FATTY ACID CARCASS MAPPING

A Thesis

by

STACEY NICOLE TURK

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2008

Major Subject: Animal Science

FATTY ACID CARCASS MAPPING

A Thesis

by

STACEY NICOLE TURK

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Approved by:

Chair of Committee,	Stephen B. Smith
Committee Members,	Davey Griffin
	David P. Anderson
Head of Department,	Gary Acuff

May 2008

Major Subject: Animal Science

ABSTRACT

Fatty Acid Carcass Mapping.

(May 2008)

Stacey Nicole Turk, B.S., Texas A&M University

Chair of Advisory Committee: Dr. Stephen B. Smith

We hypothesized that subcutaneous (s.c.) adipose tissue would differ in monounsaturated (MUFA) and saturated fatty acid (SFA) composition among different depots throughout a beef carcass. To test this, 50 carcasses from a variety of breed types and backgrounds were sampled. External fat samples were collected from eight different carcass locations: round, sirloin, loin, rib, chuck, brisket, plate and flank. Samples were used to provide information on slip points, fatty acid composition and MUFA:SFA ratios. Lipids were extracted from s.c. adipose tissue by a modified chloroform:methanol procedure, and fatty acid composition and slip points were measured. The brisket was significantly lower in palmitic (16:0) and stearic (18:0) acid than the other seven sampling sites ($P = 0.001$). The brisket demonstrated the highest values of MUFA ($P = 0.001$) with the exception of possessing the lowest value of *trans*-vaccenic (18:1*t*11) acid ($P = 0.002$). There were also significant differences in the amounts of PUFA among the eight sampling sites. The lowest values were from the brisket with a mean of 25.1. The flank had the highest slip point with a mean of 39.0 ($P \leq 0.001$). There was a high negative correlation shown between palmitoleic and stearic acid ($R^2 = 0.827$). The brisket displayed the highest values for MUFA:SFA ratios

(P = 0.001), whereas the flank was the lowest. Due to the significant differences amongst fat depots within bovine carcasses in their fatty acid composition we conclude that substantial differences exist across fat depots.

DEDICATION

To my Meme and Nanny

ACKNOWLEDGEMENTS

I would like to thank Dr. Stephen B. Smith for his encouragement, wisdom, and guidance through my career as a graduate student. If it were not for him, I would have never taken the opportunity to further my education and for his support I am grateful. Thanks to Dr. Davey Griffin for first sparking my interest in the industry while meat judging and witnessing his passion and knowledge, and to Dr. David P. Anderson for his upbeat and encouraging personality, input, and expertise as a member of my committee.

I would also like to show my gratitude to all of the other professors, graduate students, and other professionals of Texas A&M University. These people include: Margaret Schell, Lindsay Ward, Matthew Brooks, Jennifer Nall, Anne Ford, and Go Gwang- woong. I would like to thank them for encouraging me through it all and for their friendship.

Most importantly, I would like to thank my family and friends who have shown me unending support and love through everything. Finally, I would like to give all of the credit to God; I can do all things through Christ who strengthens me. Thank you all.

TABLE OF CONTENTS

		Page
ABSTRACT……...…		iii
DEDICATION……..		v
ACKNOWLEDGEMENTS……...…		vi
TABLE OF CONTENTS…….....		vii
LIST OF FIGURES……...		ix
LIST OF TABLES……		x
CHAPTER		
I	INTRODUCTION……...	1
II	REVIEW OF LITERATURE……..	4
	2.1 Subcutaneous adipose tissue……..	4
	2.2 Fatty acid composition……	6
	2.3Stearoyl-CoA desaturase activity…….	8
III	MATERIALS AND METHODS…….	11
	3.1 Sample collection…….	11
	3.2 Total lipid extraction……	11
	3.3 Fatty acid composition…….	12
	3.4 Slip points……	13
	3.5 Statistical analysis……	14
IV	RESULTS……..	15
	4.1 Saturated fatty acids…….	15
	4.2 Monounsaturated fatty acids…….	15
	4.3 Polyunsaturated fatty acids……...	15
	4.4 Slip points…….	16
	4.5 Fatty acid ratios…….	16
V	DISCUSSION……	17
VI	CONCLUSIONS……	22

Page

REFERENCES…….. 23

APPENDIX……..... 29

VITA…….. 39

LIST OF FIGURES

		Page
Figure 1	Subcutaneous slip points as a function of palmitoleic: stearic acid ratio in 50 total carcasses …….	34
Figure 2	Subcutaneous slip points as a function of stearic acid in 50 total carcasses …….....	35
Figure 3	Palmitoleic acid as a function of stearic acid in 50 total carcasses……	36
Figure 4	Palmitoleic: stearic acid ratio as a function of fat depot for 50 total carcasses……	37
Figure 5	Subcutaneous slip point as a function of fat depot for 50 total carcasses……..	38

LIST OF TABLES

		Page
Table 1	Saturated fatty acid concentrations (g/100 g total fatty acids) in eight adipose tissue depots.....	29
Table 2	Monounsaturated fatty acid concentrations (g/100 g total fatty acids) in eight adipose tissue depots……..	30
Table 3	Polyunsaturated fatty acid concentrations (g/100 g total fatty acids) in eight adipose tissue depots……..	31
Table 4	Specific fatty acid ratios and slip points of lipids from eight adipose tissue depots…….	32
Table 5	Fatty acid composition of ground beef and hamburgers purchased from local retailers…….	33

CHAPTER I

INTRODUCTION

In recent years there has been increased interest in fatty acid composition of meat due to the concerns about the healthfulness of beef. Beef is one of the major sources of saturated fat in a diet. The objective is to maximize the ratio of monounsaturated fatty acids (MUFA): saturated fatty acids (SFA). According to the United States Department of Agriculture, ground beef is the most commonly consumed beef product in the U.S. (USDA, 2008). The average American consumer eats 54.51 kg of red meat per year, and of this 13.51 kg is ground beef (American Meat Institute, 1992). Primary sources of MUFA intake by adults are: French fries, whole milk, potato chips, and ground beef (Nicklas, Hampl, Taylor, Thompson & Heird, 2004). Ground beef is utilized for various types of products such as hamburgers and casseroles. The composition of ground beef comes from meat of the lower quality cuts and trimmings from subprimals typically from cull cows. Given differences between subcutaneous (s.c.) and intramuscular (i.m.) fatty acid composition, we believe differences also occur according to anatomical location. If this is confirmed, it would be beneficial for the beef industry to sort fat trimmings according to location to optimize the functionality of beef products.

The many different qualities of beef such as tenderness, juciness, and flavor intensity have been shown to be effected by the chemical properties and amounts of lipids contained in a bovine carcass (Dryden & Marchello, 1970; Harrison, Smith, Allen,

---

This thesis follows the style and format of *Meat Science.*

Hunt, Kastner & Krof, 1978; Westerling & Hedrick, 1979; Melton, Amiri, Davis & Backus, 1982; Sturdivant, Lunt, Smith & Smith, 1992). Factors that affect the level of fat deposited on the carcass are breed, sex, and nutrition (Rumsey, Oltjen, Bovard & Priode, 1972; Eichhorn, Coleman, Wakayama, Blomquist, Bailey & Jenkins, 1986; Melton et al., 1982; Huerta-Leidenz, Cross, Savell, Lunt, Baker & Pelton, 1993; Zembayashi, Nishimura, Lunt & Smith, 1995). Subcutaneous adipose tissue accounts for the primary source of adipose tissue throughout a bovine carcass. This s.c. fat is trimmed away from primals and discarded for further use with measured trimmed lean or for rendering.

The fatty acid composition of s.c. adipose tissue determines the lipid melting point which in turn provides an estimate of SFA composition (Smith, Yang, Larsen & Tume, 1998; Smith, Lunt, Chung, Choi, Tume & Zembayashi, 2006). Oleic acid (18:1n-9) has been shown to lower low-density lipoprotein (LDL) cholesterol without altering high-density lipoprotein (HDL) cholesterol (Baggio et al., 1988; Grundy, Florentin, Nix & Whelan, 1988). Stearic acid (18:0), one of the major SFA, is converted to oleic acid in the rumen by the enzyme stearoyl-CoA desaturase (SCD) in bovine adipose tissue (Martin, Lunt, Britain & Smith, 1999). Having higher levels of oleic acid in s.c. tissue of bovine carcasses is considered nutritionally beneficial.

Previous data have shown that s.c. adipose tissue sampled from the plate and brisket differ in their concentration of MUFA (unpublished data). In a previous study it was shown high amounts of SFA can be found in cattle that were pasture- or hay-fed, whereas high amounts of MUFA are found in cattle that had been fed grains for an

extended period of time (Chung et al., 2006). Ground beef especially high in MUFA can be obtained from Wagyu steers (Sturdivant et al.,1992; Chung, Lunt, Kawachi, Yano & Smith, 2005). In a further study it was proven that ground beef can be modified to increase the healthful amounts of oleic acid present (Adams, Walzem, Smith, Tseng & Smith, 2008).

The primary objective of this study was to quantify and identify any differences in MUFA:SFA among different anatomical sites throughout bovine carcasses. We found that there are large differences in specific locations in the concentration of MUFA as well as in slip points.

