Iodine values of adipose tissue varied among breeds of pigs and were correlated with pork quality

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Abstract
Our objectives were to investigate fatty acid composition variation amongst adipose tissue sites, breed effects on fat quality, and the relationship of pork fat quality to fresh pork quality. Barrows and gilts (n = 347) of five purebred and one commercial crossbred line were fed commercial swine diets with DDGS inclusion at 30% (as fed) from 31.8 kg body weight until 30-d prior to harvest at 111.4 kg. Immediately after harvest, hot carcass weight was determined, adipose tissue was collected from the back, belly, and jowl, and meat samples were taken from the longissimus muscle for evaluation of pork quality. Iodine values (IV) varied between anatomical site and breed. Jowl fat IV were correlated to back and belly fat IV. Minor but significant correlations were observed between IV and meat quality characteristics. These results support our hypotheses that minor relationships exist between fat and fresh pork quality and that IV vary by anatomical location.

Keywords
adipose physiology; adipose tissue; fatty acid composition; fresh pork quality; iodine values

Introduction
With the increased production of ethanol, dried distillers grains with solubles (DDGS) have become readily available and are often an economical feed source for inclusion in the diet of market pigs. Feeding DDGS, however, may negatively affect pork production by increasing the incidence of soft bellies. Because DDGS often are incorporated into commercial diets for pigs, it is important to understand and evaluate fat quality of pigs fed diets containing DDGS. Indeed, it has been reported that as dietary unsaturated fatty acid consumption increased so did adipocyte iodine value (IV; a measure of fat quality, with a greater number indicating a greater concentration of unsaturated fatty acids and thus softer fat) of three different anatomical locations. Additionally, the relationship between fatty acid composition of pork muscle and adipose tissue of different breeds of pigs fed DDGS with a 30-day withdrawal period and fresh pork quality has yet to be quantified. Whole carcass near infrared spectroscopy (NIR) analysis of fat quality of pigs was performed and adipose IV (fat quality) varied amongst anatomical locations, and it was concluded that other factors (e.g., gender, breed) should be analysed. Additionally, the focus of meat quality metrics has recently shifted from fat quantity to fat quality and is considered of paramount importance to consumer acceptance of meat products. Therefore, our hypotheses were that measures of pork fat and fresh pork quality vary among breeds of pigs and that a significant relationship between pork fat IV and fresh pork quality exists. To test these hypotheses, the relationship among several measures of fat and pork quality of market pigs fed diets that included DDGS at 30% on an as-fed basis with a 30-day withdrawal period was quantified. Our objectives were to: 1) quantify measures of fat quality by determining the fatty acid composition and IV of adipose tissues from the jowl fat, belly fat, and 10th rib backfat from pigs of five purebred lines and one commercial crossbred line when fed DDGS with a 30-day withdrawal period, 2) evaluate the relationship of fat quality of jowl fat to fat quality of the belly fat and 10th rib backfat, and 3) determine the relationship between IV as a measure of fat quality and fresh pork quality traits including pH, visual firmness, marbling, and muscle color.

Materials and methods

Animals and diets
All research was approved by the Iowa State University Institutional Animal Care and Use Committee (IACUC ID 5-12-7367-S and 8-14-7851-S). A total of 347 barrows

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and gilts of five pure breeds and one PIC commercial crossbred line (for breed and gender see footnote of Table 1) were delivered to the Iowa Swine Testing Station (Ames, IA) and housed in a slatted finishing barn with eight pigs per pen. Pigs were housed in pens consisting of only one breed or genetic line. The pen average pig weight was 31.8 kg when pigs began the performance test. All pigs were fed a six-phase commercial corn/soy-based diet with DDGS inclusion at 30% on an as fed basis (finishing diet: 0.5% choice white grease, 57.8% corn, 7.5% soybean meal, 30% DDGS, 4.2% base mix with vitamin and mineral supplement). Dried distillers grains with solubles were removed from the ration for the final 30 days of the finishing period at the request of the meat processor (final diet: 0.5% choice white grease, 85.2% corn, 7.5% soybean meal, 6.8% base mix with vitamin and mineral supplement). Pigs were individually weighed every two weeks and completed the performance test at a minimum weight of 111.4 kg when they were transported to Hormel Foods (Austin, MN) for slaughter the following morning.

