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Slip points of subcutaneous adipose tissue lipids do not predict beef marbling score or percent intramuscular lipid

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ABSTRACT

We hypothesized that slip points of subcutaneous (s.c.) adipose tissue lipids would predict USDA beef marbling scores or percent intramuscular lipid (%IML). *M. longissimus* dorsi (LD) muscle and s.c. adipose tissue from 79 feedlot-finished Angus steers were analyzed for lipid slip point, %IML, and fatty acid composition. The s.c. monounsaturated:saturated fatty acid (MUFA:SFA) ratio and s.c. lipid slip points were highly correlated ($R^2 = 0.557$; $P < 0.001$), but the correlation between s.c. lipid slip point and LD lipid MUFA:SFA ratio was low ($R^2 = 0.112$; $P < 0.01$). Similarly, there was a low correlation between LD lipid slip point and s.c. lipid slip point ($R^2 = 0.185$; $P < 0.001$). Neither USDA marbling score nor %IML were correlated with s.c. lipid slip point ($R^2 = 0.001$; $P > 0.05$). These data indicate s.c. adipose tissue lipid slip point did not predict USDA marbling scores or %IML in the conventionally fed Angus steers of this study.

1. Introduction

Marbling is the primary determinant of carcass quality in many countries. As intramuscular (i.m.) lipids accumulate in bovine muscle, there is a concomitant elevation in the concentration of monounsaturated fatty acids (MUFA), especially oleic acid (18:1n-9) (Brooks, Choi, Lunt, Kawachi, & Smith, 2011; Piao et al., 2017). Oleic acid contributes positively to flavor characteristics of beef (Frank et al., 2016; Garmyn et al., 2011; Jung, Hwang, & Joo, 2016; Westerling & Hedrick, 1979). Increasing oleic acid in beef also reduces risk for cardiovascular disease by increasing HDL cholesterol concentrations in humans (Gilmore et al., 2011; Gilmore et al., 2013).

Increasing the concentration of oleic acid in beef adipose tissue decreases lipid slip points (a measure of lipid melting points) (Smith, Smith, & Lunt, 2004; Smith, Yang, Larsen, & Tume, 1998), which produces softer fat and increases the perception of juiciness (Westerling & Hedrick, 1979; Smith, Gill, Lunt, & Brooks, 2009; Brooks et al., 2011). The concentration of stearic acid (18:0) is primarily responsible for the magnitude of slip points in ovine (Wood et al., 2003) and bovine adipose tissue lipids (Chung et al., 2006; Turk & Smith, 2009), and increases in oleic acid are associated with corresponding decreases in stearic acid (Turk & Smith, 2009). As marbling scores and percent intramuscular lipid (%IML) increase, the percentage of stearic acid decreases; this in turn reduces lipid slip points (Smith et al., 1998; Smith et al., 2006; Brooks, Choi, Lunt, Miller, et al., 2011). In bovine muscle and adipose tissue, the balance between saturated fatty acids (SFA) and MUFA (and therefore the MUFA:SFA ratio) is determined by the activity of stearoyl-CoA desaturase (SCD) (Duckett, Pratt, & Pavan, 2009; Smith et al., 2006). We previously demonstrated that subcutaneous (s.c.) adipose tissue *SCD* gene expression and SCD catalytic activity increase over the time on corn-based finishing diets, elevating MUFA in s.c. adipose tissue as cattle become fatter (Smith et al., 2006; Chung, Lunt, Kawachi, Yano, & Smith, 2007; Brooks, Choi, Lunt, Kawachi, & Smith, 2011).

Previous studies suggested a high correlation between the fatty acid composition of s.c. adipose tissue, i.m. adipose tissue, and *M. longissimus* dorsi (LD) muscle (Archibeque, Lunt, Gilbert, Tume, & Smith, 2005; Sturdivant, Lunt, Smith, & Smith, 1992; Waldman, Suess, & Brungardt, 1968). More importantly, it has been demonstrated that a high correlation exists between %IML and the concentration of MUFA in the s.c. adipose tissue (Smith et al., 2006; Smith et al., 2009). These studies suggested that s.c. slip points may be correlated with USDA marbling scores. Therefore, we hypothesized that slip points of s.c. adipose tissue lipids would predict marbling scores and/or %IML. The objectives of this study were to document the relationships among USDA marbling score, %IML, lipid slip point, and s.c. and LD fatty acid composition for carcasses from feedlot-finished cattle. If s.c. slip point is reasonably correlated with marbling score, then conceivably a rapid method could be developed that could be used prior to chilling to predict USDA marbling score or %IML. Alternatively, a rapid method

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Table 1
Carcass traits, subcutaneous adipose tissue slip points, and *M. longissimus* dorsi slip points and percent intramuscular lipid (%IML) of Angus steers raised to a constant backfat thickness.

Item[a]	Trait				
	Mean	Standard deviation	Variance	Minimum	Maximum
Carcass traits					
Carcass weight, kg	397.5	21.9	483.6	361.8	445.0
Backfat thickness, cm	1.49	0.41	1.17	0.88	2.75
Ribeye area, cm^2	89.61	6.23	38.81	76.77	108.32
Yield grade	3.0	0.7	0.5	2	4
Marbling score	419.7[b]	93.9	8818	260	670
Subcutaneous adipose tissue					
Slip melting points	38.80	3.53	12.45	31.10	45.30
M. longissimus dorsi					
Slip melting points	38.50	3.12	9.72	30.80	45.30
%IML	7.01	1.80	3.25	3.62	12.89

[a] Data are for statistics 79 Angus steers.
[b] 100–199 = Practically Devoid, 200–299 = Traces, 300–399 = Slight, 400–499 = Small, 500–599 = Modest, 600–699 = Moderate.

could be developed that would predict the MUFA:SFA ratio in beef.