CHAPTER II

REVIEW OF LITERATURE

2.1 Subcutaneous adipose tissue

Excessive fat production has been identified as one of the major concerns of the beef industry (Smith et al., 1992). Beef breeders are challenged by consumers to use diverse resources to develop effective breeding schemes to produce meat products that are in demand (Indurain, Beriain, Goni, Arana & Porroy, 2006). Physiological status and management of cattle may influence fatness and fatty acid composition (Eichhorn et al., 1986; Huerta-Leidenz et al., 1993; Terrell & Bray, 1969; Zembayashi & Nishimura, 1996). In the late 1980s, retailers across the United States began the "War on Fat" (Savell, 1993). With this came the adoption of the 1/4-inch trim specifications programs. This was the result of the major finding of the National Consumer Retail Beef Study (Cross, Savell & Francis, 1986; Savell et al., 1989) that closer trimming of retail cuts could result in an improved image for sales of beef. In this study, consumers were questioned about their concerns regarding beef; price was of greatest concern, followed closely by fatness and cholesterol.

Consumers are becoming more educated about the products they are purchasing and are more aware of the nutritional value of food products. With an increased prevalence of food labeling, meat purchasers are more conscious of the healthfulness of their products. The 2006 National Market Basket Survey showed that the average fat thickness on retail cuts has decreased from 2.6 cm to 2.2 cm since the early 1990s (Adams, 2006). There is a positive relationship between s.c. adipose tissue (external fat)

and taste panel ratings of overall palatability including tastiness and juciness within a certain amount of fat thickness (~0.8 cm) (Tatum, Smith & Carpenter, 1982). Trim from these subprimals at the packer level currently is being used for processed products, including ground beef.

Savell, Harris, Cross, Hale and Beasley (1991) reported in the National Beef Market Basket Survey that beef retail cuts and ground beef have less fat today than in the past. From this survey the percent of retail packages that were observed without any external fat was 42%. It is expected that products such as stew meat and flank steak would be without external fat, but a high number of primal cuts such as steaks were even trimmed free of external fat. The highest percent of ground beef being consumed was lean ground beef with 40%. Lean and extra lean ground beef numbers are higher than what has been recorded earlier. More consumers are purchasing the "healthier" lean ground beef products rather than regular ground beef. Due to these facts there is more and more trimmed fat that isn't being utilized in any meat products because of the concept that any fat is unhealthy to consume.

Subcutaneous fat is the first depot where cattle deposit fat. The last depot cattle deposit fat is internally in i.m. fat. External fat cover is necessary to reduce cold shortening in beef, which creates myofibrillar toughening resulting in an unpleasant eating experience (Smith, Dutson, Hostetler & Carpenter, 1976). It is inevitable that most finished cattle are going to be harvested with a certain amount of unwanted external fat. This fat typically will be used for products such as ground beef.

2.2 Fatty acid composition

With cardiovascular disease being a leading cause of death in the U.S., research has become focused on the many benefits of dietary unsaturated fatty acids and fatty acid composition of beef. Oleic acid, the most abundant MUFA, is key in improving diets. Many diets that have been higher in MUFA or polyunsaturated fatty acids (PUFA) have helped with lowering cholesterol (Berry et al., 1992). A diet low in total fat, saturated fatty acids, and cholesterol is usually recommended for lowering cholesterol (Grundy, 1986). It is generally accepted that the consumption of oleic acid by humans reduces, or does not increase, serum LDL cholesterol (Grundy, 1989).

There are different fat depots which each contain their own fatty acid composition makeup. The primary SFA are palmitic acid (16:0) and stearic acid (18:0), whereas the main MUFA is oleic acid (18:1) (Rule, Smith & Romans, 1995). Fatty acid composition is tested and observed regularly because these different fatty acids affect palatability of meat, as well as the healthfulness.

Fatty acids vary greatly depending on species of animal, diet, as well as breed and many other factors. Japanese Black carcasses possessed more MUFA than Holstein, Japanese Brown, Charolais, or Angus steers (Sturdivant et al., 1992; Oka, Iwaki, Dohgo, Ohtagaki, Noda & Shiozaki, 2002; Zembayashi et al., 1995). Other studies have proven that the level of oleic acid in adipose tissue increases during growth (Clemens, Arthaud, Mandigo & Woods, 1973; Huerta-Leidenz, Cross, Savell, Lunt, Baker & Smith, 1996; Leat, 1975; Rule, MacNeil & Short, 1997). Variation in fatty acid makeup of grass-fed versus grain-fed beef and the implications of those differences on flavor and nutrition

have been evaluated in several studies. In Chung et al. (2006), adipose tissue of corn-fed steers contained more MUFA and PUFA, and higher MUFA:SFA ratios than the adipose tissue collected from hay-fed steers, which contained more SFA. Ground beef especially enriched with MUFA can be obtained from Wagyu steers (Sturdivant et al., 1992; Chung et al., 2006). In a recent study the LDL:HDL ratios of men consuming ground beef patties were measured. The MUFA:SFA ratios of the beef patties from the hay-fed and long-fed Angus steers were 0.82 and 1.34, whereas the Wagyu steers MUFA:SFA ratio was 1.38. The ground beef patties selected were representative of beef that is available in the retail market: ground beef from grass-fed cattle, and from cattle that have been grain-fed for long periods of time. The ground beef with the higher MUFA:SFA ratios reduced LDL cholesterol and increased HDL cholesterol which in turn caused a significant reduction in the LDL:HDL ratio (Adams et al., 2008). These results indicate that ground beef can be compositionally formulated to deliver nutritional beneficial amounts of oleic acid.

Several studies also have looked at differences in fatty acid composition with increased time in the feedlot. These studies have shown that adipose tissue fatty acids typically become less saturated between weaning and slaughter in steers fed a grain-based diet (Huerta-Leindenz et al., 1996; Chung et al., 2006). Also, the MUFA:SFA ratio significantly increased along with live weight in the s.c. adipose tissue of Angus steers, but was higher in the long-fed steers fed the corn-based diet to the Japanese endpoint.

In addition to being more healthful, MUFA also affect sensory traits. Previous studies have indicated that changes in the fatty acid composition of meat affect palatability, with flavor being the attribute most influenced (Dryden & Marchello, 1970; Westerling & Hedrick, 1979; Melton et al., 1982). There have been positive relationships shown between oleic acid concentration and flavor scores. Waldman, Suess, and Brungardt (1968) reported that juciness ratings were positively correlated with the MUFA:SFA ratio. Also, the perception of beef can be influenced by the oleic acid concentration. Because fatty acids have very different melting points, variation in their composition has an important effect on firmness or softness of the fat in meat, especially the s.c. and i.m. fats (Wood et al., 2003). This can also alter shelf-life depending on the double bonds of the unsaturated fatty acids, whether or not they will oxidize rapidly and become rancid and discolored.

2.3 Stearoyl-CoA desaturase activity

Archibeque, Lunt, Gilbert, Tume, and Smith (2005) confirmed that s.c. adipose tissue had approximately twice the Δ^9 desaturase catalytic activity of i.m. adipose tissue and s.c. adipose tissue, although it did not have a higher concentration of MUFA than i.m. adipose. The Δ^9 desaturase is encoded by the SCD gene. Earlier research also indicated that bovine tissues located near the body surface have higher MUFA percentages than internal tissues (Sturdivant et al., 1992), perhaps because the low temperature of the body surface would stimulate Δ^9 desaturase activity (Marchello, Cramer & Miller, 1967; Terrell & Bray, 1969).

As stated above, oleic acid is the most abundant fatty acid present in bovine adipose tissue (Waldman et al., 1968; Westerling & Hedrick, 1979; St John, Young, Knabe, Schelling, Grundy & Smith, 1987). In beef cattle, dietary oleic acid is hydrogenated largely to stearic acid (18:0) by ruminal microorganisms. In this species, the concentration of oleic acid in adipose tissue and muscle is dependent upon the activity of Δ^9 desaturase, encoded by the SCD gene (Smith et al., 2006).

Stearic acid is a main fatty acid which determines fat hardness (Smith et al., 1998, Wood et al., 2003; Chung et al., 2006). In this case converting stearic acid to oleic acid in ruminants will in turn increase the softness of fat, which is more desirable when pertaining to consumer appeal.

In Yang, Larson, Smith and Tume (1999) cattle from different backgrounds were examined and fatty acid composition and SCD activity relationship was recorded. The s.c. adipose tissue from pasture-fed cattle had higher total MUFA and SCD activity was 60-85% higher than what was shown in feedlot cattle. SCD activity was positively correlated with MUFA and negatively correlated with SFA.

Within a single carcass, samples taken from the same location (i.e., rib) do not differ in the MUFA:SFA ratios. Across different animals however, there may be recorded differences due to the breed or background. As mentioned above, SCD gene expression differs within carcass fat depots. Depending on the stage of development, different sites may exhibit different MUFA:SFA ratios.

Given these differences between s.c. and i.m. adipose tissue, we believe differences in fatty acid composition also occur according to anatomical location. This

is supported by preliminary data that indicate that s.c. adipose tissue contains a higher concentration of MUFA than lipids from the plate and brisket (unpublished data). If this can be confirmed, it could be beneficial for the beef industry to sort fat trim according to location to possibly generate more healthful trimmings according to fatty acid composition. Once these more healthful trimmings are sorted they can be used to make processed products such as ground beef that have an improved nutritional composition.

