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Effectiveness of different corn dried distillers grains with solubles feeding strategies and increasing the time intervals between the second Improvest dose and slaughter of immunologically castrated pigs on belly and pork fat quality

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ABSTRACT

Effects of dried distillers grains with solubles (DDGS) feeding strategies (a corn-soybean meal (CS) fed continously; CS + 40% DDGS fed continously; CS + 40, 30, 20, or 10% DDGS in 4 phases, respectively; or CS + 40% DDGS in phases 1 to 3 and CS in phase 4 before slaughter) on belly and pork fat quality of immunologically castrated (n = 192) pigs were evaluated. All pigs received the first Improvest dose at 11 week of age, and the second dose at 9, 7, or 5 week before slaughter at 24 week of age. Increasing the time interval of the second Improvest dose before slaughter reduced IV in all fat depots and increased belly thickness. Gradually decreasing dietary DDGS and DDGS withdrawal feeding strategies reduced IV in all fat depots. Calculated IV were greater using the Meadus et al. (2010) equation compared with using the AOCS (1998) equation because it includes more long-chain unsaturated fatty acids.

1. Introduction

Feeding diets containing up to 60% corn dried distillers grains with solubles (DDGS) reduces firmness of backfat, jowl, and belly fat and increases iodine value (IV) in physical castrates and gilts (Leick et al., 2010; McClelland, Rentfrow, Cromwell, Lindemann, & Azain, 2012; Xu et al., 2010), resulting from the relatively high lipid and PUFA content in DDGS (NRC, 2012). Soft pork bellies are more difficult to handle, may have reduced slicing yield, an unattractive appearance, and are more susceptible to peroxidation and off-flavor development than firm bellies (Morgan, Smith, Cannon, McKeith, & Heavner, 1994; Wood et al., 2008).

Immunologically castrated pigs have less backfat than physical castrates (Boler et al., 2012; Dunshea et al., 2001), and as a result, are a greater concern for having carcass fat that contains high concentrations of unsaturated fatty acids. Pigs with less backfat have carcass fat that is more unsaturated, and are more sensitive to dietary changes in fatty acid composition (Wood, Enser, Whittington, Moncrieff, & Kempster, 1989). Immunologically castrated pigs can be slaughtered between 3 and 10 week after the second Improvest (*gonadotropin releasing factor analog - diphtheria toxoid conjugate*; Zoetis, Inc., Florham Park, NJ) dose (FDA, 2011), but increasing this interval up to 6 week, results in a linear increase in backfat thickness (Lealiifano et al., 2011). Thus, immunologically castrated pigs slaughtered with shorter time intervals between the second Improvest dose and harvest are predisposed to have fat depots with greater unsaturated fatty acid content. Furthermore, belly fat IV in immunologically castrated pigs can be reduced by increasing the time interval between the second Improvest dose and harvest (Asmus et al., 2014; Boler et al., 2014), and minimizing linoleic acid intake before slaughter is essential for minimizing carcass fat depot IV (Kellner, 2014). Although withdrawing 30% DDGS from the diet 50 days before slaughter resulted in immunologically castrated pigs having a greater decrease in belly fat IV than physical castrates (Asmus et al., 2014), no studies have compared the effects of various feeding strategies that involve feeding 40% DDGS diets to immunologically castrated pigs throughout the grower-finisher period, gradually reducing dietary DDGS inclusion rate, or withdrawing 40% DDGS from the diet 5 week before slaughter, at different time intervals after the second

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Improvest dose is administered, on belly and pork fat quality.

Additionally, multiple IV equations have been used, and may affect the interpretation of acceptable pork fat quality. Therefore, the objectives of this study were to determine the effectiveness of feeding strategies that remove 40% DDGS from the diet 5 week before slaughter (withdrawal) and gradually decreasing dietary DDGS inclusion rate in immunologically castrated pigs slaughtered after receiving the second dose of Improvest at 9, 7, or 5 week before slaughter, on belly and pork fat quality, and to compare the use of 2 common IV equations for assessing pork fat quality.

2. Materials and methods

2.1. Animals and housing

Carcass fat samples used in this study were collected from immunologically castrated pigs fed 4 DDGS feeding strategies during the growing-finishing period as previously described (Harris, Mellencamp, Johnston, & Shurson, 2017). Briefly, 4 groups of intact male pigs (n = 863; V40 Large White boars × V100 Landrace females; Genetiporc, Alexandria, MN) fed for 16 week (8 to 24 week of age) at the West Central Research and Outreach Center (Morris, MN) using a 4 × 3 factorial arrangement of treatments which provided 8 replicate pens per treatment combination. Group 1 consisted of a total of 215 pigs, while groups 2, 3, and 4 consisted of 216 pigs each. Pigs in each group were randomly allotted to one of 24 pens (9 pigs/pen) to provide 2 pens each for the 12 treatment combinations in each group. Four feeding strategies, each consisting of 4-phases (3, 4, 4, and 5 week for phases 1 to 4, respectively), were evaluated. Feeding strategies included: 1) a positive control where pigs were fed corn-soybean meal based diets with 0% DDGS (CS) throughout phases 1 to 4; 2) a gradual decrease in dietary DDGS inclusion rate strategy where pigs were fed CS containing 40, 30, 20, and 10% DDGS in phases 1 to 4, respectively; 3) a DDGS withdrawal feeding strategy where pigs were fed 40% DDGS in phases 1 to 3, and DDGS was withdrawn from the diet in phase 4 and a CS diet was fed; and 4) a negative control feeding strategy where pigs were fed CS diets with 40% DDGS throughout phase 1 to 4. These feeding strategies were chosen to evaluate the effects of diet inclusion rate and growth phase of feeding DDGS (containing 10.4% ether extract and 34.1% neutral detergent fiber) to immunologically castrated pigs on pork fat quality responses. The NRC (2012) model was used to estimate nutrient requirements for intact male pigs, and diets were formulated to contain similar standardized ileal digestible lysine to ME ratios within phase. All DDGS batches were obtained from the same source to minimize nutrient content variation that exists among sources. Detailed ingredient and nutrient composition of experimental diets are shown in Harris, Mellencamp, Johnston, Cox, and Shurson (2017), Harris, Mellencamp, Johnston, and Shurson, 2017. All pigs had ad libitum access to feed and water throughout the experiment. Improvest (gonadotropin releasing factor analog - diphtheria toxoid conjugate; Zoetis, Inc., Florham Park, NJ) was administered to all pigs at 11 week of age, which coincided with the beginning of feeding the phase 2 diets. The second dose was administered according to treatment assignment at 15, 17, or 19 week of age to correspond with 9, 7, or 5 week before slaughter, respectively. These selected time intervals between the second Improvest dose and slaughter fit within the approved 3 to 10 week time period after the second dose when immunologically castrated pigs can be slaughtered (FDA, 2011).