2. Material and methods

2.1. Sample collection

Seventy-nine facings of the LD at the 12th–13th rib interface were supplied by Merial (Duluth, GA) from yearling-fed Angus steers raised to a constant back fat thickness (approximately 1.52 cm). Steers were fed the same corn-based, feedlot-finishing diet (of unknown composition) for 139 ± 7 days, starting at approximately 12 months of age. All steers were raised and fed at Triangle Ranch in western Kansas, and were slaughtered at Texas Tech University between late June and early July. Carcass traits are presented in Table 1.

The LD facings were 8–10 mm thick and were cut from entire surface of the 12th–13th thoracic rib interface immediately after slaughter. The samples were labeled, immediately frozen at −20 °C, and shipped from Texas Tech University to Texas A&M University on dry ice. The LD facings were stored at −20 °C for up to 3 months.

2.2. Total lipid extraction

Fifty grams of the center of each LD facing were ground to homogeneity. Total lipid was extracted from 100 mg of s.c. adipose tissue overlying each LD muscle facing and 1 g of the blended muscle sample by the method of Folch, Lees, and Stanley (1957). The extracted lipid was used for fatty acid analysis and slip point determination.

2.3. Fatty acid composition

Fatty acid methyl esters (FAME) were prepared as described by Morrison and Smith (1964) modified as described previously (Archibeque et al., 2005). The FAME were analyzed using a Varian gas chromatograph (model CP-3800 fixed with a CP-8200 autosampler, Varian Inc., Walnut Creek, CA, USA) (Smith et al., 2002). Separation of FAME was accomplished on a fused silica capillary column CP-Sil88 [100 m × 0.25 mm (i.d.)] (Chrompack Inc., Middleburg, The Netherlands), with helium as the carrier gas (flow rate = 1.2 mL/min). After 32 min at 180 °C, oven temperature increased at 20 °C/min to 225 °C and held for 13.75 min. Total run time was 48 min. Injector and detector temperatures were at 270 °C and 300 °C, respectively. Standards (Nu-Check Prep, Inc., Elysian, MN, USA) were used for identification of individual FAME, which were quantified as a percentage of total FAME identified.

2.4. Total fat content of the LD muscle

Total fat percentage was determined for the ground LD muscle samples with the SMART Trac (NMR system manufactured by CEM Corp., Matthews, NC) as outlined by Keeton et al. (2003).

2.5. Slip point determination

Melting points of the s.c. adipose tissue and LD muscle lipids were approximated by determining slip points (American Oil Chemists' Society, 1993; Smith et al., 1998). After heating to approximately 45 °C, the extracted lipid was drawn 1 cm into glass capillary tubes and frozen at −20 °C. After freezing, the capillary tubes were suspended vertically in a chilled water bath with the portion of the tube containing the lipid submerged in the water. The water bath was heated at 2 °C/min with constant stirring. Temperature of the water was monitored with a Type K thermocouple (model KTSS-HH, Omega Engineering, Inc., Stamford, CT) attached to a digital thermometer (model 91100-50, Cole-Parmer Instrument Co., Vernon Hills, IL). Slip point is defined as the temperature at which the lipid moves up the capillary tube.

2.6. Statistical analysis

The results of fatty acid composition and slip point analyses are presented as means, standard deviations, and ranges of the samples from 79 LD muscle and 79 s.c. adipose tissue samples. Simple regressions were performed to determine the relationships among slip points, marbling score, %IML, fatty acid composition and the MUFA:SFA ratio with the REG procedure of SAS (SAS Inst. Inc., Cary, NC). Including backfat thickness as a covariate did not increase correlations among dependent variables, so backfat thickness was dropped from the model to increase degrees of freedom. The significance of the equation parameters for each response variable was assessed by *F*-test. A probability level of $P \leq 0.05$ was established for statistical significance.

3. Results

3.1. Carcass characteristics

Mean ± SD carcass weight was 397.5 ± 21.9 kg; minimum and maximum carcass weights were 361.8 and 445 kg, respectively (Table 1). Mean ± SD backfat thickness was 1.49 ± 0.41 cm; minimum and maximum backfat thicknesses were 0.88 and 2.75 cm, respectively. Mean ± SD ribeye area (LD muscle cross-sectional area at the 12th–13th LM rib interface) was 89.61 ± 6.23 cm^2; minimum and maximum ribeye areas were 76.77 and 108.32 cm^2, respectively. Mean ± SD yield grade was 3.0 ± 0.68; minimum and maximum yield grades were 2 and 4, respectively. Mean ± SD marbling score was 419.7 ± 93.9; minimum and maximum marbling scores were 260 and 670, respectively.

3.2. Slip point and %IML

The mean ± SD slip point values for s.c. adipose tissue and LD muscle lipids were 38.80 ± 3.53 °C and 38.50 ± 3.12 °C, respectively (Table 1). The minimum values for s.c. adipose tissue and LD muscle slip points were 31.1 and 30.8 °C, respectively and the maximum slip point was 45.3 °C for both s.c. adipose tissue and LD muscle lipids.

The mean %IML in the LD muscle was 7.01 ± 1.80%. The minimum and maximum values were 3.6 and 12.8%, respectively (Table 1). The mean ± SD value for USDA marbling score was 419.7 ± 93.9. The minimum value was 260 (Practically Devoid[60]) and the maximum value was 670 (Moderate[70]).