CHAPTER III

MATERIALS AND METHODS

3.1 Sample collection

Fifty carcasses at random were selected from Rosenthal Meat Science and Technology Center at the Texas A&M University of College Station. The carcasses represented a variety of breed types and backgrounds. External fat samples were collected from eight carcass locations: round, sirloin, loin, rib, chuck, brisket, plate, and flank. Theses samples were taken approximately 30 min after slaughter at the point of evisceration. All samples were collected from the same side of the carcass. The sample from the round was taken from the outside on the lower end. The sirloin s.c. fat was taken in the middle of the sirloin-short loin juncture. All the other s.c. fat samples were collected at the mid-point of each section. The total amount of s.c fat samples collected was 400. After taking these samples they were stored at -20ºC until further testing.

3.2 Total lipid extraction

Total lipid was extracted by a modification of the methods of Folch, Lees and Stanley (1957). Approximately 1 g of s.c. adipose tissue was homogenized with 5.0 mL of chloroform:methanol (2:1, vol/vol) in a Brinkmann Polytron Homogenizer (Brinkmann Instruments, Westbury, NY). After homogenization, 10 mL of chloroform:methanol was added to the sample for a final volume of 15 mL, which was then left to sit at room temperature (approximately 20°C) for 30 to 60 min for lipid extraction. The homogenate was vacuum filtered through a sintered glass filter funnel fitted with Whatman GF/C filters (Whatman Ltd., Maidstone, England) into a test tube

containing 8 mL of 0.74% KCl (wt/vol). The sample was vortexed and allowed to sit for 2 h to allow for phase separation. Once the phases had separated, the aqueous layer was removed and discarded and the lower phase was transferred to 20 mL scintillation vials. The samples were evaporated to dryness by heating at 60°C under N_2 gas. The remaining liquid was the total extracted lipid used for fatty acid analysis or slip point determination.

3.3 Fatty acid composition

Lipid was extracted according to Folch et al. (1957). Fatty acid methyl esters (FAME) were prepared as described by Morrison and Smith (1964). The total extracted lipid obtained from the procedure described above had 1 mL of 0.5 KOH in MeOH and submerged in a 70°C water bath for 10 min. Then, 1 mL of BF_3 (14%, wt/vol) was added to the sample which was then flushed with N_2, loosely capped, and placed back into the 70°C water bath for 30 min. The samples were removed from the bath and allowed to cool before 2 mL HPLC grade hexane and 2 mL of saturated NaCl were added to the samples and vortexed. This produced two distinct phases of which the upper phase was transferred to a new test tube with 800 mg of Na_2SO_4 to remove any moisture from the sample. Two milliliters of the vortexed solution were added to the tube with the saturated NaCl and vortexed again. The upper layer was transferred into the tube with Na_2SO_4. This final volume was transferred to the scintillation vial to give a final volume of 5 mL of sample in the scintillation vial. The sample was then evaporated to dryness at 60°C under nitrogen and finally reconstituted with HPLC grade hexane and analyzed using a Varian gas chromatograph (model CP-3800 fixed with a

CP-8200 autosampler, Varian Inc., Walnut Creek, CA) (Smith et al., 2002). Separation of FAME was accomplished on a fused silica capillary column CP-Sil88 [100 m x 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 from Nu-Check Prep, Inc. (Elysian, MN) were used for identification of individual FAME. Individual FAME were quantified as a percentage of total FAME analyzed. This equipment can accurately measure all fatty acids normally occurring in beef lean and fat trim, including isomers of conjugated linoleic acid and the omega-3 fatty acids.

3.4 Slip points

Melting points of the s.c. adipose tissue lipids were approximated by determining slip points (Smith et al., 1998). After heating to approximately 45°C, the lipids were drawn 1 cm into glass capillary tubes and frozen at 20°C. After freezing, the capillary tubes are 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.

3.5 Statistical analysis

The null hypothesis for this study was that the individual fatty acid will not differ among adipose tissue depots. The data were analyzed by analysis of variance with adipose tissue depot as the main effect (SuperAnova, Abacus concepts, Berkley, CA). Simple correlation coefficients between depots were generated with the same program. When analysis of variance indicates a significant difference ($P \leq 0.05$), means were separated by Fischers Least Squares differences (SuperAnova).

CHAPTER IV

RESULTS

4.1 Saturated fatty acids

There were significant differences found in the eight different locations in terms of saturated fatty acids (Table 1). The brisket was significantly lower (P = 0.0001) in palmitic (16:0) and stearic (18:0) acid from the other seven sampling sites. The concentration of myristic acid (14.0) in the brisket was significantly lower (P = 0.0019) than all the other sites with the exception of the chuck.

4.2 Monounsaturated fatty acids

There were significant differences in the eight different locations in terms of monounsaturated fatty acids (Table 2). The brisket was significantly highest (P = 0.0001) in myristoleic (14:1n-5), palmitoleic (16:1n-7), oleic (18:1n-9), and cis-vaccenic (18:1*c*11) acid compared to the other seven sampling sites. Conversely, the concentration of *trans*-vaccenic (18:1*t*11) acid was the lowest in the brisket than in the other sites with a (P = 0.0014).

4.3 Polyunsaturated fatty acids

There were significant differences found in the concentration of linoleic (18:2n-6) acid (Table 3), with the brisket containing less (P = 0.017) than the other sampling sites with the exception of the round. The brisket contained the highest amount of 18:2*cis*9,*trans*11 (P = 0.05) than the other fat depots except the chuck and round. There were no significant differences in the concentrations of 18:2*trans*10,*cis*12 among any of the locations (P = 0.31).

4.4 Slip points

There were significant differences in slip points among the eight fat depots. The flank, being the most saturated, had the highest value with a mean of 39°C. The brisket had the lowest slip point with a mean of 25°C. The brisket was significantly lower than all other fat depots ($P \leq 0.0001$, Table 4).

4.5 Fatty acid ratios

There was a high correlation between palmitoleic acid and stearic acid ($R^2 = 0.827$, Figure 3), and the brisket displayed the highest palmitoleic:stearic acid ratio with a mean of 0.914 (Table 4). The site with the lowest palmitoleic:stearic ratio was the flank ($P \leq 0.0001$).

There were significant differences among the eight depots for the MUFA:SFA ratio (Table 4). The brisket was significantly higher than all other sites with a mean of 1.4 ($P \leq 0.0001$). The flank had the lowest ratio with a mean of 0.89.

CHAPTER V

DISCUSSION

Adams et al. (2008) demonstrated that ground beef can be compositionally changed to provide greater amounts of oleic acid. We have demonstrated that ground beef can be altered to be more healthful (i.e., contain more oleic acid) by selecting s.c. fat trimmings from specific fat depots. This can provide a means of economically benefitting the meat industry through making more use of fat trimming that would have been previously destined for rendering.

The ground beef chosen for consumption in Adams et al. (2008) represented the wide variety of choices seen in retail stores. "Guaranteed tender" ground beef has the lowest MUFA:SFA ratio (0.73) and grain-fed Wagyu branded ground beef has the highest MUFA:SFA ratio (1.45, Table 5). The Wagyu branded ground beef is not typically found in retail stores in the U.S. because of the high carcass value. Even some of the highest quality breeds in the U.S. fed high concentrate diets cannot achieve the MUFA:SFA of Wagyu beef. As shown in this study, the MUFA:SFA ratio of the brisket is 1.47 and that of the flank is 0.88 (Table 4, Figure 4). Thus, by selecting fat trimmings from the brisket of domestic cattle, ground beef can be produced that is as enriched with oleic acid as the branded ground beef from Wagyu cattle.

Apparently, breed type of cattle plays a role in determining unsaturation or saturation of fat depots. Sturdivant et al. (1992) and May, Sturdivant, Lunt, Miller and Smith (1993) reported that Wagyu s.c. and i.m. adipose tissue contained higher percentages of palmitoleic and oleic and lower percentages of palmitic acid and stearic

acid than Angus steers. Tanaka (1985) documented that there is a higher concentration of oleic acid and a lower concentration of palmitic in adipose tissue of Japanese Black steers than in Japanese Shorthorn or Holstein steers. Chung et al. (2006) demonstrated that American Wagyu steers contain higher concentrations of MUFA in their muscle and adipose tissue than high quality Angus steers. *Bos indicus* cows possess more MUFA in s.c. adipose tissue than *Bos taurus* cows (Huerta-Ledidenz et al., 1993). Therefore, breed type is a factor that should be considered when trying to maximize the total concentration of MUFA in a carcass.

Diet and time on feed strongly affect total fatty acid composition of fat depots. Yang et al. (1999) demonstrated the s.c. adipose tissue from pasture-fed cattle had significantly lower (42.8%) total SFA and higher UFA (53.2%) than feedlot cattle. Also, cattle that were fed cottonseed oil (CSO) more amounts of SFA (49.5%) than control cattle (45.2%). In turn, the SCD activity in the cattle fed CSO was reduced by over 50% in s.c. adipose tissue.

