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To the Graduate Council:

I am submitting herewith a dissertation written by Kadhim Abdul Ruhman Khalil entitled "The Relationship of Intramuscular and Subcutaneous Fat to the Physical and Chemical Composition and the Organoleptic Properties of Beef." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Animal Science.

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THE RELATIONSHIP OF INTRAMUSCULAR AND SUBCUTANEOUS FAT TO THE PHYSICAL AND CHEMICAL COMPOSITION AND THE ORGANOLEPTIC PROPERTIES OF BEEF

A Dissertation

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

by

Kadhim Abdul Ruhman Khalil

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ABSTRACT

One hundred and thirty-five steer and heifer carcasses were used to study the relationship of intramuscular and subcutaneous fat to the physical and chemical composition and to the organoleptic properties of beef. Steer carcasses ranging in USDA grade from high standard to high choice and heifer carcasses ranging from low good to hich choice were included.

A significant ($P < 0.05$) positive relationship existed between USDA carcass grade and taste-panel tenderness scores of 6-7-8th rib roasts. Grade, marbling and percent ether extract of *longissimus dorsi* muscle were each significantly ($P < 0.05$) related to juiciness scores of 6-7-8th rib roasts and club steaks. These relationships were not generally high and were somewhat inconsistent. Overall grade marbling or percent ether extract of *l. dorsi* muscle had almost the same influence on the eating quality of beef. Eating quality was not significantly ($P < 0.05$) affected by fat thickness. For the 9-10-11th rib roasts from both sexes, percent separable fat was influenced more by fat thickness than by grade.

Percent protein content of cooked rib roasts had a significant positive influence on shear values obtained on roasts from heifers and a significant negative effect on juiciness scores of roasts from both sexes. Flavor was significantly related to percent protein content of cooked roasts from heifers. Juiciness and tenderness scores were significantly ($P < 0.05$) increased as percent ether extract of cooked roasts from heifers increased. Percent protein content of

cooked steaks from both sexes had a significant positive effect on shear value of club steaks and a significant negative effect on juiciness. For steaks from steers tenderness and flavor scores were significantly affected in a positive and curvilinear manner by percent protein content of cooked steaks.

It was concluded that USDA quality grade and marbling cannot be used effectively to predict the degree of eating satisfaction experienced by the consumer.

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CHAPTER I

INTRODUCTION

The volume of research dealing with the factors which affect beef palatability is rather large. The effects of changes in composition, processing techniques, cooking procedures, animal maturity and a host of other variables have been investigated by numerous workers.

Consumer satisfaction must be one of the ultimate goals of the beef producer. Beef which is tender, juicy and flavorful and is fabricated from carcasses with the minimum of fatness to insure these organoleptic properties should maximize profit to everyone in the beef production chain from the producer to the retailer. Since the eating quality of today's beef apparently fulfills the consumer's desires, any recommended production procedure which might have a deleterious effect upon any aspect of this quality must be viewed with trepidation.

The effects of fat on the eating quality of beef have been the concern of many researchers. The results of their findings do not clearly indicate the degree of fatness necessary to insure the greatest degree of palatability while minimizing the trimmable or waste fat in the carcass.

The objectives of the research reported herein were:

1. To elucidate the effects of variation in marbling on tenderness, juiciness and flavor of beef from carcasses of similar maturity.

2. To investigate the effects of variation in the level of sub-

cutaneous fat on eating quality of beef from carcasses of similar maturity.

3. To study the interrelationships among adipose tissues and their effect on eating quality.

4. To determine the relationships among composition variables of raw and cooked cuts and eating quality variables.

CHAPTER II

REVIEW OF LITERATURE

A tremendous amount of research has been conducted to find methods of improving the eating quality of beef. However, the quality characteristics associated with consumer acceptance are extremely variable, and the exact cause for much of this variation has not been determined.

Brady (1957) concluded that most consumers know very little about beef quality or grades. Consumer dissatisfaction with beef seemed related mostly to tenderness. There was a general aversion to fat. The consumer wanted an almost impossible combination of leanness, juiciness, tenderness and flavor. It was admitted that providing this is difficult but not impossible.

