vitro DIG nutrients with chemical composition. Variance inflation factor was used to determine multicollinearity, where variables with $VIF > 10$ were considered to have multicollinearity (Kaps and Lamberson, 2004), and were removed

Table 1. Chemical composition from LCA and NIRS, IVDMD, ATTD of nutrients, and DIG nutrients of 12 corn DDGS samples (DM basis)

Measurement	Least	Mean	Greatest	SD	CV
Chemical composition (Kerr et al., 2013)					
GE, kcal/kg	4,780	4,966	5,167	114	2.3
DE, kcal/kg	3,500	3,638	3,870	132	3.6
ME, kcal/kg	3,266	3,417	3,696	147	4.3
DM, %	84.8	87.7	90.0	1.8	2.1
CP, %	29.0	30.6	32.9	1.2	3.8
Starch, %	0.8	2.2	3.9	1.1	48.9
EE, %	4.9	9.1	13.2	2.4	26.4
NDF, %	30.5	34.2	38.9	3.3	9.8
ADF, %	9.0	11.3	13.9	1.8	15.8
NIR predicted chemical composition, %					
DM, %	89.9	90.5	91.7	0.7	0.8
CP, %	27.7	29.6	32.2	1.4	4.7
EE, %	7.1	8.6	14.4	2.2	25.8
NDF, %	15.4	20.3	28.4	4.0	19.6
ADF, %	11.1	13.5	17.2	1.7	12.6
IVDMD and asymptotic gas production (Huang et al., 2017)					
IVDMD _h ^a , %	45.3	54.6	59.4	3.9	7.1
IVDMD _f ^b , %	44.3	52.6	64.2	5.9	11.1
IVDMD _t ^c , %	77.2	78.8	83.5	2.0	2.5
ATTD, % (Kerr et al., 2013)					
DM	67.7	71.2	77.3	2.7	3.8
CP	78.0	80.9	84.8	2.2	2.7
EE	52.7	63.9	81.2	8.5	13.3
NDF	44.5	53.4	61.5	5.2	9.7
ADF	55.2	67.3	76.7	6.8	10.0
DIG nutrients ^d , g/kg					
DM	601.0	626.7	686.0	25.1	4.0
CP	233.0	248.8	268.0	9.9	4.0
Starch ^e	8.0	22.4	39.0	11.0	48.9
EE	32.0	59.5	91.0	16.8	28.3
NDF	145.0	187.7	235.0	30.6	16.3
ADF	55.0	79.2	104.0	18.2	22.9

^aIVDMD_h = IVDMD from simulated gastric and small intestinal hydrolysis.

^bIVDMD_f = IVDMD from simulated large intestine fermentation.

^cIVDMD_t = IVDMD from simulated total tract digestion.

^dCalculated as chemical composition × ATTD of nutrients × 10.

^eAssumed starch was 100% digested.

from the prediction EQS. The *P* value, *R*², and root of the mean square error (SEM) were used as parameters to determine the accuracy of the prediction EQS.

RESULTS

Variability of Composition and Digestibility of Nutrients

All comparisons in this section are numerical values and were not statistically analyzed. The GE (4,780 to 5,167 kcal/kg), DE (3,500 to 3,870 kcal/