Chung et al. (2006) examined corn-fed and hay-fed Wagyu and Angus steers and found that feeding a hay-based diet reduced oleic acid. Also, feeding to the Japanese endpoint increased the concentration of oleic acid. Chung et al. (2006) also demonstrated that the s.c. adipose tissue of corn-fed steers contained more MUFA and PUFA and higher MUFA:SFA ratios than in s.c. adipose tissue of hay-fed steers, which in turn contained more total SFA. Feeding steers to the Japanese endpoint (650 kg BW) increased the concentration of MUFA, the MUFA:SFA ratio, and the 16:1:18:0 ratios compared to steers raised to the US endpoint (Chung et al., 2006). This study indicated

that corn-fed cattle produced a healthier overall fatty acid composition than hay-fed cattle. Additionally, feeding for a longer period of time (Japanese endpoint) produced more desirable qualities and a healthier overall product than a shorter feeding regiment (US endpoint).

Previous research (Huerta-Leidenz et al., 1996; Rule et al., 1997; Waldman et al., 1968) demonstrated that oleic acid in fat depots increased with age in feedlot cattle. Chung et al., (2006) confirmed that the concentration of oleic acid increases strongly with the age of cattle. A study recently performed in this laboratory showed SCD gene expression and MUFA:SFA levels increased with age on feedlot steers (Brooks & Smith, 2007). Also, backgrounding on pasture depressed SCD gene expression.

Link, Bray, Cassens and Kauffman (1970) found that fatness and/or age altered the fatty acids present in the meat at different stages of growth. Zembayashi and Nishimura (1996) later used linear regression analyses between carcass fat percentage and fatty acid composition, and demonstrated that leaner or younger steers contained more SFA in the i.m. lipids. Also, there are increased amounts of MUFA with increased fatness or animal age (Clemens et al., 1973; Garcia, Casal, Parodi & Marangunich, 1979; Leat, 1975; Westerling & Hedrick, 1979). Cattle are found to fatten cranially to caudally, and one of the fattest cuts on the carcass is the brisket, which may explain why the brisket contained the most palmitoleic acid and proved to have the highest MUFA:SFA ratio.

SCD gene expression is required for converting SFA to their respective MUFA. SCD activity is the highest in the s.c. adipose tissue of bovine species (St. John, Lunt &

Smith, 1991). As cattle fatten, SCD activity increases, which converts more SFA to their respective MUFA. Yang et al. (1999) measured SCD activity and compared it to different fatty acids and ratios. According to Chung et al. (2006) palmitoleic acid is primarily determined by SCD activity since it exists in such low levels in the diet. When SCD activity is plotted against palmitoleic acid there is a positive correlation ($R^2 = 0.541$), whereas when SCD activity is compared to stearic acid there is a strong negative correlation ($R^2 = -0.341$). As shown in this study, when plotting palmitoleic acid against stearic acid there is a high correlation ($R^2 = 0.827$, Figure 3). We conclude that the 16:1:18:0 ratio provides a strong estimator for predicting SCD activity.

The melting point (slip point) of fat affects overall consumer acceptance of a product. Wood et al. (2003) stated that as the unsaturation of a meat product increases, the slip point decreases. The more unsaturated a product, the easier it melts in the mouth. Smith et al. (1998), Wood et al. (2003) and Chung et al. (2006) demonstrated that fat hardness is dictated primarily by stearic acid. Perry, Nicholls, and Thompson (1998) stated that variation in SFA in turn alters the firmness of fat which affects the economics of meat processing and overall acceptance of consumers. Enser and Wood (1993) showed that the relationship between stearic acid and the melting point of the lipid was highly correlated. Also, Chung et al. (2006) provided evidence that there is a strong relationship between stearic acid and slip points in bovine s.c. tissue ($R^2 = 0.917$). In this study this relationship between stearic acid and slip point displayed a positive correlation ($R^2 = 0.611$). It is also shown that when comparing slip points to the 16:1:18:0 ratio there is a negative correlation ($R^2=0.570$). Given these two comparisons,

knowing the slip point of a specific animal can be a good predictor for estimating SCD activity.

Smith et al. (1998) measured slip points of corn-fed Australian cattle, Japanese Black and Murray Gray cattle fed by traditional Japanese methods. The slip points of the Australian cattle and the Murray Gray cattle were similar (30.7°C and 28.4°C). The Japanese Black cattle demonstrated the lowest values with 22.8°C. In this study the brisket displayed a slip point of 25.1°C similar to what is seen in Japanese Black cattle. This confirms we can compositionally alter ground beef to achieve low slip point values without using fat trim from American Wagyu or Japanese Black cattle.

CHAPTER VI

CONCLUSIONS

The results obtained in the current study confirm the hypothesis that fatty acid composition differs among depot sites throughout a bovine carcass. The highest values for MUFA were displayed in the brisket and the highest values for SFA were displayed in the flank. Also, we confirmed that stearic acid provides a strong indication of melting point. The beef industry can utilize this information to adopt a relatively easy and inexpensive method to increase the nutritional quality of processed beef products by selecting specific fat trimmings.

REFERENCES

Adams, C.L. (2006). *Benchmarking U.S. beef retail cut composition*. M.S. thesis, College Station: Texas A&M University.

Adams, T.H., Walzem, R.L., Smith, D.R., Tseng, S., & Smith, S.B. (2008). Ground beef enriched in monounsaturated fatty acids depresses plasma palmitic acid concentration and increases HDL cholesterol in mildly hypercholesterolemic men. *Journal of Nutrition,* (Submitted).

American Meat Institute. (1992). *Meat & Poultry Facts*. Washington, DC.

Archibeque, S.L., Lunt, D.K., Gilbert, C.D., Tume, R.K., & Smith, S.B. (2005). Fatty acid indices of stearoyl-CoA desaturase do not reflect actual stearoyl-CoA desaturase enzyme activities in adipose tissues of beef steers finished with corn-, flaxseed-, or sorghum-based diets. *Journal of Animal Science, 83*(5), 1153-1166.

Baggio, G., Pangnan, A., Muraca, M., Martini, S., Opportuno, A., Bonanome, A., Amrosio, G.B., Ferrari, S., Guarini, P., Piccolo, D., Manzato, E., Corrocher, R., & Crepaldl, G. (1988). Olive-oil-enriched diet: effect on serum kipoprotein levels and bilary cholesterol saturation. *American Journal of Clinical Nutrition, 47*, 960-964.

Berry, E.M., Eisenberg, S., Friedlander, Y., Harats, D., Kaufmann, N.A., Norman, Y., & Stein, Y. (1992). Effects of diets rich in monounsaturated fatty acids on plasma lipoproteins- the Jerusalem Nutrition Study. 2. Monounsaturated fatty acids vs carbohydrates. *American Journal of Clinical Nutrition, 56*, 394-403.

Brooks, M.A., & Smith, S.B. (2007). Feeding calves as yearlings optimizes beef fatty acid composition. M.S. thesis, College Station: Texas A&M University.

Chung, K.Y., Lunt, D.K., Choi, C.B., Chae, S.H., Rhoades, R.D., Adams, T.H., Booren, B., & Smith, S.B. (2006). Lipid characteristics of subcutaneous adipose tissue and M. longissiumus thoracis of Angus and Wagyu steers fed to U.S. and Japanese endpoints. *Meat Science, 73*(3), 432-441.

Chung, K.Y., Lunt, D.K., Kawachi, H., Yano, H., & Smith, S.B. (2005). Stearoyl coenzyme A desaturase gene expression mediates fatty acid composition of adipose tissue of Angus and Wagyu steers raised to U.S. and Japanese weight endpoints. *Proceedings International Congress of Meat Science and Technology, 50*, 593-599.

Clemens, E., Arthaud, V., Mandigo, R., & Woods, W. (1973). Fatty acid composition of bulls and steers as influenced by age and dietary energy level. *Journal of Animal Science, 37*(6), 1326-1331.

Cross, H.R., Savell, J.W., & Francis, J.J. (1986). Natl. Consumer Retail Beef Study. *Proc. Recip. Meat Conf., 39*, 112-116.

Dryden, F.D. & Marchello, J.A. (1970). Influence of total lipid and fatty acid composition upon the palatability of three bovine muscles. *Journal of Animal Science, 31*(1), 36-41.

Eichhorn, J.M., Coleman, L.J., Wakayama, E.J., Blomquist, G.J., Bailey, C.M., & Jenkins, T.G. (1986). Effects of breed type and restricted versus ad libitum feeding of fatty acid composition and cholesterol content of muscle and adipose tissue from mature bovine females. *Journal of Animal Science, 63*(3), 781-794.

Enser,M. & Wood, J.D. (1993). Effect of time of year on fatty acid composition and melting point of UK lamb. *Proceedings of the 39th International Congress of Meat Science and Technology, 2*, 74.

Folch, J., Lees, M., & Stanley, G.H.S. (1957). A simple method for the isolation and purification of total lipids from animal tissues. *Journal of Biological Chemistry, 226*(2), 497-509.

Garcia, P.T., Casal, J.J., Parodi, J.J., & Marangunich, L. (1979). Effect of body fat distribution on the fatty acid composition of the depot fat of cattle. *Journal of Meat Science, 3*(3), 169-177.

Grundy, S.M. (1986). Comparison of monounsaturated fatty acids and carbohydrates for lowering plasma cholesterol. *New England Journal of Medicine, 314*(12), 745-748.

Grundy, S.M. (1989). Monounsaturated fatty acids and cholesterol metabolism: implications for dietary recommendations. *Journal of Nutrition, 119*(4), 529-533.