Influence of Grade on Eating Quality

Most of the research related to USDA grades indicates that carcasses with higher grades are expected to provide more palatable cuts. Since major changes in grades were made in 1950, it is difficult to interpret the results of studies of grade conducted prior to that date. Research results concerning specific differences between grades and the magnitude of these differences have been extremely varied (Briskey and Bray, 1964).

Increases in overall palatability of beef have been reported to be highly related to increases in carcass grade (Black, Warner and Wilson, 1931; Cole, Backus and Orme, 1960; McBee and Wiles, 1967; and Simone, Carrol and Clegg, 1958). However, other workers indicated no significant relationship between carcass quality grade and the overall palatability of the subsequent meat product (Kidwell et al., 1959; and Satorius and Child, 1938).

Consumer acceptance studies have indicated that tenderness is the most important factor related to satisfaction during consumption (Rhodes, Kiehl and Brady, 1955 and Van Syckle and Brough, 1958). Tenderness can be measured in the laboratory using either a laboratory taste-panel composed of trained evaluators or a mechanical device. Relatively low, but significant positive coefficients of correlation of 0.45, 0.40, 0.20, 0.39, and 0.28 were found for the relationship between carcass quality grade and taste-panel tenderness by Alsmeyer et al. (1959), Harris et al. (1965), Hiner (1956), King (1958) and Palmer et al. (1958), respectively. Brown, Bartee and Lewis (1962) reported negative coefficients of correlation between the same two variables, -0.40 for bulls averaging 700 lb live weight and -0.65 for steers averaging 700 lb live weight. Suess et al. (1966) also reported a coefficient of correlation of -0.23 between carcass quality grade and taste-panel tenderness. These researchers suggested that carcass grade was a relatively unreliable indicator of tenderness.

Positive but non-significant correlations of 0.43, 0.26 and 0.12 between Warner-Bratzler shear value (W-B) and carcass quality grade were reported by Brown et al. (1962), Cover and Hostetler (1960) and Cover, King and Butler (1958), respectively. However, a few workers have found relatively low, significant negative relationships between shear force values and carcass quality grade (Abraham, 1967; Cover and Hostetler, 1960; Cover et al., 1958; Hasaini, Deatherage and Kunkle, 1950; King, 1958 and McBee and Wiles, 1967).

Palmer et al. (1958) in a large study (536 animals) found that grade accounted for only 8 percent of the variation in tenderness and total palatability. Comparing Prime and Good grades, Doty and Pierce (1961), in a study of 153 cattle, found the Prime grade to be superior to the Good grade in tenderness. In a study of 334 beef carcasses, including steers, heifers and cows, Kropf and Graf (1959) reported larger but non-significant differences in tenderness among the higher grades.

In an extensive study of loins varying by one-third of a grade from Low Good to High Choice, Nauman et al. (1961) found no natural breaks in degree of acceptability. The 560 loins used in this study were graded on the carcases before removal. A positive but weak relationship existed between grade and consumer acceptance. The distributions of the adjacent grade segments, High Good and Low Choice, overlapped considerably.

Cole and Badenhop (1958), Kiehl (1960) and Harrison et al. (1959) found a preference for higher grades, but, in general there was no difference in eating characteristics of Good and Choice carcasses. Most Choice and Good carcasses were inferior to Choice carcases. Kiehl (1960) pointed out that it is the occasional "odd-ball" or "counterfeit" with respect to palatability which causes merchandising difficulties. Lewis, Bray and Brungardt (1964) noted an increase in tenderness as grade increased from Standard to Prime. However, Cover (1937) and Lane and Walters (1958) reported that variation in tenderness was as great within grades as between grades. They suggested that carcases in the lower grades were as likely to be as tender as those in the higher grades.

Tenderness is undoubtedly related to a number of factors that are not considered in current quality grade standards. The literature previously cited indicates that carcass grades are neither accurate nor precise in classifying carcases according to tenderness. However, if an exact indicator of tenderness exists, it should certainly be incorporated in the USDA grading standards.

A significant positive relationship between meat juiciness and carcass quality grade was reported by Hiner (1956), King (1958) and McBee and Wiles (1967). However, Brown et al. (1962) and Suess et al. (1966) found negative and non-significant correlations of -0.50 and -0.11, respectively between meat juiciness and carcass quality grade. These researchers indicated that carcass quality grade was not an accurate indicator of juiciness in meat.