2.2. Dietary lipid and linoleic acid intake

Feed disappearance was determined at the beginning and end of each dietary phase, and 2 week after the beginning of phases 2 to 4 (Harris, Mellencamp, Johnston, & Shurson, 2017). Feed offered during each feeding period was recorded and the feed remaining at the end of each feeding period was subtracted from the total feed offered to calculate feed disappearance. For each feeding period, average daily lipid intake was calculated as (total feed intake × analyzed diet lipid content) / (pigs per pen × d on feed). Average daily linoleic acid intake was calculated for each feeding period as [(total feed intake × (analyzed diet lipid content × analyzed linoleic acid content of lipid)] / (pigs per pen × d on feed).

2.3. Slaughter and sample collection

A subsample of pigs (n = 192) from each of the 4 groups (2 pigs were selected randomly at 11 week of age from each of 24 pens representing each of the 12 treatment combinations) were slaughtered at the University of Minnesota Meat Science Laboratory (St. Paul, MN) to assess belly and pork fat quality. Slaughter and carcass fabrication occurred as described by Harris, Mellencamp, Johnston, and Shurson (2017). During fabrication, subcutaneous carcass fat from the jowl and 10th rib backfat along the midline were collected. The belly (IMPS #408) was chilled for 24 h after fabrication at 4 °C.

2.4. Quality assessment and fatty acid analysis

The length and width of each belly was measured by ruler at the mid-point. Belly thickness was determined at 4 locations along the dorsal and 4 locations along the ventral edges. Bellies were draped skin-side down over a smoke stick and the distance between skin-to-skin anterior and posterior ends was measured with a ruler. The belly flop angle was calculated as $\cos^{-1}[0.5(L^2) - D^2] / [0.5(L^2)]$, where L = belly length and D = skin-side down, skin-to-skin belly distance (Whitney, Shurson, Johnston, Wulf, & Shanks, 2006). Carcass fat from the anterior dorsal corner of the belly was collected after morphometric assessment. Objective Hunter (MiniScanEZ 4500S; Hunter Lab, Reston, VA; D65 illuminate and 10° observer) colorimetry values of carcass fat from each depot were determined immediately after sample collection. Subjective Japanese Color Score (1 = white and 4 = yellow; NPPC, 2000) of belly samples was evaluated by a single human observer. All carcass fat samples were frozen immediately at −20 °C for further analysis following morphometric and color assessment.

Fatty acid analysis of carcass fat samples was conducted by the University of Missouri Agricultural Experiment Station Chemical Laboratories using AOCS 996.06 (Columbia, MO). Total SFA was calculated as the summation of C8:0, C10:0, C12:0, C14:0, C15:0, C16:0, C18:0, C20:0, C21:0, C22:0, C23:0, and C24:0. Fatty acids C6:0, C11:0, C13:0, and C17:0 were not detectable in carcass fat samples. Total MUFA were calculated as the summation of C16:1n-6 palmitoleic, C17:1n-10 heptadecenoic, C18:1n-9t elaidic, C18:1n-9 oleic, C18:1n-11 vaccenic, C20:1n-9 gonodic, C22:1n-9 erucic, C24:1n-9 nervonic acids, and total PUFA was calculated as the summation of C18:2t linoelaidic, C18:2n-6 linoleic, C18:3n-3 linolenic, C20:2 eicosadienoic, C20:2n-3 homo-γ-linolenic, C20:4n-6 arachidonic, C22:2n-6, C20:5n-3 eicosapentaenoic (EPA), C22:4n-6 adrenic, C22:5n-3clupanodonic, and C22:6n-3 docosahexaenoic (DHA) acids. Total n3 fatty acids included C18:3n-3, C20:2n-3, C20:5n-3, C22:5n-3, and C22:6n-3, and total n6 fatty acids included C18:2n-6, C20:3n-6, C20:4n-6, C22:2n-6, C22:4n-6. Iodine value was calculated using AOCS (1998) and Meadus et al. (2010) equations (Table 1), and the difference in IV between these equations (IV-diff) was also calculated.

2.5. Statistical analysis

Data were analyzed using Proc MIXED in SAS (Cary, NC) where feeding strategy and timing of the second Improvest dose treatments, carcass fat depot, and all interactions between feeding strategy and timing of the second Improvest dose and carcass fat depots were included as fixed effects. The replication group was included as a random effect. Hot carcass weight was used as a covariate ($P < 0.01$) for belly length, width, thickness, and flop distance. The residuals were used to