Grundy, S.M., Florentin, L., Nix, D., & Whelan, M.F. (1988). Comparison of monounsaturated fatty acids and carbohydrates for reducing raised levels of plsma cholesterol in man. *American Journal of Clinical Nutrition,* 47, 965-969.

Harrison, A.R., Smith, M.E., Allen, D.M., Hunt, M.C., Kastner, C.L., & Krof, D.H. (1978). Nutritional regime effects on quality and yield characteristics of beef. *Journal of Animal Science, 47*(2), 383-388.

Huerta-Liedenz, N.O., Cross, H.R., Savell, J.W., Lunt, D.K., Baker, J.F., Pelton, L.S. & Smith, S.B. (1993). Comparison of the fatty acid composition of subcutaneous adipose tissue from mature Brahman and Hereford cows. *Journal of Animal Science, 71*(3), 625-630.

Huerta-Liedenz, N.O., Cross, H.R., Savell, J.W., Lunt, D.K., Baker, J.F., & Smith, S.B. (1996). Fatty acid composition of subcutaneous adipose tissue from male calves at different stages of growth. *Journal of Animal Science, 74*(6), 1256-1264.

Indurain, G., Beriain, M.J., Goni, M.V., Arana, A., & Purroy, A. (2006). Composition and estimation of intramuscular and subcutaneous fatty acid composition in Spanish young bulls. *Meat Science, 73*(2), 326-334.

Leat, W.M.F. (1975). Fatty acid composition of adipose tissue of Jersey cattle during growth and development. *Journal of Agriculture and Science, Cambridge, 85*, 551-558.

Link, B.A., Bray, R.W., Cassens, R.G. & Kauffman, R.G. (1970). Fatty acid composition of bovine subcutaneous adipose tissue lipids during growth. *Journal of Animal Science, 30*, 722-725.

Marchello, J.A., Cramer, D.A., & Miller, L.G. (1967). Effect of ambient temperature on certain ovine fat characteristics. *Journal of Animal Science, 26*(2), 294-297.

Martin, G.S., Lunt, D.K., Britain, K.G., & Smith, S.B. (1999). Postnatal development of stearoyl coenzyme A desaturase gene expression and adiposity in bovine subcutaneous adipose tissue. *Journal of Animal Science, 77*(3), 630-636.

May, S.G., Sturdivant, C.A., Lunt, D.K., Miller, R.K., & Smith, S.B. (1993). Comparison of sensory characteristics and fatty acid composition between Wagyu crossbred and Angus steers. *Journal of Meat Science, 35*(3), 289-298.

Melton, S.L., Amiri, M., Davis, G.W., & Backus, W.R. (1982). Flavor and chemical characteristics of ground beef from grass-, forage-grain- and grain-finished steers. *Journal of Animal Science, 55*(1), 77-87.

Morrison, W.R. & Smith, L.M. (1964). Preparation of fatty acid methyl esters and dimethylacetals from lipids with boron fluoride—methanol. *Journal of Lipid Research, 5*(10), 600-608.

Nicklas, T.A., Hampl, J.S., Taylor, C.A., Thompson, V.J., & Heird, W.C. (2004). Monounsaturated fatty acid intake by children and adults: temporal trends and demographic differences. Nutrition Review, *62*(4), 132-141.

Oka, A., Iwaki, F., Dohgo, T., Ohtagaki, S., Noda, M., & Shiozaki, T. (2002). Genetic effects on fatty acid composition of carcass fat of Japanese Black Wagyu steers. *Journal of Animal Science, 80*(4), 1005-1011.

Perry, D, Nicholls, P.J., & Thompson, J.M. (1998). The effect of sire breed on the melting point and fatty acid composition of subcutaneous fat in steers. *Journal of Animal Science, 76*(1), 87-95.

Rule, D.C., MacNeil, M.D., & Short, R.E. (1997). Influence of sire growth potential, time on feed, and growing-finishing strategy on cholesterol and fatty acids of the ground carcass and longissimus muscle of beef steers. *Journal of Animal Science, 75*(6), 1525-1533.

Rule, D.C., Smith, S.B., & Romans, J.R. (1995) Fatty acid composition of muscle and adipose tissue of meat animals, *Biology of Fat in Meat Animals: Current Advances*, American Society of Animal Science, Savoy, IL, pp. 144-165.

Rumsey, T.S., Oltjen, R.R., Bovard, K.P., & Priode, B.M. (1972). Influence of widely diverse finishing regimens and breeding on depot fat composition in beef cattle. *Journal of Animal Science, 35*(5), 1069-1075.

Savell, J.W. (1993). Value-based marketing of beef. Farmland Industries, Inc., University Advisory Board Meeting, Kansas City, MO, July 22, 1993. Available: http://meat.tamu.edu/vbm.html. Accessed September 4, 2007.

Savell, J.W., Cross, H.R., Francis, J.J., Wise, J.W., Hale, D.S., Wilkes, D.L., & Smith, G.C. (1989). National Consumer Retail Beef Study: Interaction of trim level, price, and grade on consumer acceptance of beef steaks and roasts. *Journal of Food Quality, 12*, 251-274.

Savell, J.W., Harris, J.J., Cross, H.R., Hale, D.S., & Beasley, L.C. (1991). National Beef Market Basket Survey. *Journal of Animal Science, 69*(7), 2883-2893.

Smith, G.C., Dutson, T.R., Hostetler, R.L., & Carpenter, Z.L. (1976). Fatness, rate of chilling, and tenderness of lamb. *Journal of Food Science, 41*, 748-756.

Smith, G.C., Savell, J.W., Clayton, R.P., Field, T.G., Griffin, D.B., Hale, D.S., Miller, M.F., Montgomery, T.H., Morgan, J.B., Tatum, J.D., & Wise, J.W. (1992). Improving the consistency and competitiveness of beef: A blueprint for total quality management in the fed beef industry. The Final Report of the National Beef Quality Audit – 1991. National Cattlemen's Association, Englewood, CO.

Smith, S.B., Hively, T.S., Cortese, T.S., Han, J.J., Chung, K.Y., Castenada, P., Gilbert, C.D., Adams, V.L., & Mersmann, H.J. (2002). Conjugated linoleic acid dpresses the Δ^9 desaturase index and stearoyl coenzyme A desaturase enzyme activity in porcine adipose tissue. *Journal of Animal Science, 80*(8), 2110-2115.

Smith, S.B., Lunt, D.K., Chung, C.B., Choi, K.Y., Tume, R.K., & Zembayashi, M. (2006). Adiposity, fatty acid composition, and delta-9 desaturase activity during growth in beef cattle. *Journal of Animal Science*, *77*(2), 478-486.

Smith, S.B., Yang, A., Larsen, T.W., & Tume, R.K. (1998). Positional analysis of triacylglycerols from bovine adipose tissue lipids varying in degree of unsaturation. *Lipids, 33*(2), 197-207.

St John, L.C., Lunt, D.K., & Smith, S.B. (1991). Fatty acid elongation and desaturation enzyme activities of bovine liver and subcutaneous adipose tissue microsomes. *Journal of Animal Science, 69*(3), 1064-1073.

St John, L.C., Young, C.R., Knabe, D.A., Schelling, G.T., Grundy, S.M., & Smith, S.B. (1987). Fatty acid profiles and sensory and carcass traits of tissues from steers and swine fed an elevated monounsaturated fat diet. *Journal of Animal Science, 64*(5), 1441-1447.

Sturdivant, C.A., Lunt, D.K., Smith, G.C., & Smith, S.B. (1992). Fatty acid composition of subcutaneous and intramuscular adipose tissues and M. *longissiumus dorsi* of Wagyu cattle. *Meat Science, 32*(3), 449-458.

Tanka, S. (1985). Chemical studies on the adipose tissues and muscle lipids of fattening beef cattle IV. Fatty acid composition and their interrelationships of subcutaneous, intermuscular and abdominal adipose tissues from three beef breeds. *Japanese Journal of Dairy and Food Science, 34*(4), A91-A102.

Tatum, J.D., Smith, G.C., & Carpenter, Z.L. (1982). Interrelationships between marbling, subcutaneous fat thickness, and cooked beef palatability. *Journal of Animal Science, 54*(4), 777-784.

Terrell, R.N., & Bray, R.W. (1969). Influence of sex, live weight and anatomical location on bovine lipids. III. Fatty acid composition of the neutral and phospholipids fraction from three muscles. *Journal of Animal Science, 29*(2), 288-293.

United States Department of Agriculture. (USDA). Development of accurate and representative food composition data for the U.S. food supply. Available: http://www.ars.usda.gov./nutrientdata. Accessed: January 20, 2008.

Waldman, R.C., Suess, G.G., & Brungardt, V.H. (1968). Fatty acids of certain bovine tissue and their association with growth, carcass and palatability traits. *Journal of Animal Science, 27*(3), 632-635.

Westerling, D.B. & Hedrick, H.B. (1979). Fatty acid composition of bovine lipids as

influenced by diet, sex and anatomical location and relationship to sensory characteristics. *Journal of Animal Science, 48*(6), 1343-1348.

Wood, J.D., Richardson, R.I., Nute, G.R., Fisher, A.V., Campo, M.M., Kasapidou, E., Sheard, P.R., & Enser, M. (2003). Effects of fatty acids on meat quality: a review. *Meat Science, 66*(1), 21-32.