Highly significant correlations of 0.25 and 0.32 were found between quality grade and meat flavor by Hiner (1956) and King (1958) respectively. However, negative correlations of -0.14 for bulls and -0.33 for steers were found by Brown et al. (1962) between these same variables. These data are evidence that desirable flavor components may be located in fatty tissue of meat. However, only about 7 percent of the variation in flavor can be accounted for by knowledge of the USDA carcass grade (Jeremiah et al.,1970a).

Influence of Finish on Eating Quality

Research indicates that USDA quality grade and marbling score are both positively associated with the level of finish the animal has attained at the time of slaughter. Jeremiah et al. (1970), in a study involving 1,710 steers, found a highly significant positive correlation of 0.28 for Angus steers, 0.35 for Hereford steers, 0.47 for Shorthorn steers and 0.30 for crossbred steers between fat thickness and USDA quality grade. Another highly significant positive correlation of 0.69 was found by Wellington and Stouffer (1959) between fat thickness and USDA quality grade in a study involving cattle which were variable in finish and marbling.

Highly significant positive correlations between subcutaneous fat thickness and marbling score were reported by Jeremiah et al. (1970). The values obtained were 0.28 (Angus steers), 0.37 (Hereford steers), 0.42 (Shorthorn steers) and 0.35 (Crossbred steers). Wellington (1968) found a highly significant correlation of 0.23 between the same variables in Holstein steers. But Ramsey, Cole and Hobbs (1967) found nonsignificant correlations -0.15 (Jersey steers) and 0.19 (steers variable in breed) between subcutaneous fat thickness and marbling score.

It appears from these findings that only about 14 percent of the variation in USDA quality grade and marbling score is accounted for by the level of external finish. These researchers indicated also that fat is essential in producing meat with high USDA grades and, thus, higher palatability with increased fatness is implied.

Some research findings suggest that fatter animals produce more palatable cuts. However, the differences are small and inconsistent. Hankins and Ellis (1939) used a group of 728 cattle, which varied widely with respect to fat cover, to study fatness in relation to quantity and quality factors of beef carcasses. A low correlation (r = -0.11) was found between percentage of fat (ether extract, EE) in the l. dorsi muscle of the 9-10-11th rib section and tenderness of the same muscle. these workers concluded that variation in tenderness was caused mainly by factors other than fatness. Barbella, Tanner and Johnson (1939) studied 728 cattle, ranging in weight from 250 to 1,580 lb and in age from 8 to 42 months, to study the relationship of flavor and juiciness of beef to fatness and other factors. They found small but statistically significant associations of degree of fatness with desirability and intensity of flavor of fat and with quality (richness) and quantity of juice. Cover, Butler and Cartwright (1956) studied the relationship of fatness in yearling steers to juiciness and tenderness of broiled and braised steak. Forty-seven Hereford and 50 Brahman x Hereford steers were used. Fatness was measured by physical separation, by estimated marbling and by percent EE of trimmed muscles. Juiciness scores were shown to be more closely correlated with fatness in broiled longissimus dorsi than in braised l. dorsi or in broiled or braised biceps femoris . Juiciness scores were more closely correlated with ether extract than with other measures of fatness. Fatness seemed more closely related to tenderness scores in the bottom round muscle than in the loin muscle. Tenderness scores were more highly correlated with ether extract than with measures of fatness. Variations in fatness of loin steaks cooked by broiling accounted for only about 10 percent of the variation in tenderness and about 25 percent of the variation in juiciness. Fatness of the braised bottom round muscle accounted for about 30 percent of the variation in tenderness and about 5 percent of the variation in juiciness. Pilkington, Walters and Whiteman (1960) showed that fat content of beef ribs was positively correlated with tenderness.

Backus et al. (1967), Cole et al.(1966) and Husaini et al. (1950a) concluded that the degree of finish is not a determinant of meat palatability and that selection based upon degree of finish would be ineffective in improving eating quality. These reports disagree with the results of Barbella et al. (1939), who reported higher juiciness scores; Kidwell et al. (1959), who reported higher flavor scores and Simone, Carroll and Clegg(1958) who reported higher tenderness and flavor scores for beef cuts from cattle possessing higher degrees of finish.

