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Predicting fat quality from pigs fed reduced-oil corn dried distillers grains with solubles by near infrared reflectance spectroscopy: Fatty acid composition and iodine value

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ABSTRACT

This study tested the ability of near infrared reflectance spectroscopy (NIRS) to estimate the fatty acid (FA) composition and iodine value (IV) of backfat from carcasses of pigs fed reduced-oil corn dried distillers grains with solubles. NIRS was suitable for screening purposes for the proportions of total saturated, monounsaturated, polyunsaturated, n−3 and n−6 FAs and some individual FAs such as C16:0, C18:1, C18:2n−6 and C18:3n−3 (R^2 = 0.80–0.89; RMSECVs, root mean square errors of cross-validation = 0.21–1.37% total FA) in both cold and warm intact backfat samples. This technology also met the requirements for a quick screening for the backfat IV in both cold and warm intact samples (R^2 = 0.90 and 0.87; RMSECVs = 1.66 and 1.80% total FA, respectively), which would help provide differential feed-back to pig producers and the feed industry and may provide the opportunity for breeding pigs for a desirable fat quality.

1. Introduction

For the last 15 years, the North American ethanol industry has increased the availability of corn dried distillers grains with solubles (cDDGS) for livestock feeding. Hence, this alternative feedstuff has been successfully included in swine diets (Stein & Shurson, 2009). Many North American pork processors are concerned about the potential for decreased pork fat quality when grower-finisher pigs are fed diets containing DDGS. As a consequence, US ethanol plants have begun to partially remove oil from cDDGS, reducing it from 10–12 to 6–9%. This oil content reduction in turn requires a reassessment of both its net energy (NE) value and effects on carcass quality.

Feeding cDDGS increases the proportion of dietary unsaturated fatty acids (FAs), which can in turn influence carcass fat quality. Pigs are monogastrics, therefore carcass fat composition is strongly affected by dietary FA (Wood, 1984). The increased concentration of dietary unsaturated FA results in softer carcass fat, which can lead to processing problems, affect the quality and shelf life of processed pork products, and influence their ability to meet fresh pork export specifications (Carr et al., 2005).

Traditional quantitative chemical techniques for the comprehensive determination of FA profiles involve solvent extraction of total lipids, followed by conversion of FA to their methyl esters and then analysis by gas chromatography (Aldai et al., 2013), a time-consuming and costly process. Carcass fat iodine value (IV) can also be used to measure the degree of carcass fat unsaturation (procedure Cd 1b-87; AOCS, 2004), but through a laborious method requiring the use of toxic solvents and reagents, although most commonly it is calculated from the FA composition of a fat sample using a prediction equation (AOCS, 1998). In contrast to conventional chemical analysis, near infrared reflectance spectroscopy (NIRS) is a rapid and non-destructive method which requires no reagent, thus no waste is produced. Additionally, the structure of FA can produce individual spectral characteristics and is, therefore, accessible for detection and classification by NIRS (González-Martín, González-Pérez, Hernández-Méndez, Alvarez-García, & Merino Lázaro, 2002). Hence, NIR spectroscopy has been applied for prediction of the FA profile in perirenal and subcutaneous fat from cattle (Prieto, Dugan, López-Campos, Aalhus, & Uttaro, 2013, Prieto et al., 2012) and subcutaneous fat from pigs (González-Martín et al., 2002; Pérez-Juan et al., 2010; Pérez-Marín, De Pedro Sanz, Guerrero-Ginel, & Garrido-Varo, 2009).

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Nevertheless, to our knowledge, there are no studies testing the ability of this technology to estimate not only the FA composition but also the iodine value in intact subcutaneous fat of pigs, particularly in those fed reduced-oil cDDGS. Hence, this paper examined the potential of NIRS technology to predict fat quality from pigs fed reduced-oil cDDGS with particular emphasis on the proportions of major FA groups and those individual FA used to calculate the backfat IV.

2. Materials and methods

2.1. Animals and diets

Animals used were a subset of a larger study where the estimated NE value of cDDGS was estimated using 1056 pigs housed in 48 pens, split by gender (barrows or gilts), and fed diets containing 30% cDDGS with assumed NE values of 1.70, 1.85, 2.00, 2.15, 2.30 and 2.45 Mcal/kg over 5 feeding phases. Diets were formulated to provide equal grammes of standardized ileal digestible lysine per Mcal NE within phase. Canola oil was added when NE values of cDDGS were assumed to be low and greater inclusions of barley replaced wheat grain as assumed NE value of cDDGS increased.

2.2. Slaughter and sample collection

A subset of 96 animals randomly selected from the 6 diets was slaughtered at an average live weight of 124.9 kg at Agriculture and Agri-Food Canada Lacombe Research Centre, Alberta, Canada. Approximately 45 min postmortem, the temperature of the outer layer of backfat was recorded and approximately 200 g of backfat immediately anterior to the grading site (7.5 cm off the mid-line, between the 10th and 11th rib) was collected and refrigerated at 2 °C for solidification.