Yang, A., Larsen, T.W., Smith, S.B., & Tume, R.K. (1999). Δ^9 desaturase activity in bovine subcutaneous adipose tissue of different fatty acid composition. *Lipids, 34*(9), 971-978.

Zembayashi, M., & Nishimura, H. (1996). Genetic and nutritional effects on the fatty acid composition of subcutaneous and intramuscular lipids of steers. *Meat Science, 43*(2), 83-90.

Zembayashi, M., Nishimura, K., Lunt, D.K. & Smith, S.B. (1995). Effect of breed type and sex on the fatty acid composition of subcutaneous and intramuscular lipids of finishing steers and heifers. *Journal of Animal Science, 73*(11), 3325-3332.

APPENDIX

Table 1. Saturated fatty acid concentrations (g/100 g total fatty acids) in eight adipose tissue depots

Fatty acid	Brisket	Chuck	Flank	Loin	Plate	Rib	Round	Sirloin	SE	*P*-values
14:0	3.22^{c}	3.43^{bc}	3.66^{a}	3.68^{a}	3.58^{ab}	3.59^{ab}	3.49^{ab}	3.54^{ab}	0.030	0.002
16:0	24.3^{d}	26.4^{bc}	25.8^{c}	27.0^{ab}	26.0^{c}	27.2^{a}	25.9^{c}	26.9^{ab}	0.102	0.001
18:0	8.35^{e}	10.8^{d}	16.3^{a}	12.7^{bc}	12.3^{c}	13.5^{b}	10.9^{d}	11.3^{d}	0.165	0.001

^{abcde}Means with common superscripts are not different. Data are means for 50 carcasses.

Table 2. Monounsaturated fatty acid concentrations (g/100 g total fatty acids) in eight adipose tissue depots

Fatty acid	Brisket	Chuck	Flank	Loin	Plate	Rib	Round	Sirloin	SE	*P*-values
14:1n-5	1.91^{a}	1.58^{b}	1.07^{e}	1.38^{cd}	1.40^{cd}	1.26^{d}	1.46^{bc}	1.49^{bc}	0.023	0.001
16:1n-7	7.22^{a}	5.57^{b}	3.19^{e}	4.46^{d}	4.49^{d}	4.21^{d}	5.14^{bc}	5.04^{c}	0.081	0.001
18:1n-9	43.1^{a}	40.2^{bc}	36.8^{e}	38.4^{d}	39.5^{cd}	38.4^{d}	41.0^{b}	39.8^{c}	0.181	0.001
18:1*c*11	2.33^{a}	1.55^{b}	1.09^{e}	1.22^{cde}	1.33^{cd}	1.17^{de}	1.38^{c}	1.34^{cd}	0.028	0.001
18:1*t*11	2.02^{b}	3.08^{a}	3.47^{a}	3.56^{a}	3.61^{a}	3.38^{a}	2.94^{a}	3.21^{a}	0.100	0.002

^{abcde}Means with common superscripts are not different. Data are means for 50 carcasses.

Table 3. Polyunsaturated fatty acid concentrations (g/100 g total fatty acids) in eight adipose tissue depots

Fatty acid	Brisket	Chuck	Flank	Loin	Plate	Rib	Round	Sirloin	SE	*P*-values
18:2n-6	1.63[c]	1.86[ab]	1.95[ab]	1.97[ab]	1.98[a]	1.95[ab]	1.76[bc]	1.87[ab]	0.028	0.017
18:2*c*9,*t*11	0.70[a]	0.62[ab]	0.56[b]	0.53[b]	0.57[b]	0.52[b]	0.63[ab]	0.57[b]	0.015	0.050
18:2*t*10,*c*12	0.20	0.15	0.16	0.11	0.18	0.19	0.08	0.09	0.014	0.314

[abcde]Means with common superscripts are not different. Data are means for 50 carcasses.

Table 4. Specific fatty acid ratios and slip points of lipids from eight adipose tissue depots

Item	Brisket	Chuck	Flank	Loin	Plate	Rib	Round	Sirloin	SE	*P*-values
16:1/18:0	0.91^{a}	0.55^{b}	0.22^{d}	0.37^{c}	0.39^{c}	0.33^{c}	0.52^{b}	0.47^{b}	0.078	0.001
MUFA:SFA	1.47^{a}	1.14^{bc}	0.88^{g}	0.98^{ef}	1.05^{de}	0.96^{f}	1.16^{b}	1.08^{cd}	0.012	0.001
Slip points, °C	25.1^{e}	31.8^{d}	39.0^{a}	35.9^{bc}	34.3^{c}	37.1^{ab}	31.5^{d}	34.3^{c}	0.331	0.001

^{abcde}Means with common superscripts are not different. Data are means for 50 carcasses.

Table 5. Fatty acid composition of ground beef and hamburgers purchased from local retailers

Item	Fatty acid 16:0	18:0	18:1*t*11	18:1(n-9)	MUFA:SFA[2]
	g/100 g total fatty acids				
Branded Tender	24.4	15.1[b]	8.2[a]	31.5[d]	0.73[d]
Chub pack ground beef	23.2	14.9[b]	7.2[a]	35.0[c]	0.85[c]
Branded Pasture-fed	21.6	18.4[a]	5.5[bc]	35.7[c]	0.86[c]
Fast food hamburger	23.7	15.2[b]	6.3[ab]	35.9[c]	0.87[c]
Ground chuck	23.1	15.2[b]	7.0[ab]	35.8[c]	0.87[c]
Ground round	24.3	14.9[b]	5.0[bc]	36.1[c]	0.90[bc]
Branded Pasture-fed Wagyu	25.6	11.9[c]	1.5[d]	34.7[c]	1.02[b]
Branded Angus	22.9	12.8[c]	3.9[c]	40.9[b]	1.12[b]
Branded Grain-fed Wagyu	24.3	9.1[d]	1.5[d]	45.1[a]	1.45[a]
SEM	0.26	0.39	0.41	0.64	0.003
P-values[3]	0.25	0.0001	0.0001	0.0001	0.0001

[1]Data are means for a minimum of three samples per ground beef type. [ab]Means within a column with common superscripts are not different ($P > 0.05$).

[2]Monounsaturated:saturated fatty acid ratio =

$$\frac{[14:1(n\text{-}5) + 16:1(n\text{-}7) + 18:1(n\text{-}9) + 18:1(n\text{-}7) + 18:2(\textit{cis}\text{-}9,\textit{trans}\text{-}11)]}{[14:0 + 16:0 + 18:0 + 18:1(\textit{trans}\text{-}11) + 18:1(\textit{trans}\text{-}9)]}$$

Not all fatty acids present in the ground beef are listed in the table.

[3]Data were analyzed by analysis of variance, with ground beef type as the main effect.

From Adams et al. (2008).