**Carcass evaluation**

After harvest, hot carcass weight was determined. Backfat thickness, loin muscle area, and carcass weight were obtained 24-h post-mortem after a 24-h chill at Hormel Foods (Austin, MN). Standard carcass collection procedures, as outlined in the Pork Composition and Quality Assessment Procedures,5 were followed to obtain measurements of the 10th rib backfat thickness and loin muscle area. Ultimate pH was measured on the 10th-rb of the longissimus muscle by using a pH probe (SFK Ltd; Hvidovre, Denmark). Hunter L score (a measure of light reflectance where lower values indicate darker color) was measured on the 10th rib face of the loin after allowing the sample to bloom by using a Minolta CR-310 (Minolta Camera Co., Ltd., Japan) with a 50-mm diameter aperture and D65 illuminant that was calibrated to the white calibration plate. A section of bone-in loin containing the 10–12th ribs was excised from the carcass and transported on ice to the Iowa State University Meat Laboratory (Ames, IA) for additional pork quality assays. The 11th and 12th rib sections were cut into 2.54 cm thick chops and placed freshly cut side up for 10 min to allow the sample to bloom. Subjective measures of color (1-6), marbling (1-10), and firmness (1-3) were evaluated on the 11th rib face by the same panelist according to NPPC procedures.5

Fat-free lean tissue (FFL) and percentage fat-free lean tissue (%FFL) of carcasses were calculated as previously described by the National Pork Producers Council.5

\[
FFL = 8.588 - (21.896 \times \text{backfat thickness}) + (3.005 \times \text{longissimus muscle area}) + (0.465 \times \text{carcass weight})
\]

**Fatty acid analysis and iodine values**

Following harvest, and upon arrival of the split carcasses to the chillbox and while on the slaughter line, subcutaneous adipose tissue samples from all three layers of adipose (about 20 g) were excised as soon as possible from 1) the right side of the jowl where the carcass was split, 2) the back over the 10th rib, 3) and the middle of the lateral side of the belly, and placed in 0.9% NaCl solution at 37°C and transported to Iowa State University (Ames, IA) at 37°C for cellularity assays (not reported) and fatty acid analysis. Subsamples for fatty acid analysis were frozen at −20°C within six hours of animal death until assay.

To verify that storage at 37°C in 0.9% NaCl solution would not cause oxidation of fatty acids, adipose tissue (about 20 g) from the jowl, back over the 10th rib, and middle of the lateral side of the belly was excised immediately following harvest (consistent with how samples were collected at Hormel Foods) from seven crossbred

**Table 1.** Average daily gain, fat-free lean percentage, and backfat thickness of five purebred and one crossbred line of pigs.

| Item          | Berkshire | Chester White | Crossbred | Duroc | Landrace | Yorkshire | Barrow | Gilt |
|---------------|-----------|---------------|-----------|-------|----------|-----------|--------|------|
| ADG, kg       | 0.806     | 0.836         | 0.856     | 0.876  | 0.796     | 0.879     | 0.858  | 0.829 |
| FFL, %        |           |               |           |       |           |           |        |      |
| BF, cm³       | 2.346     | 2.366         | 2.422     | 2.493  | 2.467     | 2.415     | 2.455  | 2.382 |

| Breed x Sex   | P-Values  |
|---------------|-----------|
| Sex           | Breed     | Breed × Sex |
| Barrow Gilt   | <0.001    | 0.011       | 0.151    |

Note. Within a row and main effect, means without a common superscript differ (P < 0.05).

Specific mean in parenthesis below mean values.