kg), and ME (3,266 to 3,696 kcal/kg) content of the 12 corn DDGS samples was variable (Table 1). The LCA values of DM (88.8% to 90.0%) and CP (29.0% to 32.9%) were less variable than energy values, while EE (4.9% to 13.2%), NDF (30.5% to 38.9%), and ADF (9.0% to 13.9%) content had greater variability than CP. The NIRS estimated chemical composition also reflected similar variability in estimates compared with values derived from the LCA for EE (7.1% to 14.4%), NDF (15.4% to 28.4%), and ADF (11.1% to 17.2%), compared with DM (89.9% to 91.7%) and CP (27.7% to 32.2%). The variability in in vivo nutrient digestibility showed similar trends. The ATTD of EE (65.7% to 81.2%), NDF (44.5% to 61.5%), and ADF (55.2% to 76.7%) were more variable than ATTD of DM (67.7% to 77.3%) and CP (78.0% to 84.8%). Furthermore, IVDMD_f (44.3% to 64.2%) was more variable than IVDMD_h (56.1% to 59.4%), and IVDMD_t (77.2% to 83.5%) because IVDMD_f is mainly a measure of fiber digestibility, and IVDMD_h mainly represents CP, EE, and starch digestibility. Digestible nutrients were calculated based the chemical composition and digestibility of nutrients, resulting in DIG EE (3.2% to 9.1%), NDF (14.5% to 23.5%), ADF (5.5% to 10.4%) being more variable than DIG DM (60.9% to 68.6%) and CP (23.3% to 26.8%).

Correlation Between Chemical Composition of Wet Lab Analysis and NIR Scan

There were no significant correlations for DM, CP, starch, EE, ADF, and NDF concentrations between LCA and NIRS data (Table 2). These results indicate that the NIR scan was not an accurate method to predict chemical composition of corn DDGS. The lack of correlations between LCA and NIRS data was likely due to the limited number of samples evaluated in this study.

DE and ME Prediction EQS Using Chemical Composition for LCA or NIRS

The DE and ME prediction EQS (1) and (2) derived from using only chemical composition values from LCA had significant *P* values (*P* = 0.04) but low *R*² values (Table 3). However, using only NIRS determined chemical composition values as variables to develop EQS (3) and (4) did not result in a significant *P* value (*P* = 0.11) and resulted in a lower *R*² than observed using LCA data (EQS 1 and 2). These results suggest that chemical composition of this number of samples was not useful for accurately predicting DE and ME content of corn

Table 2. Correlation of chemical composition of 12 corn DDGS samples between LCA and NIRS values

Item	DM	CP	Starch	EE	ADF	NDF
r^a	0.22	0.27	0.29	0.10	0.38	0.41
<i>P</i> -value	0.49	0.39	0.36	0.75	0.22	0.19

^a r = Pearson's correlation coefficient.

DDGS samples. It also confirmed that NIRS estimates were no better than LCA values for use as predictors of DE and ME content.

The DE and ME Prediction EQS Developed from DIG Nutrients

As EQS (5) and (6) indicate, in vivo DIG DM, NDF, and EE were good predictors of DE ($P < 0.01$; $R^2 = 0.83$) and ME ($P < 0.01$; $R^2 = 0.76$) content in DDGS (Table 4). In vitro DIG DM could also be used to replace in vivo DIG DM as a predictor for DE (equation 7; $P = 0.07$; $R^2 = 0.45$) and ME (equation 8; $P = 0.05$; $R^2 = 0.49$) content. However, neither in vivo nor in vitro DIG NDF and ADF values were selected for use in the prediction EQS. The prediction accuracy of EQS (7) and (8) was less for than EQS (5) and (6). When using chemical composition from LCA, along with in vitro DIG DM and fiber as potential predictors, the stepwise procedure did not use these variables in the prediction (EQS 9 and 10), and the prediction accuracy was relatively low ($P = 0.04$ and $R^2 = 0.35$ for DE equation 9; $P = 0.04$ and $R^2 = 0.52$ for ME equation 10). These results indicate that DIG EE is an important predictor of DE and ME content for corn DDGS.