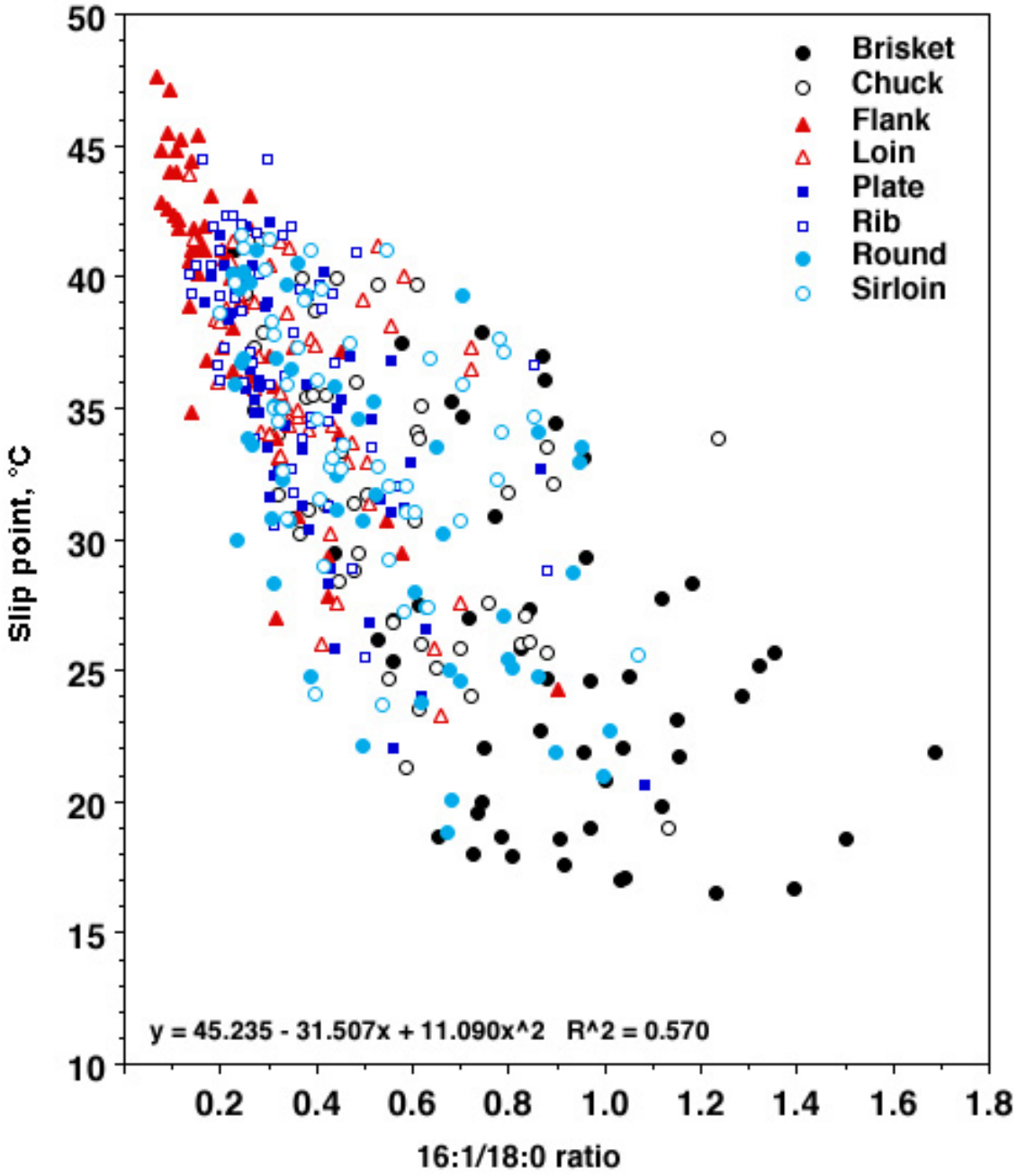

Figure 1. Subcutaneous slip points as a function of palmitoleic:stearic acid ratio in 50 total carcasses. Dark closed symbols, brisket; open symbols, chuck; closed triangles, flank; open triangles, loin; closed squares, plate; open squares, rib; gray closed symbols, round; gray open symbols, sirloin.

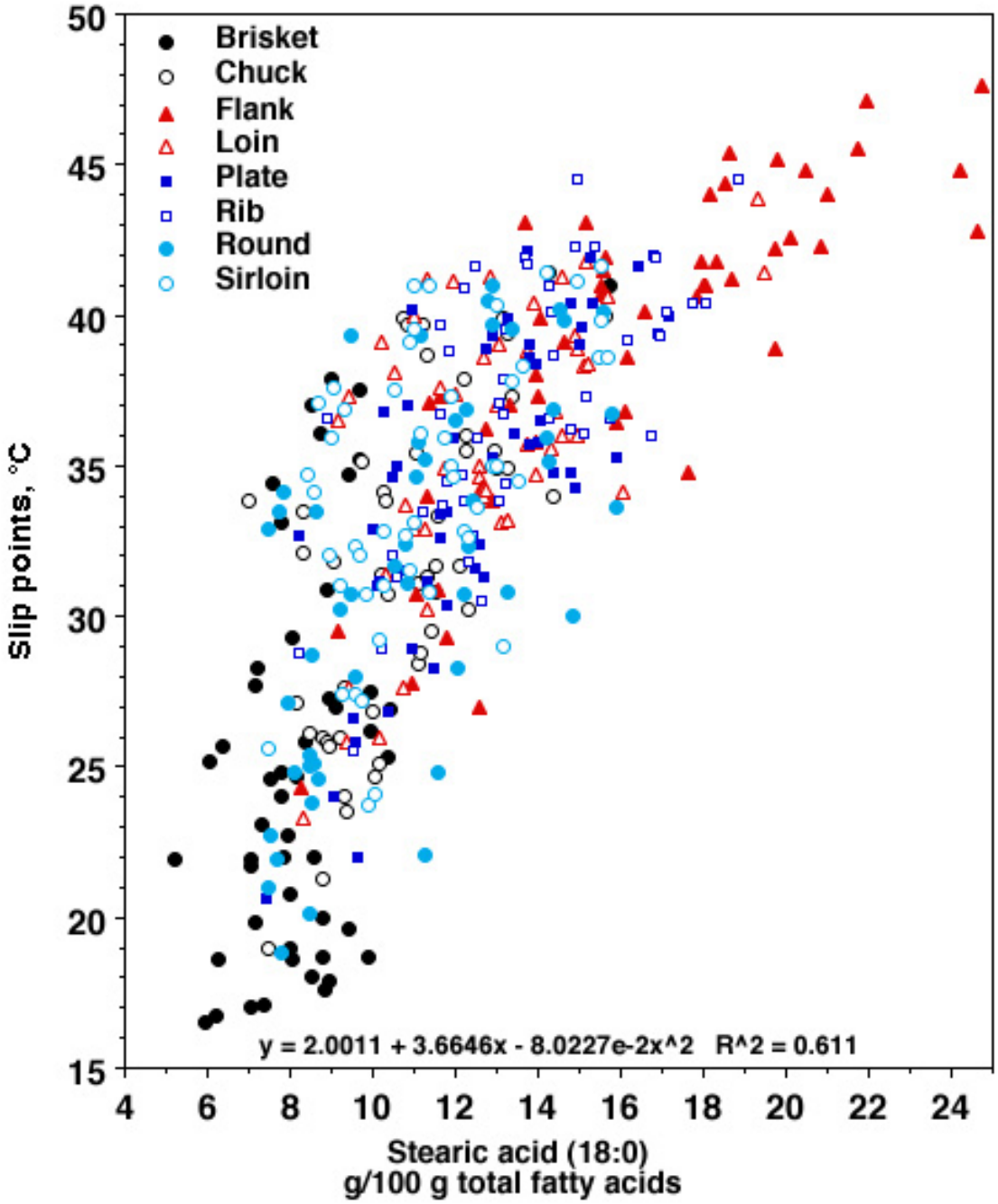

Figure 2. Subcutaneous slip points as a function of stearic acid in 50 total carcasses. Dark closed symbols, brisket; open symbols, chuck; closed triangles, flank; open triangles, loin; closed squares, plate; open squares, rib; gray closed symbols, round; gray open symbols, sirloin.

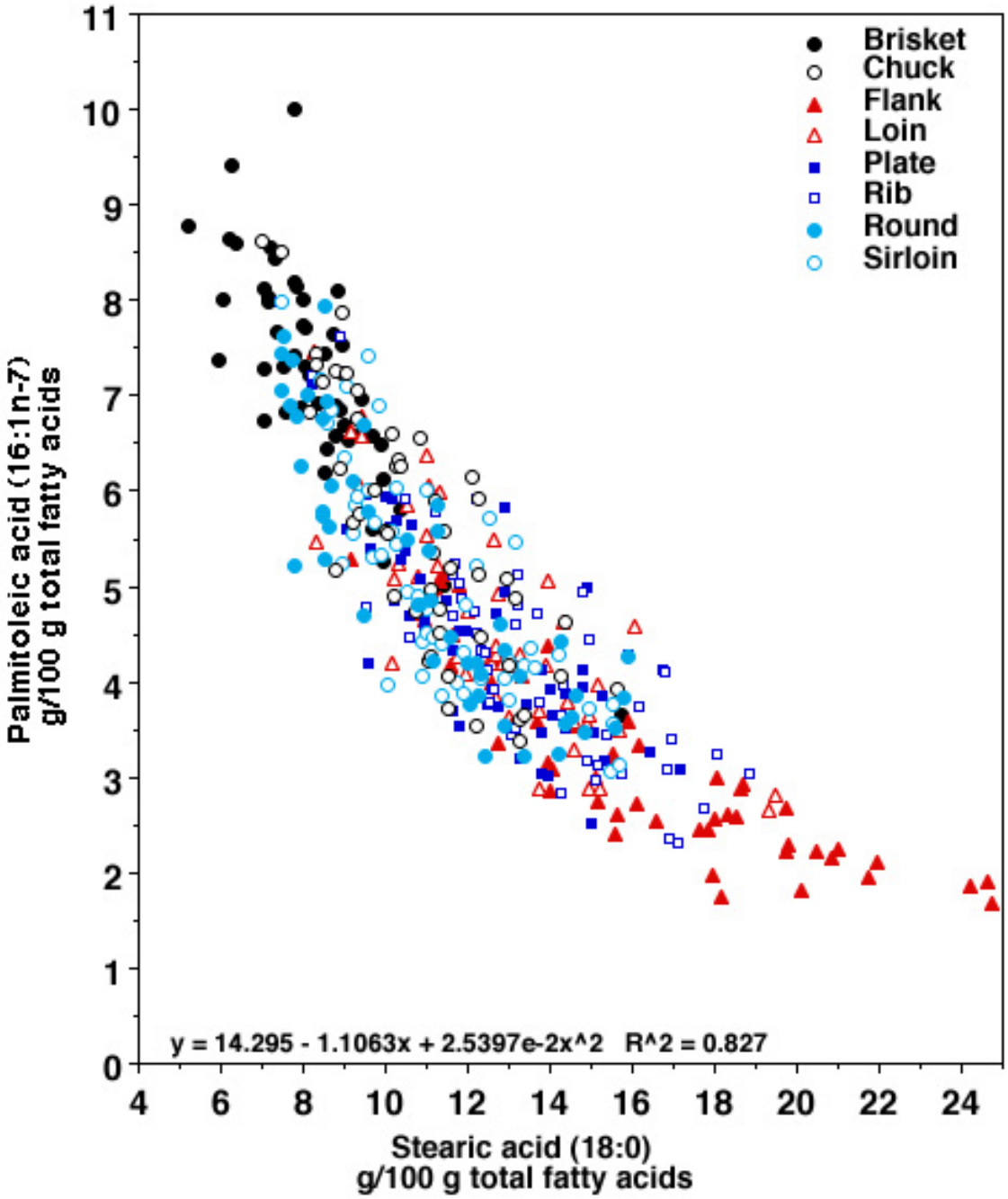

Figure 3. Palmitoleic acid as a function of stearic acid in 50 total carcasses. Dark closed symbols, brisket; open symbols, chuck; closed triangles, flank; open triangles, loin; closed squares, plate; open squares, rib; gray closed symbols, round; gray open symbols, sirloin.