\(n = 347\) pigs; number of pigs within each breed (number of barrows, number of gilts): Berkshire, \(n = 87\) (61, 26); Chester White, \(n = 22\) (20, 2); crossbred, \(n = 40\) (23, 17); Duroc, \(n = 76\) (40, 36); Landrace, \(n = 52\) (22, 30); Yorkshire, \(n = 70\) (47, 23).

ADG = average daily gain.

FFL = fat-free lean percentage.

BF = backfat thickness in cm.
pigs at the Iowa State University Swine Research Farm. Following on-farm collection, tissues were stored either in 0.9% NaCl solution for 6 hours at 37°C and then frozen (−20°C) or immediately frozen (−20°C) until analysis. Analysis of fatty acid composition of adipose tissue confirmed that storage at 37°C up to six hours did not significantly affect any measured fatty acid of any anatomical location including unsaturated fatty acids that would be most vulnerable to oxidation (e.g., C18:1, C18:2, C18:3; data not shown).

Total lipids were extracted in triplicate from 2 g of adipose tissue by using a chloroform and methanol mixture, quantified gravimetrically, and methylated directly with acetyl chloride and methanol. Fatty acid methyl esters were quantified by a gas chromatograph (Varian 3800, Agilent Technologies, Palo Alto, CA) equipped with a Supelco SP-2380 (L × I.D., 100 m × 0.25 mm) column and a flame ionization detector. Gas chromatograph conditions were as follows: The initial column temperature was 70°C with a hold time of four min, and the temperature ramp was 13°C per min with a final column temperature of 215°C. Peaks were identified by using commercially available fatty acid methyl ester standards (Nu-Chek-Prep Inc., Elysian, MN). Fatty acid composition was expressed on a weight percentage basis. The activities of the stearoyl-CoA desaturase (Δ9-desaturase or SCD) were estimated by calculating the ratio of enzyme substrate to product. Three different indices of SCD activity were calculated with the following formulas:

\[ \Delta^9 (16) \text{ desaturase index} = 100 \times \frac{[16:1]}{[16:0]} \]

\[ \Delta^9 (18) \text{ desaturase index} = 100 \times \frac{[18:1]}{[18:0]} \]

\[ \Delta^9 \text{ desaturase index} = 100 \times \frac{[16:1] + [18:1]}{[16:0] + [18:0]} \]

Iodine values were calculated from the fatty acid composition of fat samples isolated from each of the three adipose depots by using the following American Oil Chemists Society formula:

\[ IV = \frac{[C16:1] \times 0.95 + [C18:1] \times 0.86 + [C18:2] \times 1.732 + [C18:3] \times 2.616 + [C20:1] \times 0.785 + [C22:1] \times 0.723}{C} \]

**Results and discussion**

**Grow-finish performance data**

Performance data expressed as both ADG and %FFL of the five purebred and one crossbred line are summarized in Table 1. For these experimental conditions, Crossbred, Duroc, and Yorkshire pigs had the greatest rate of gain, with Chester White being equal to all breeds. Additionally, at harvest, Berkshire had the least %FFL. Chester White had the least backfat thickness whereas Duroc had the thickest, but differences were less than a tenth of a cm. Our data were consistent with those of previous studies that have shown leaner breeds of pigs to grow faster than more obese breeds of pigs.