DISCUSSION

The aim of this study was to investigate if data obtained from common in vitro nutrient digestibility methods could be used to accurately predict

DE and ME content of corn DDGS that were previously estimated using chemical composition of each source (Urriola et al., 2014). The use of DIG nutrients to predict energy is based on the notion that digestibility of nutrients varies among sources of DDGS (Stein and Shurson, 2009; Urriola et al., 2009), and that DIG nutrients account for the greatest differences among ingredients (Kil et al., 2013). In vitro ileal DIG CP and carbohydrates, along with calculated ileal DIG EE, are used as predictors in the Danish Potential Physiological Energy (PPE) system (Kil et al., 2013). In addition, using in vitro DIG nutrients as predictors of DE, ME, and NE content can save time and cost compared with using traditional in vivo methodologies to determine the utilizable energy and nutrients. Noblet and Jaguelin-Peyraud (2007) successfully used in vitro OM digestibility and chemical composition to predict DE and NE of feed ingredients, but Anderson et al. (2012) did not observe accurate predictions for DE and ME content of the 20 corn coproducts using in vitro OM digestibility as the only variable. However, no studies have been conducted to evaluate the accuracy of using IVDMD or in vitro DIG DM to predict DE and ME content of a single feed ingredient like corn DDGS.

Results from the current study confirm that using in vivo DIG nutrients as predictors improves the accuracy of DE and ME estimates in corn DDGS compared with using chemical composition and in vitro DIG nutrients. The accuracy of the best prediction EQS (5 and 6) generated in the current study, was numerically comparable with that reported in a previous study (Noblet and Perez, 1993). Compared with observed in vivo DE values, the difference between the predicted DE (kcal/kg) from equation (5) varied by about -405 kcal/kg (range from -483.9 to -321.8 kcal/kg, SD = 45.9, $R^2 = 0.83$; Table 5); while the difference between predicted and in vivo determined DE from Noblet and Perez (1993) varied by about 57.2 kcal/

Table 3. The DE and ME prediction equations derived from chemical composition using LCA or NIRS values (DM basis) of 12 samples of corn DDGS

Equations	<i>P</i>	R^2	SE ^a
LCA composition			
(1) DE, kcal/kg DM = 4,152.6 - (43.8 × ADF, g/kg)	0.04	0.35	111.0
(2) ME, kcal/kg DM = 3,826.1 + (27.9 × EE, g/kg) ^b - (57.5 × ADF, g/kg)	0.04	0.52	112.9
NIR predicted composition			
(3) DE, kcal/kg DM = 4,158.3 - (37.2 × ADF, g/kg)	0.11	0.23	120.9
(4) ME, kcal/kg DM = 3,147.6 + (32.2 × EE, g/kg)	0.11	0.24	134.6

^aSE of the regression estimate defined as the root of the mean square error (MSE).

^bEE = ether extract.

Table 4. Equations for DE and ME content predicted from DIG nutrients, in vitro DIG nutrients, in vivo with DIG nutrients, or in vitro DIG nutrients with chemical composition (DM basis) of 12 corn DDGS samples

Equations	<i>P</i>	<i>R</i> ²	SE ^a
In vivo DIG nutrients			
(5) DE, kcal/kg DM = 854.5 + (3.6 × DIG DM, g/kg) + (3.7 × DIG EE, g/kg) ^b + (2.0 × DIG NDF, g/kg)	<0.01	0.83	63.0
(6) ME, kcal/kg DM = 704.5 + (3.3 × DIG DM, g/kg) + (4.8 × DIG EE, g/kg) + (2.6 × DIG NDF, g/kg)	<0.01	0.76	84.9
In vitro DIG nutrients in combination with in vivo DIG nutrients			
(7) DE, kcal/kg DM = 6,383.6 – (4.2 × in vitro DIG DM, g/kg) + (3.5 × in vivo DIG EE, g/kg)	0.07	0.45	108.2
(8) ME, kcal/kg DM = 6,635.1 – (5.0 × in vitro DIG DM, g/kg) + (4.1 × in vivo DIG EE, g/kg)	0.05	0.49	116.2
In vitro DIG nutrients with chemical composition			
(9) DE, kcal/kg DM = 4,152.6 – (43.8 × ADF, g/kg)	0.04	0.35	111.0
(10) ME, kcal/kg DM = 3,969.1 + (27.9 × EE, g/kg) – (57.5 × ADF, g/kg)	0.04	0.52	112.9

^aSE of the regression estimate defined as the root of the mean square error (MSE).