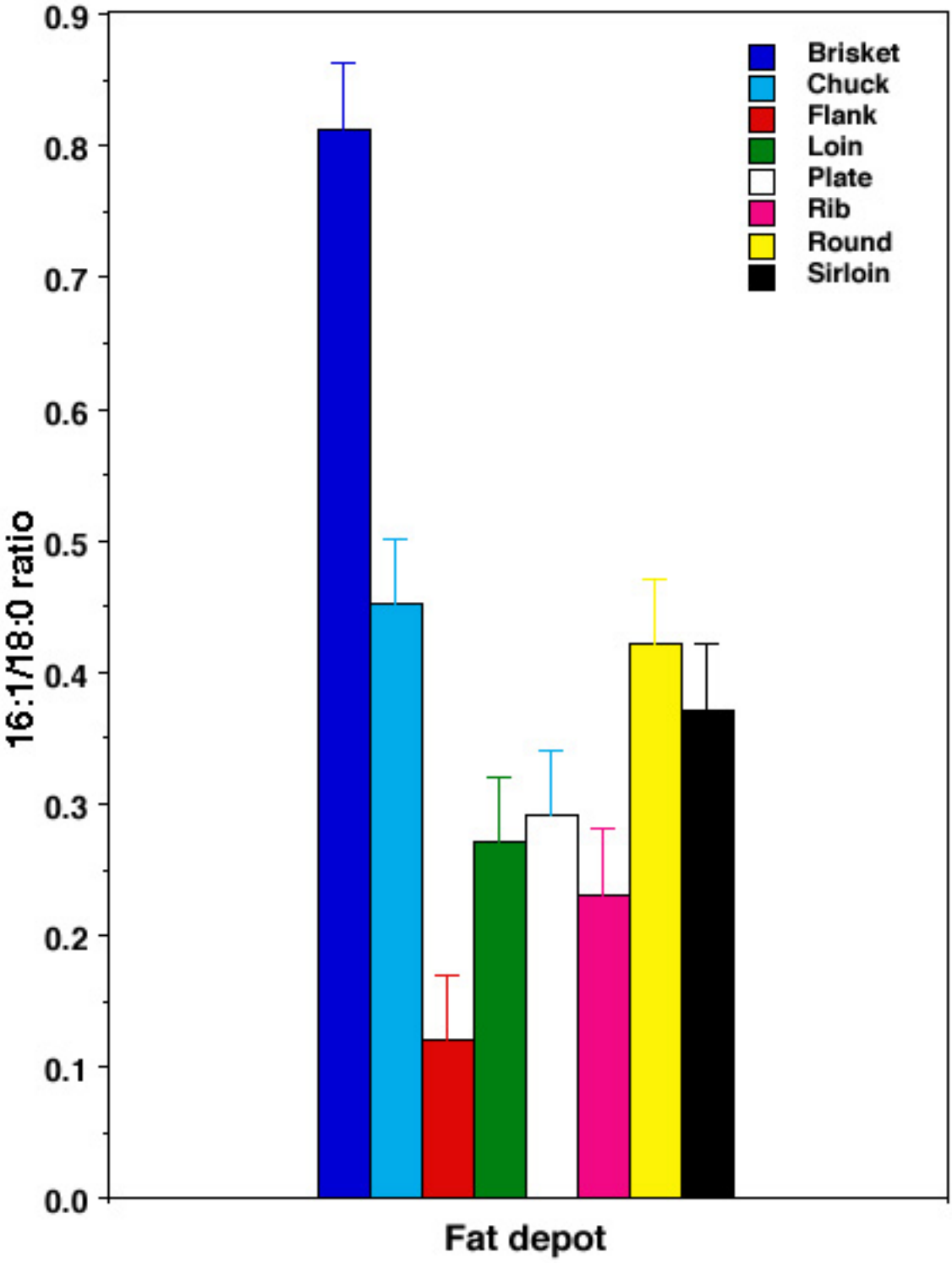

Figure 4. Palmitoleic:stearic acid ratio as a function of carcass fat depot for 50 total carcasses.

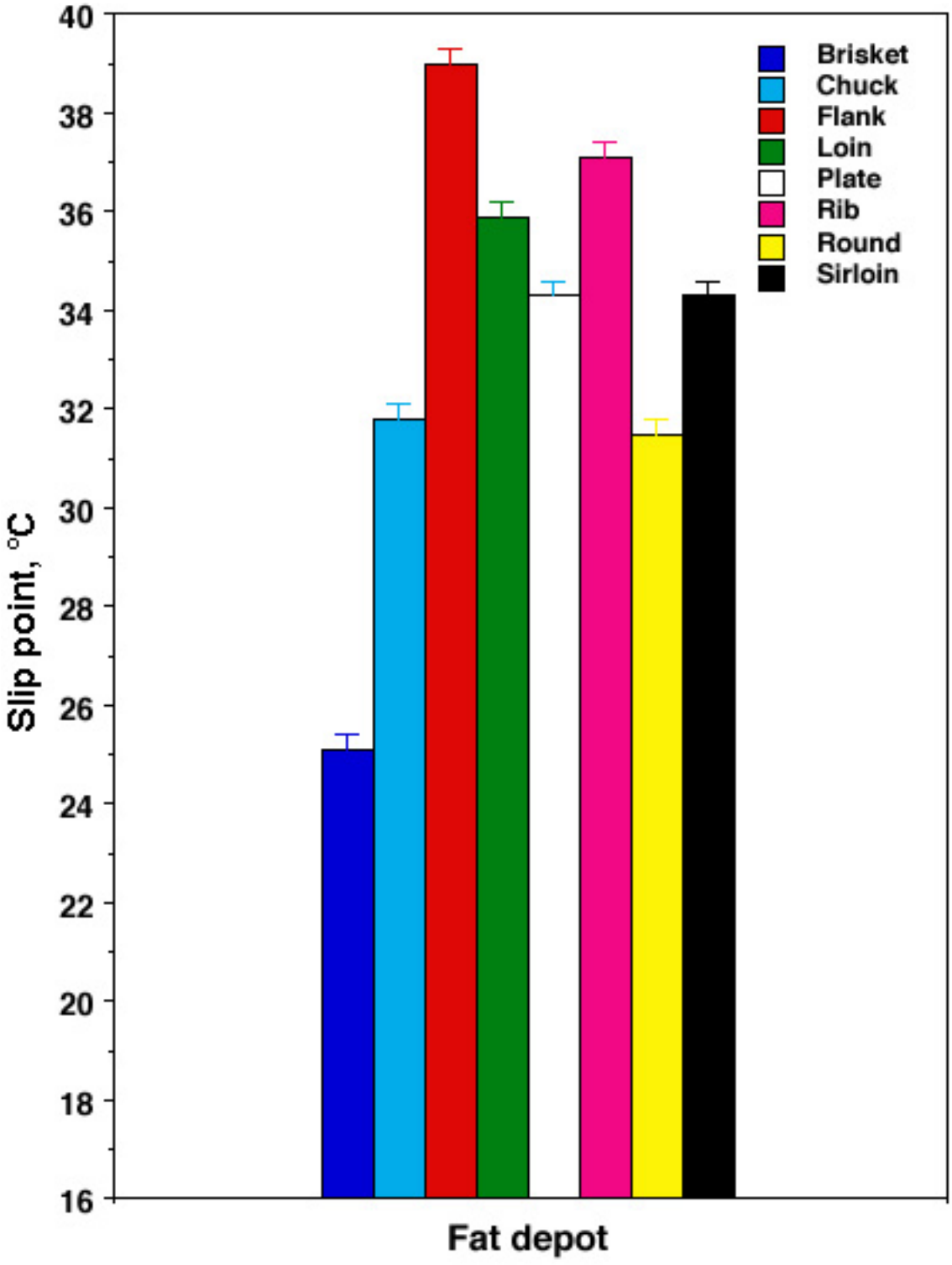

Figure 5. Subcutaneous slip point as a function of carcass fat depot for 50 total carcasses.

VITA

Stacey Nicole Turk
c/o Texas A&M University
Department of Animal Science
317 Kleberg Center,
College Station, TX 77843
stacey06@tamu.edu

Stacey Nicole Turk was born in Iraan, TX and attended middle school and high school in Liberty City, TX. She is the daughter of Doc Turk and Jackie Horvath. She has one sister, Tracey, and 4 stepsisters and 3 stepbrothers.

Stacey graduated from Texas A&M University in 2006 with a Bachelor of Science in Animal Science. After much consideration, Stacey began her master's program at Texas A&M University as a graduate student in Meat Science. She conducted her research under the direction of Dr. Stephen B. Smith and received her M.S. in Animal Science in May 2008.

Stacey was a member of the Texas A&M Meat Judging Team, the Meat Animal Evaluation Team, and the Animal Science Graduate Student Association.