2.3. Spectra collection

When backfat was solidified enough to core (approximately 1 h under refrigeration), duplicate intact circular fat cores of an appropriate diameter (38 mm) were obtained using a custom-constructed stainless steel corer, and skin and hair follicles from the outer layer of backfat were removed by knife (Fig. 1). Subsequently, the fat cores of outer backfat were put into a sampling device and cut to 7 mm to fit the ring cups of the NIRS machine, as shown in detail by Prieto et al. (2012). Each fat disc was placed in a ring cup so that surface closest to the skin was scanned, all visible air bubbles were removed by squeezing, and the cup backed with thin black foam. Subsequently, the samples were placed in open plastic bags and heated in a water bath at 39 °C. A DuaLogR model 600-1050 (Barnant Company Barrington, USA) thermocouple was inserted into the centre of each fat sample for temperature monitoring during warming. As soon as the core sample reached the average temperature of backfat recorded from the dressed hot carcass (35 °C), samples were removed from the water bath and NIR spectra were collected (warm backfat samples). Fat cores were then kept under refrigeration overnight to cool to the temperature of a chilled carcass and then scanned cold at 4 °C (cold backfat samples). Each backfat sample was scanned 32 times over the range (400–2498 nm) using a NIRSystems Versatile Agri Analyzer (SY-3665-II Model 6500, FOSS, Hillerød, Denmark) benchtop equipment and spectra were averaged by the equipment software. Two fat samples per animal were scanned using two different cells. The two spectra were visually examined for consistency and then averaged. The spectrometer interpolated the data to produce measurements in 2 nm steps, resulting in a diffuse reflectance spectrum of 1050 data points. Absorbance data were stored as log $(1/R)$, where R was the reflectance. Instrument control and initial spectral manipulation were performed with WinISI II software (v1.04a; Infrasoft International, Port Matilda, MD, USA).

2.4. Fatty acid analysis

After NIR spectra collection, the two fat cores from each animal were stored at −80 °C for subsequent FA determinations. From the backfat collected, 5 g was sampled and 50 mg of subsamples was freeze-dried, direct methylated with 0.5 M sodium methoxide, and FA methyl esters analysed by gas chromatography according to Turner et al. (2014).

From the FA analysis, IV was calculated using the following equation (AOCS, 1998): $IV = [C16:1] \times 0.95 + [C18:1] \times 0.86 + [C18:2] \times 1.732 + [C18:3] \times 2.616 + [C20:1] \times 0.785 + [C22:1] \times 0.723$, where brackets indicate the proportion of a particular FA (% total FA).

2.5. Data analysis

Calibration and validation were performed using The Unscrambler program (version 10.2, Camo, Trondheim, Norway). Two passes of elimination of outliers (H and T) were allowed. Spectral data were subjected to standard normal variate and detrend (SNV-D; Dhanoa, Lister, & Barnes, 1995) to reduce multicolinearity and the confounding effects of baseline shift and curvature on spectra arising from scattering effects due to physical effects. First or second-order derivatives (1D/2D), based on the Savitzky–Golay procedure (Naes, Isaksson, Fearn, & Davies, 2002), were applied to the spectra to heighten the signals related to the organic compounds of the fat samples (Davies & Grant, 1987). Partial least square regression (PLSR) was used for predicting FA proportions using NIR spectra as independent variables. Internal

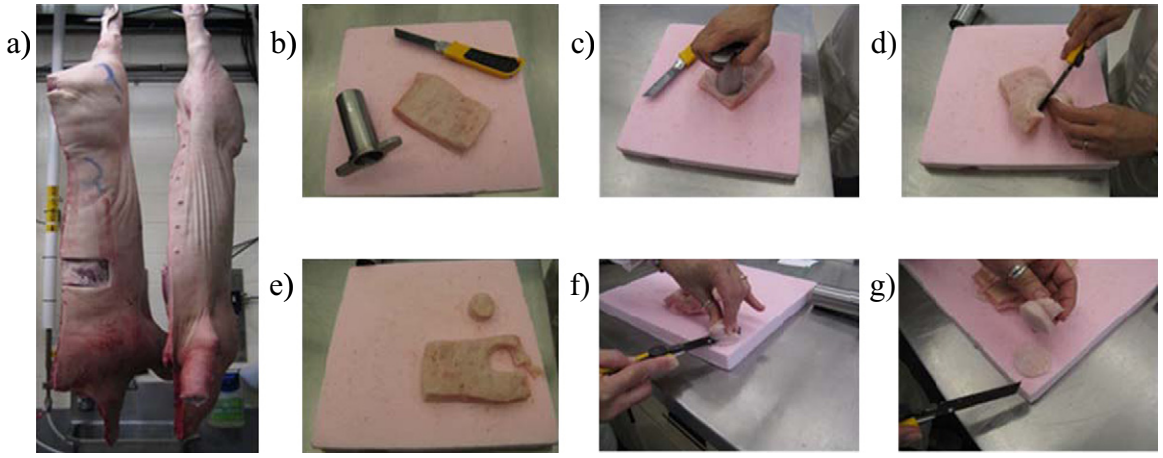

Fig. 1. Backfat sampling and preparation of the intact circular cores from the outer layer of backfat: a) sampling site; b) backfat sample and coring tools; c–e) isolation of cored backfat; f–g) skin removal.