^bEE = ether extract.

kg (range from –52.2 to 193.9 kcal/kg; SD = 84.9, *R*² = 0.89). Similarly, when comparing the predicted ME content with observed in vivo ME value differences using equation (6), ME estimates varied by about 134.7 kcal/kg (range from –38.4 to 284.3 kcal/kg, SD = 106.1, *R*² = 0.76); while the difference between predicted and observed ME from [Noblet and Perez \(1993\)](#) varied about –370 kcal/kg (range from –469.5 to –279.8 kcal/kg; SD = 67.1, *R*² = 0.79).

In vitro DIG DM alone, or including in vitro DIG NDF or ADF, did not improve or have equivalent prediction accuracy of DE or ME for corn DDGS compared with in vivo DIG nutrients, based on the comparison of EQS (5) and (6) with EQS (7) and (8). Also, by comparing EQS (9) and (10) with EQS (1) and (2), we observed that using in vitro DIG DM and fiber as variables did not improve DE and ME prediction precision compared with using chemical composition data as predictor variables.

The poor prediction from in vitro DIG DM may be explained by the poor correlation of IVDMD_i with ATTD of DM (*P* = 0.65; *R*² = 0.02; [Huang et al., 2017](#)), and low variability of DIG DM (SD = 2.40, CV = 4%) among the limited number of samples (*n* = 12) used in this study. In theory, DIG DM should be strongly associated with DE and ME content of corn DDGS. The explanation for the lack of correlation between in vitro and in vivo DM digestibility is not clear. According to [Boisen and Fernández \(1997\)](#), the prediction of apparent ileal digestibility of CP using an in vitro 2-step (pepsin and pancreatin digestion) procedure had a very strong association (*R*² = 0.92). Therefore, we speculate that the difference may be related to lipid digestibility because the emulsification of lipid is critical for in vivo lipid digestion, and it is difficult to mimic these conditions using the current 3-step procedure. Also, the negative effects of in vitro DIG DM on DE and ME content (as indicated in EQS

Table 5. Comparison of differences of predicted DE and ME values, based on in vivo DIG nutrients (DM basis), with in vivo determined DE and ME values of 12 corn DDGS samples

Equations	<i>R</i> ²	Least	Mean	Greatest	SD
Predicted from current study					
DE, kcal/kg DM = 854.5 + (3.6 × DIG DM, g/kg) + (3.7 × DIG EE, g/kg) ^a + (2.0 × DIG NDF, g/kg)	0.83	–483.9	–405.0	–321.8	45.9
ME, kcal/kg DM = 704.5 + (3.3 × DIG DM, g/kg) + (4.8 × DIG EE, g/kg) + (2.6 × DIG NDF, g/kg)	0.79	–38.4	134.7	284.3	106.1
Predicted from Noblet and Perez (1993)					
DE, kcal/kg DM = (5.66 × DIG CP, g/kg) + (9.37 × DIG EE, g/kg) + (4.13 × starch, g/kg) + (3.91 × sugar, g/kg) + (4.18 × DIG HC, g/kg) ^b + (3.37 × DIG ADF, g/kg) + (4.24 × DIG RES, g/kg) ^c	0.89	–52.2	57.2	193.9	84.9
ME, kcal/kg DM = (4.83 × DIG CP, g/kg) + (9.58 × DIG EE, g/kg) + (4.14 × starch, g/kg) + (3.9 × sugar, g/kg) + (4.4 × DIG HC, g/kg) + (2.81 × DIG ADF, g/kg) + (4.04 × DIG RES, g/kg)	0.79	–469.5	–370.7	–279.8	67.1

^aEE = ether extract.

^bHC = hemicellulose.

^cRES = residue.