Influence of Marbling on Eating Quality

If finish contributes to the eating quality of a meat product, then some measure of finish deposited within the muscle should serve as an indication of its relative palatability. Marbling score is one of several factors related to the palatability of beef, according to Doty and Pierce (1961). Marbling has been correlated with overall eating satisfaction, and rather small correlations were reported by Kropf and Graf (1959) ($r = -0.03$) and Rea (1968) ($r = 0.10$). However, Legg et al. (1965) found a significant correlation of 0.28 between marbling score and beef palatability. Other researchers have concluded that marbling does not contribute to overall eating satisfaction in beef (Gilpin, Butcher and Deary, 1965). Therefore, marbling does not appear to be a major factor in the determination of overall palatability in beef.

Rogers et al. (1966) stated that, although the usefulness of marbling in predicting palatability of meat is not necessarily high, the relationship between the two variables appears to be positive. Shear values of cooked rib steaks indicated that those with a "devoid" marbling score were less tender than those with "traces" of marbling. Steaks with these two degrees of marbling were significantly less tender than those having "slight," "small," "modest," "moderate" or "slightly abundant" marbling scores. Wellington and Stouffer (1959) used 121 beef cattle of widely varying fatness and marbling to study the influence of marbling on tenderness and juiciness. The differences in tenderness among beef from carcasses of different marbling score classes as measured by mechanical shear resistance of cooked *l. dorsi* were not significant. However, tenderness evaluation by an experienced sensory panel was positively correlated with marbling, but the differences in tenderness associated with marbling accounted for only 7 percent of the total variation in tenderness. Sliger (1966) used 138 beef females ranging in age from 3 to 211 months to study the influence of chronological age on carcass composition, meat characteristics and palatability. The coefficients of simple correlation between marbling score with shear value (-0.01) and with sensory panel tenderness score (-0.13) were not significant.

Walter *et al.* (1965) emphasized the finding that tenderness was not affected by marbling over a wide range of marbling while Romans, Tuma and Tucker (1965) found no significant difference with respect to either shear force or panel tenderness between "slight" and "moderate" marbling groups. Tuma *et al.* (1962) found that the association between marbling and tenderness varied with animal age.

Hendrickson and Moore (1965) reported that fat within muscle was relatively unimportant in steaks from animals under 20 months of age, but, in their data, it did play a more important role in determining tenderness of steaks from older animals. Alsmeyer *et al.* (1959), Cover, King and Butler (1958) and Palmer (1958) found that variation in marbling accounted for 6.9, 10.0 and 11.0 percent respectively, of the variation in tenderness. Breidenstein *et al.* (1968) and Wellington and Stouffer (1959) stated that factors other than marbling must have a greater influence on muscle tenderness than does marbling itself.

The majority of published research indicates that marbling contributes to the tenderness of meat but that it does not account for a large portion of the total variation (Blumer, 1963; Harris et al., 1965 and Suess et al., 1966).

Jeremiah et al. (1970a) stated that marbling serves only as a dilution factor so that, within a given area of muscle, fewer muscle fibers must be severed in the chewing or shearing process.

Another important criterion for evaluation of meat by the consumer is juiciness of the cooked product. A positive and significant effect of marbling upon juiciness of meat was found by many workers. Blumer (1963), considering extensive evidence, noted that marbling and juiciness were significantly correlated but that the correlation was only about 0.38, which would be sufficient to account for only approximately 15 percent of the variation in juiciness. Hiner and Yao (1954) found the quality of juice to be related to marbling and to be highly heritable. Weir (1960) reported that the taste sensation induced by juiciness in cooked meat was closely related to intramuscular fat content and that tenderness and juiciness were closely associated. Doty and Pierce (1961) found a significant relationship between marbling and juiciness but observed that this relationship was not apparent when marbling score was above "moderate" to "slightly abundant." Wellington and Stouffer (1959) found a significant increase in the juiciness of beef as the degree of marbling increased. Sliger (1966) found that marbling score was significantly associated with panel juiciness score ($r = 0.48$). Therefore, it appears that marbling contributes to juiciness in cooked meat products, although this does not agree with the results of Goll et al. (1965) and Walter et al. (1965).