**Sex, breed, and anatomical location effects on fatty acid composition**

Because the objectives of the study were to determine how fat quality varied between anatomical locations, concentrations of individual fatty acids in adipose tissue are presented in Table 2. For additional comparison, fatty acids have been separated into SFA, MUFA, PUFA, and the calculated ratio of PUFA to SFA (P:S) (Table 2). Although there were significant differences in C14:0 concentration in these animals, they are likely not of any practical significance because the concentrations are only about one percent of the total pork fatty acid content.
| Fatty Acid | Sex | Barrow | Gilt | Berkshire | Chester White | Crossbred | Duorc | Landrace | Yorkshire | Location | Back | Belly | Jowl | P - Values |
|-----------|-----|--------|------|-----------|--------------|----------|-------|---------|-----------|----------|------|-------|------|-----------|
| 12:0      |     | 0.04   | 0.04  | 0.06c     | 0.06c        | 0.03b    | 0.03b | 0.043   | 0.043     | 0.043    | 0.04   | 0.04   | 0.07  | 0.279     |
| 14:0      |     | 0.185  | 0.21  | 0.21c     | 0.15c        | 0.21c    | 0.15c | 0.21c   | 0.21c     | 0.21c    | 0.27   | 0.27   | 0.29  | 0.001     |
| 16:0      |     | 0.216  | 0.218 | 0.21a     | 0.21b        | 0.21a    | 0.21b | 0.221   | 0.221     | 0.221    | 0.22   | 0.22   | 0.22  | 0.001     |
| 18:1      |     | 0.130  | 0.149 | 0.149     | 0.146        | 0.149    | 0.149 | 0.150   | 0.150     | 0.150    | 0.15   | 0.15   | 0.15  | 0.001     |
| 18:2      |     | 0.03   | 0.03  | 0.03c     | 0.03c        | 0.03c    | 0.03c | 0.03c   | 0.03c     | 0.03c    | 0.03   | 0.03   | 0.03  | 0.001     |
| 18:3      |     | 0.195  | 0.205 | 0.206     | 0.206        | 0.206    | 0.206 | 0.206   | 0.206     | 0.206    | 0.21   | 0.21   | 0.21  | 0.001     |
| 20:1      |     | 0.03   | 0.03  | 0.03c     | 0.03c        | 0.03c    | 0.03c | 0.03c   | 0.03c     | 0.03c    | 0.03   | 0.03   | 0.03  | 0.001     |
| 20:2      |     | 0.22   | 0.22  | 0.22c     | 0.22c        | 0.22c    | 0.22c | 0.22c   | 0.22c     | 0.22c    | 0.22   | 0.22   | 0.22  | 0.001     |
| 20:3      |     | 0.04   | 0.04  | 0.04c     | 0.04c        | 0.04c    | 0.04c | 0.04c   | 0.04c     | 0.04c    | 0.04   | 0.04   | 0.04  | 0.001     |
| 20:4      |     | 0.075  | 0.07  | 0.07c     | 0.07c        | 0.07c    | 0.07c | 0.07c   | 0.07c     | 0.07c    | 0.07   | 0.07   | 0.07  | 0.001     |
| 20:5      |     | 0.13   | 0.13  | 0.13c     | 0.13c        | 0.13c    | 0.13c | 0.13c   | 0.13c     | 0.13c    | 0.13   | 0.13   | 0.13  | 0.001     |
| 20:6      |     | 0.02   | 0.02  | 0.02c     | 0.02c        | 0.02c    | 0.02c | 0.02c   | 0.02c     | 0.02c    | 0.02   | 0.02   | 0.02  | 0.001     |
| SFA       |     | 0.84   | 0.84  | 0.84c     | 0.84c        | 0.84c    | 0.84c | 0.84c   | 0.84c     | 0.84c    | 0.84   | 0.84   | 0.84  | 0.001     |
| MUFA      |     | 0.03   | 0.03  | 0.03c     | 0.03c        | 0.03c    | 0.03c | 0.03c   | 0.03c     | 0.03c    | 0.03   | 0.03   | 0.03  | 0.001     |
| PUFA      |     | 0.12   | 0.12  | 0.12c     | 0.12c        | 0.12c    | 0.12c | 0.12c   | 0.12c     | 0.12c    | 0.12   | 0.12   | 0.12  | 0.001     |
| P/S       |     | 0.05   | 0.05  | 0.05c     | 0.05c        | 0.05c    | 0.05c | 0.05c   | 0.05c     | 0.05c    | 0.05   | 0.05   | 0.05  | 0.001     |

Note. a,b,c,d,e: Within a row and main effect, means without a common superscript differ (P < 0.05).