7 and 8) cannot be explained physiologically. This suggests that this may be just a calculation artifact because there was no correlation between IVDMD_t and in vivo DM digestibility ($P = 0.65$; $R^2 = 0.02$; Huang et al., 2017). Using in vitro DIG NDF and ADF alone to predict DE and ME may be difficult because in vitro NDF and ADF digestibility had only moderate R^2 with ATTD of NDF ($P = 0.05$; $R^2 = 0.32$) and ATTD of ADF ($P = 0.01$; $R^2 = 0.47$), as discussed in Huang et al. (2017), even though the P values were significant. These results indicate that in vitro DIG fiber is a good indicator of ATTD of NDF and ADF, but it appears to not be a good predictor with high precision in regression EQS for estimating DE and ME content of DDGS.

Our results show that DIG EE is an essential prediction variable for use in DE and ME EQS for corn DDGS. This is expected given that we observed the greatest CV in the concentration of DIG EE among DDGS samples evaluated. This large CV, in addition to large contribution of lipids to energy, suggests the necessity of measuring digestibility of lipids in corn DDGS. However, in vitro lipid digestibility was not determined in the current study. In vitro lipid digestion has been measured using the pH-stat method with pancreatic lipase in humans (Li and McClements, 2010; Li et al., 2011), but not in the 3-step or modified 3-step procedure used in this study. Further studies are needed to determine in vitro lipid digestibility to improve the accuracy of prediction of DE and ME in feed ingredients, especially those like DDGS which contain a substantial amount of EE.

None of the EQS used in vivo DIG CP or CP concentration from LCA as predictors for estimating DE and ME content. This may be because of the relatively low variability in DIG CP ($\text{SD} = 0.95$, $\text{CV} = 4\%$) among samples and the limited sample size ($n = 12$) used in this study. Another limitation of the EQS generated in this study was the assumption that starch digestibility was 100% instead of measuring it directly. However, this assumption may be of minor importance because most of the starch in corn DDGS may be in the form of resistant starch, and the total concentration of starch in corn DDGS was relatively low (0.8% to 3.9%).

The accuracy of using NIRS composition data to predict DE and ME content of DDGS samples was also evaluated in this study. The NIRS has been used to predict DE and ME of corn DDGS (Zhou et al., 2012). Unfortunately, calibrations developed by Zhou et al. (2012) used DE and ME values that were calculated from ingredient chemical composition using EQS derived for diets by Noblet and

Perez (1993). The Noblet and Perez (1993) EQS were specifically developed for diets and not for use with individual feed ingredients. The spectral model of NIRS has also been shown to have greater power to predict ME content than using chemical components or in vitro DIG nutrients for wheat and barley fed to sheep (Deaville et al., 2009). However, the spectral method of NIRS requires a large number (>200) of samples to develop robust calibrations, and the calculation process is very complicated. As a result, NIRS has not been evaluated for use in predicting DE and ME content in corn DDGS fed to pigs until this study was conducted. The use of NIRS to estimate chemical composition of feed ingredients and complete feeds is widely used in the feed industry because it is a faster and less expensive method to quantify nutrient content compared with using LCA (Paulsen et al., 2010). Therefore, one of the aims of the current study was to attempt to use NIRS scanned chemical composition to replace LCA values as an easier, less expensive and time-consuming method to improve the DE and ME prediction. Unfortunately, data from current study did not show any correlation of NIRS scanned chemical composition with LCA values, and the regression EQS for predicting DE and ME were not significant when using NIRS scanned chemical composition as predictor variables. We suspect that the database used for the NIRS calibration was not as robust as it needed to be to more accurately match the laboratory-based chemical composition of corn DDGS samples used in the study, and that the sample size used in this study was too small.

In conclusion, in vivo DIG fiber, DM, and EE are the best predictors for DE and ME content of corn DDGS fed to growing pigs, whereas the NIRS determined values of chemical composition, in vitro DIG fiber, and in vitro DIG DM were not good predictors. In vitro DIG EE of corn DDGS needs to be investigated as a potential predictor. Increasing the number of samples and their variability in chemical composition may improve the accuracy of EQS for predicting DE and ME content of corn DDGS fed to pigs.

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