The other important component contributing to overall acceptance or eating satisfaction rating is flavor. The characteristic flavors responsible for distinguishable differences in flavor and aroma of beef, pork, lamb and poultry are derived from compounds thought to reside in the fatty tissues of the muscle, according to Jeremiah et al. (1970a). Research indicates that increased intromuscular fatness is positively associated with desirability of beef flavor. Blumer (1963) reported a weighted coefficient of determination of 5 percent. Sliger (1966) found that marbling score was significantly related to flavor score ($r = 0.36$). Field, Nelms and Schoonover (1966) reported a highly significant correlation of 0.57 between marbling scores and flavor scores of beef from steers and heifers. However, a relatively low percentage of the total variation in flavor can be attributed to variations in marbling as reported by Jeremiah et al. (1970a), but Rea (1968) reported a low correlation -0.08 between marbling and flavor scores for bulls and steers of 500 to 800 lb live weight.

Evidence indicates that marbling or fat content of the muscle does not give much indication or assurance of the organoleptic properties of beef.

It appears from the foregoing review that USDA quality grade, subcutaneous fat thickness and marbling score cannot be used very effectively to predict the degree of eating satisfaction experienced by a consumer in eating beef from carcasses on which these variables were measured.

Efforts should be made to change the quality grading standards so that quality grade would be a more reliable indicator of eating quality. This would require studying the relationships of chemical composition of raw and cooked beef with eating quality and developing quality grade standards on the basis of findings in such studies. A grading system developed in this manner, namely, by modifying the present weights given the various visually determined carcass characteristics in arriving at quality grade to make them proportional to their relationship to eating quality, would be useful to all segments of the industry in making for more effective production of beef which satisfies the consumer's desires.

CHAPTER III

EXPERIMENTAL PROCEDURE

Data were collected from 68 steer carcasses weighing 550-650 pounds and 67 heifer carcasses weighing 450-550 pounds obtained from a local packing plant. Production history of the cattle from which the carcasses came was unknown. Steer carcasses ranging in USDA grade from high standard to high choice and heifer carcasses ranging from low good to hich choice were included. One to nine carcasses of each one-third grade class in each sex representing the subcutaneous fat thickness range normally found in each one-third grade class were selected.

Carcass Data Obtained at the Packing Plant

Individual hot carcass weight, marbling score, muscle color score muscle firmness score, conformation score, carcass grade and fat thickness at the 12th rib were recorded for each carcass selected for the study.

After being measured and graded, the left side of each carcass was purchased and brought to the meat laboratory of the University of Tennessee at Knoxville for detailed cutting tests, chemical analyses and organoleptic studies. All carcasses were aged for seven days post-mortem before they were processed.

Data Obtained at the Meat Laboratory

The carcass halves were then dissected into wholesale cuts as described by Wellington (1953). The round, loin, rib and chuck were further cut into trimmed, partially boneless retail cuts. Subcutaneous fat in excess of three-eighths inch was trimmed. Intermuscular fat was removed when it was possible to do so without dividing the muscles of the cut. The chine bones were removed from the blade pot roasts and sections of ribs and sternum were removed from the arm pot roasts. The chine bones and rib ends were removed from the rib roasts. The sacral vertebrae were removed from the sirloin steaks, and all bones were removed from the rump roasts.

The 6-7-8th rib roast and two one-inch thick club steaks were retained from each carcass for determination of palatability, shear value and chemical properties. The roasts were wrapped and frozen at -29°C. After freezing they were stored at -18°C until they could be cooked for sensory evaluation. Storage time varied with the test material; the roasts were held from four to twelve months.

The 9-10-11th rib roast was separated into lean, fat and bone. The _l. dorsi_ was excised from the twelfth rib section and ground for chemical determination of amount of intramuscular fat. A one-inch thick club steak was separated into lean, fat and bone, and the lean and fat protions were mixed together and prepared for chemical analysis.