1Standard error in parenthesis below mean value. Values are expressed as a weight percentage.
2n = 347 pigs. Number of pigs within each breed shown in footnote 2 of Table 1.
3Ratio of polyunsaturated to saturated fatty acids.
Gilts had a higher concentration of PUFA than did barrows. Because gilts are generally leaner than barrows and backfat thickness is inversely related to C18:2 concentration (a major PUFA), it is to be expected that gilts would have a greater concentration of PUFA. Additionally, the P:S ratio was similar among all breeds except for Durocs that had a significantly lower concentration of PUFA than did all other breeds. The P:S ratio difference in Durocs is discussed in detail in the following section. Finally, P:S ratio varied significantly amongst anatomical locations, with belly fat having the lowest ratio and backfat having the highest ratio, indicating belly fat would be less nutritionally desirable from a consumer perspective than backfat. Our results that show belly fat has the least P:S ratio are in agreement with previously published data that showed belly fat to have a lower P:S ratio than jowl fat when pigs were fed a traditional corn/soy diet.

**Iodine values**

Iodine value is a valuable tool for describing the degree of unsaturation of the fatty acids contained in the fat of food. The practical implication of measuring IV relates to the fact that, as IV or unsaturated fatty acids increase, fat becomes softer in texture and eventually less desirable to the consumer, producer, and the processor. Additionally, although consumers generally desire food with less SFA and more PUFA, increases in unsaturated fatty acids (UFA) can negatively affect pork quality in general because pork adipose is typically composed of approximately 60% UFA; so, increasing the UFA content through feeding of PUFA beyond 60% can negatively affect oxidative stability and promote the generation of undesirable off-odors and -flavors. The relationship of soft pork fat (soft bellies) with feeding DDGS is a result of the inclusion of DDGS in the diets of pigs in our study because feeding DDGS increases IV of pork fat. Indeed, when Cromwell et al. (2011) fed pigs 30% DDGS with no withdrawal period, they observed an IV in backfat of 77.1. Likely, the lack of withdrawal period explains the difference between our IV data and those of Cromwell et al. (2011) because the IV reported in our study would have likely been higher had we not removed DDGS from the finishing diet for the last 30 days. It has been reported that up to 30% DDGS could be included in the diet of the grower-finisher pig and removed for 3 weeks prior to slaughter without adverse effects on pork fat quality.

A likely partial explanation for the greater IV (P < 0.05) of backfat can be made when considering the activity indices of SCD (Table 4). Stearoyl-CoA desaturase is responsible for the conversion of palmitic acid (C16:0) to palmitoleic acid (C16:1) and stearic acid (C18:0) to oleic acid (C18:1), and a greater calculated value for the three indices indicates greater SCD activity. When considering the Δ9 (16) index, a measure of the conversion of C16:0 to C16:1, backfat had the lowest index of all locations for both barrows and gilts (P < 0.05; Table 4). Additionally, the Δ9 (18) index, an indicator of the conversion of C18:0 to C18:1, of backfat is lower than that of all other locations for both barrows and gilts (P < 0.05), with the exception of belly fat of gilts. Jowl adipose tissue had the highest SCD index, an indicator of the conversion of C16:0 to C16:1 and C18:0 to C18:1, (Table 4) but had an intermediate IV of the three assayed adipose depots (Table 3), indicating that SCD activity is not the sole contributor to IV.

Additionally, barrows had a lower IV for the three depots than did gilts (P = 0.0003; Table 3). This observation led us to hypothesize that the increased concentration of UFA found in the adipose depots of gilts was a result of estrogenic stimulation of SCD. Estrogen increases SCD activity seven-fold when injected into roosters. These data do not, however, support the hypothesis that increased concentrations of estrogen in gilts compared with that in barrows results in increased activity of SCD because of the.

| Location | Sex | Breed | P-Values |
|----------|-----|-------|----------|
| Back     | Barrow | 67.72 | Berkshire 70.09 | <0.001 | 0.003 | <0.001 |
| Belly    | Gilt | 69.21 | Chester | 69.55 | <0.05; Table 4) | Barrow 68.72 | Berkshire 70.09 | <0.05 | 0.003 | <0.001 |
| Jowl     | Crossbred | 69.39 | Duroc 67.19 | <0.05 | 0.003 | <0.001 |
| Landrace | 69.56 | (±0.30) | Duroc 67.19 | <0.05 | 0.003 | <0.001 |
| Yorkshire | 69.81 | (±0.30) | Duroc 67.19 | <0.05 | 0.003 | <0.001 |

Note. a,b,cWithin a column, means without a common superscript differ (P < 0.05). 
1Standard error in parenthesis below mean value. Values are expressed as milligrams iodine per 100 grams of lipid.
Table 4. Indices of stearoyl-CoA desaturase activity from adipose tissue as influenced by breed of pig and anatomical location within sex.

| Location          | Back   | Belly | Jowl   | P - Values |
|-------------------|--------|-------|--------|------------|
| Breeds            |        |       |        |            |
|                   | Berkshire | Chester | White | Crossbred | Duroc | Landrace | Yorkshire | Barrow | Gilt | Barrow | Gilt | Barrow | Gilt | Breed | Location | X Sex |
| Δ⁹ (16)           | 9.55d   | 9.75c  | 8.33a  | 8.41a     | 8.84b  | 9.11bc  |           | 8.27a   | 7.91a | 10.01d | 8.72b | 9.65b  | 9.44b | <0.001 | <0.001   |
|                   | (±0.13) | (±0.31)| (±0.16)| (±0.11)  | (±0.13)| (±0.12)|           | (±0.11)| (±0.17)| (±0.11)| (±0.11)| (±0.17) | (±0.17)|         |
| Δ¹⁸ (18)          | 79.68e  | 78.33c | 78.60d | 76.56a   | 79.91a | 79.50b  |           | 77.66a  | 77.76a| 78.61d | 77.41a| 79.91c | 80.25c | <0.001 | <0.001   |
|                   | (±0.19) | (±0.48)| (±0.25)| (±0.17)  | (±0.19)| (±0.18)|           | (±0.17)| (±0.26)| (±0.17)| (±0.17)| (±0.26) | (±0.26)|         |
| Δ⁸-desaturase      | 57.00ab | 55.00c | 56.33b | 54.76bc  | 56.54bc| 57.10ab  |           | 55.25bc | 55.47bc| 56.08b | 54.62b| 57.49bc | 57.84bc| <0.001 | <0.001   |
|                   | (±0.19) | (±0.47)| (±0.24)| (±0.17)  | (±0.19)| (±0.18)|           | (±0.17)| (±0.26)| (±0.17)| (±0.17)| (±0.26) | (±0.26)|         |

Note. a,b,c,dWithin a row and main effect, means for breeds without a common superscript differ (P < 0.05).

1Standard error in parenthesis below mean value.

4n = 347 pigs, number of pigs within each breed shown in footnote 2 of Table 1.

4Δ⁹ (16) = Δ⁶ (16) desaturase index = 100 * ([16:1]/([16:1]+[16:0]).

5Δ¹⁸ (18) = Δ¹⁸ (18) desaturase index = 100 * ([18:1]/([18:1]+[18:0]).

6Δ⁸-desaturase = Δ⁸ desaturase index = 100 * ([16:1] + [18:1])/([16:1] + [16:0] + [18:1] + [18:0]).

source of the increase in IV. Increased IV in gilts is a result of increased proportions of the dietary-derived fatty acids, C18:2,12 and C18:3,12,15 in adipose tissue, rather than of desaturase-derived C16:1 Δ⁵ and C18:1 Δ⁶. Rather, the likely explanation is that the gilts were leaner than the barrows (backfat thickness of 2.30 cm and 2.46 cm respectively, P < 0.0001; loin muscle area of 45.33 and 42.28 cm², respectively, P < 0.001; hot carcass weight of 85.82 and 87.20 kg, respectively, P = 0.003; %FFL, Table 1) and the dietary PUFAs are “diluted” in barrows by de novo fatty acid synthesis. Our data support the hypothesis that leaner pigs have a greater IV, as supported by the negative correlation between backfat thickness and backfat IV (r = 0.358, P < 0.001) and the positive association between %FFL and IV (r = 0.337, P < 0.001).