Cooking and Palatability Data

The cooking of the 6-7-8th rib roasts for cooking, palatability and shear tests was done by the personnel of the Food Science and Institution Management Department of the College of Home Economics. Roasts were cooked in groups of four. Roasts from steers and heifers were cooked separately. For assignment to cooking groups, the roasts from each sex were divided into four groups according to fat thickness and grade (Tables I and II). One roast from each of the four divisions was randomly selected and comprised a unit for cooking.

Roasts were thawed at room temperature on the day prior to cooking and then refrigerated over night. Weights were taken to determine cooking time. For cooking, roasts were placed rib side down in roasting pans in a rotary Despatch oven that had been preheated to 163°C. The end point temperature of 68°C was determined by mercury filled thermometers that had been inserted in the center of the _l. dorsi_ muscle. Roasts were placed in the oven at different times in order that they would reach the end point temperature at approximately the same time and about one hour before the scheduled panel session. The cooked roasts were placed in a holding oven at 66°C until the _l. dorsi_ muscle was removed and sliced for the sensory evaluation. The 6th and 7th rib areas were sliced with a Hobart electric meat slicer into 3/16 inch slices which were numbered from the sixth rib end so that each judge received a half slice from the same relative location in each roast. The scoring sessions for the roasts were scheduled at 11:00 a.m. on Monday, Wednesday and Friday to obtain a subjective measurement of tenderness (scale of 1 to 10), juiciness and flavor (scale of 1 to 9). For correlation of objectively measured tenderness with the judges score for tenderness, a three-inch section from the eighth rib end of the _l. dorsi_ muscle was removed from each roast, and two one-inch cores were obtained for shearing with the Warner-Bratzler shear device. Each core was sheared three times and placed in plastic bags for freezing prior to chemical analysis.

The two club steaks from each carcass were cooked using the same groupings as were used for the roasts. A rotary gas grill was used for

TABLE I

PLAN FOR SCORING TESTS OF 6-7-8th RIB ROASTS AND CLUB STEAKS OF STEERS

Test Number	USDA Grade[a]			
1	8	11	12	13
2	8	11	11	12
3	10	12	14	13
4	9	11	12	14
5	9	11	12	14
6	9	13	13	14
7	9	10	14	14
8	9	11	11	14
9	8	11	13	14
10	10	10	13	12
11	10	12	10	12
12	10	10	14	13
13	9	13	12	13
14	10	10	12	12
15	9	11	14	12
16	8	10	13	12
17	8	12	14	13

[a]Numbers represent the following grades: 8 = High Standard, 9 = Low Good, 10 = Average Good, 11 = High Good, 12 = Low Choice, 13 = Average Choice, 14 = High Choice.

TABLE II

PLAN FOR SCORING TESTS OF 6-7-8th RIB ROASTS AND CLUB STEAKS OF HEIFERS

Test Number	Numerical USDA Grade[a]			
1	11	13	10	14
2	14	14	14	10
3	13	11	12	9
4	13	10	12	11
5	12	11	14	10
6	11	12	13	9
7	11	12	12	11
8	14	12	12	10
9	11	11	10	13
10	14	9	11	11
11	14	11	11	12
12	10	13	12	14
13	11	12	10	14
14	13	9	14	11
15	9	12	13	14
16	14	13	13	11
17	14	13	13	--

[a]Numbers represent the following grades: 9 = Low Good, 10 = Average Good, 11 = High Good, 12 = Low Choice, 13 = Average Choice, 14 = High Choice.

cooking. A meat thermometer was inserted into the center of the l. dorsi muscle of one steak of each pair. Steaks were cooked to an internal temperature of 68°C. One steak from each pair was used for sensory panel evaluation of tenderness, juiciness and flavor. Three one-inch cores were removed from the l. dorsi of the other club steak and sheared one time each to obtain an objective evaluation of tenderness. The sheared cores were retained, placed in plastic bags and frozen for subsequent chemical analysis.

Chemical Analysis Data

The sheared cores from both the roasts and steaks were finely ground, mixed and frozen until the time of analysis. The samples were taken from the freezer, allowed to that slightly and re-mixed before sampling.

Modified AOAC (1960) methods were used to determine moisture, ether extract and protein contents.