Backfat thickness is inversely related to C18:2, a significant factor in the calculation of IV.14,15 This negative correlation between backfat thickness and backfat IV (r = −0.358, P < 0.001) of the dietary-derived fatty acids, C18:2, C16:0, and C18:1,

Table 2. Indices of stearoyl-CoA desaturase activity from adipose tissue as influenced by breed of pig and anatomical location within sex.

| Indices          | Berkshire | Chester | White | Crossbred | Duroc | Landrace | Yorkshire | Barrow | Gilt | Barrow | Gilt | Barrow | Gilt | Breed | Location | X Sex |
|------------------|-----------|---------|-------|-----------|-------|----------|-----------|--------|------|--------|------|--------|------|-------|----------|------|
| Δ⁹ (16)          | 9.55d     | 9.75c   | 8.33a | 8.41a     | 8.84b | 9.11bc   |           | 8.27a  | 7.91a| 10.01d | 8.72b| 9.65b | 9.44b| <0.001| <0.001   |
|                  | (±0.13)   | (±0.31) | (±0.16)| (±0.11)   | (±0.13)| (±0.12)|           | (±0.11)| (±0.17)| (±0.11)| (±0.11)| (±0.17)| (±0.17)|         |
| Δ¹⁸ (18)         | 79.68e    | 78.33c  | 78.60d| 76.56a    | 79.91a| 79.50b   |           | 77.66a | 77.76a| 78.61d | 77.41a| 79.91c| 80.25c| <0.001| <0.001   |
|                  | (±0.19)   | (±0.48) | (±0.25)| (±0.17)   | (±0.19)| (±0.18)|           | (±0.17)| (±0.26)| (±0.17)| (±0.17)| (±0.26)| (±0.26)|         |
| Δ⁸-desaturase     | 57.00ab   | 55.00c  | 56.33b| 54.76bc   | 56.54bc| 57.10ab  |           | 55.25bc| 55.47bc| 56.08b | 54.62b| 57.49bc| 57.84bc| <0.001| <0.001   |
|                  | (±0.19)   | (±0.47) | (±0.24)| (±0.17)   | (±0.19)| (±0.18)|           | (±0.17)| (±0.26)| (±0.17)| (±0.17)| (±0.26)| (±0.26)|         |

PUFA in the adipose tissue (Table 2) in combination with low SCD activity (Table 4).

The results of IV data in the present study (i.e., back is greater than jowl and jowl is greater than belly) are supported by previous research that assessed IV of the back, belly, and jowl of PIC crossbred medium-weight barrows fed 40% DDGS (9.6% oil).23 However, our results for IV of the belly may differ from those of other researchers because we sampled adipose from the middle of the lateral side of the belly for consistency, but it has been shown that the IV of the belly is highly variable depending upon sampling location (i.e., dorsal, central, and ventral belly adipose differ in IV).24 The variability of adipose IV amongst anatomical location is also supported by whole body NIR imaging used to determine fatty acid composition that showed different anatomical locations in the same animal had different IV.3

The only significant difference found when comparing the adipose tissue IV of the six breeds assayed was that the adipose tissue of Durocs had a significantly lower IV than did the other five breeds (P < 0.05; Table 3). Likely the reason for Durocs having adipose tissue with the least IV is a genotypic difference resulting in decreased SCD activity (Table 4) that was less than other breeds except for Chester White (P < 0.05); a phenomenon that occurs both within breeds of a species and between breeds a species.25,26 Several variants of the SCD gene have been identified that showed significant association between SCD haplotypes and fatty acid composition in a population of Duroc pigs.27 The presence of SNPs in SCD gene resulted in the identification of three different genotypes of SCD that accounted for some of the difference in fatty acid profiles that were found within this breed of cattle.28 Also, SCD activity varied between breed which was also demonstrated in our data (Table 4).
Relationship of iodine values to fresh loin meat quality

Pork fat in North America is recommended to have an IV of 74 or less. In this study, IV of all breeds and sampling locations were under the threshold values for most packing plants, even with 30% inclusion of DDGS (as fed basis) until 30 days before harvest (Table 3). Additionally, IV varied by location (back, belly, and jowl); thus, sampling site may be of consequence when evaluating pork fat quality.

Back, jowl, and belly fat IV were analyzed to determine if statistically significant correlations between IV and measurements of meat quality existed. Iodine values from all anatomical locations were significantly correlated with laboratory measures of meat quality, but jowl fat IV were the most highly correlated with the laboratory measures of meat quality shown in Table 5. Jowl IV were positively correlated to Hunter L values (P < 0.001); So, as IV increase, laboratory measures typically associated with a reduction in meat quality are impacted negatively. Additionally, jowl IV were correlated negatively with ultimate pH, visual color, visual marbling (P < 0.05) and tended to be correlated negatively with visual firmness (P = 0.052). These correlations, although small, support the hypothesis that a relationship between pork fat quality and pork meat quality exists, although not all of the correlations may be of practical relevance.

Relationship of iodine values of the jowl to iodine values of back and belly fat

Meat processors have expressed a desire to determine relationship of jowl fat IV with IV of backfat and belly fat. In this research, we identified that jowl fat IV is strongly and positively correlated to both back and belly fat IV (P < 0.001; Fig. 1). Our data, however, do not show the IV of the jowl to be as strongly correlated to IV of the belly (r = .733), possibly owing to sampling location (midsection of the belly versus left side of the carcass), which has been shown to influence IV.

Conclusion

Pork from pigs with greater adiposity have a lower IV. The pork from pigs of all breeds had similar IV except that of Durocs, which were lower, suggesting that there may be genetic influences on IV. Additionally, IV, specifically jowl IV, were significantly correlated, albeit correlations were small, with several meat quality laboratory measurements, indicating that, as IV increases, fresh pork quality decreases. Because, the correlations were small, the practical significance of the relationships seem minor rather than major. It was additionally found that 30% DDGS could be fed to six breeds of pig in a six-phase commercial swine diet (excluding the last 30 days) without IV exceeding recommended values. Finally, of value to the pork industry, is the finding presented that IV of the jowl can predict IV of other anatomical sites.

Table 5. Correlation of iodine values of jowl fat and of meat quality metrics.

| Item            | Value¹ | Std. Dev. | r     | P - Value² |
|-----------------|--------|-----------|-------|------------|
| pH              | 5.65   | 0.18      | -0.18 | 0.001      |
| Hunter L        | 47.86  | 3.28      | 0.22  | < 0.001    |
| Visual color    | 2.89   | 0.86      | -0.27 | < 0.001    |
| Visual marbling | 1.90   | 0.89      | -0.24 | < 0.001    |
| Visual firmness | 2.27   | 0.85      | -0.11 | 0.052      |

Note.
1Mean value n = 315 pigs.
2P-values for difference from zero.

Figure 1. Relationship of iodine values of jowl adipose tissue of six breeds of pig to iodine values of back and belly adipose tissue. Numbers are expressed in grams iodine consumed per 100 grams of lipid. P-value is for difference from zero. (A) Relationship of iodine value of back adipose tissue and iodine value of jowl adipose tissue. (B) Relationship of iodine value of belly adipose tissue and iodine value of jowl adipose tissue.

Abbreviations

ADG  average daily gain
BF   backfat thickness
DDGS dried distillers grains with solubles
Disclosure of potential conflicts of interest

The authors have no conflicts of interest to disclose.

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