The excised l. dorsi muscle from the twelfth rib and the mixed separable fat and lean from the one-inch thick club steak section were chemically analyzed by the same procedures.

Method of Analysis

The data were statistically analyzed using the method of least squares as described by Harvey (1960).

For the analyses of multiple regression of each of the twenty-four dependent variables (See Table III) on grade, marbling and fat thickness, three models were specified. The general forms of these models, written from a sample standpoint, were as follows:

TABLE III

DEPENDENT VARIABLES

Organoleptic Properties[a]	Physical Properties	Chemical Properties[c]
Tenderness	Percent separable fat[b]	Percent protein
Juiciness	Percent separable lean[b]	Percent ether extract (EE)
Flavor	Warner-Bratzler shear value (W-B)[a]	Percent moisture

[a]These variables were all measured on 6-7-8th rib roasts and on club steaks.

[b]These variables were all measured on 9-10-11th rib roasts.

[c]These variables were measured on raw club steaks and excised _l. dorsi_ muscle, on cooked club steaks and on rib roasts.

$$(1)\quad Y_i = \bar{Y} + b_1(X_{1i} + \bar{X}_1) + b_1(X_{2i} - \bar{X}_2) + \text{random error}$$

$$(2)\quad Y_i = \bar{Y} + b_1(X_{1i} - \bar{X}_1) + b_2(X_{1i}^2 - \bar{X}_1^2) + b_1(X_{2i} - \bar{X}_2) + \text{random error}$$

$$(3)\quad Y_i = \bar{Y} + b_1(X_{1i} - \bar{X}_1) + b_2(X_{1i}^2 - \bar{X}_1^2) + b_1(X_{2i} - \bar{X}_2) + b_2(X_{2i}^2 - \bar{X}_2^2) + \text{random error}$$

where

Y_i = dependent variable recorded for the ith carcass

$\bar{Y}$ = overall mean

X_{1i}= grade, marbling or ether extract of l. dorsi muscle of ith carcass

X_{2i}= fat thickness at the 12th rib of ith carcass

b_1 = estimate of coefficient of regression of Y on the independent variable in question

b_2 = estimate of coefficient of regression of Y on the square of the independent variable in question

The data from the two sexes were analyzed separately. In the steer data $i = 1, 2, \ldots, 68$, and in the heifer data $i = 1, 2, \ldots, 67$.

For the analyses of multiple regression of each of four dependent variables measured on rib or club steaks and roasts namely, tenderness score, Warner-Bratzler shear value, (W-B), juiciness score and flavor score, only models (1) and (3) above were used where:

X_{1i} = percent protein of cooked rib roast or club steak from the ith carcass

X_{2i} = percent ether extract (EE) of cooked rib roast or club steak from the ith carcass.

For both steer and heifer carcasses, each dependent variable was subjected to analysis by each of the above mentioned models. The appropriate model for each variable was chosen by examination of the significance level for the quadratic term for each independent variable.

All tests of significance were for significance at the 5 percent level of probability of chance occurrence ($P < 0.05$) or at the one percent level of probability ($P < 0.01$) of chance occurrence. Throughout the tables showing the results, the convention of using one asterisk to denote significance at the 0.05 level and two asterisks to denote significance at the 0.01 level was followed.

CHAPTER IV

RESULTS AND DISCUSSION

I. INFLUENCE OF INDEPENDENT VARIABLES ON ORGANOLEPTIC PROPERTIES OF RIB ROASTS AND CLUB STEAKS

Tenderness

Grade. A multiple regression analysis which included carcass fat thickness as an independent variable in the model was used to assess the effect of USDA quality grade on tenderness score recorded by taste-panel members (Table IV). Hereafter, this variable will be called taste-panel score. The fraction of the variation in tenderness of the roasts which could be explained by variation in grade and fat thickness was quite small for both heifers and steers (R^2 = 0.07 and 0.13, respectively). The coefficients of partial regression of tenderness of roasts on grade were significant for both sexes (b_1 = 0.2495 for heifers and 0.3948 for steers). The fractions of the variation in tenderness of steaks which could be attributed to changes in quality grade and fat thickness also were small (R^2 = 0.12 and 0.02, respectively). Partial (fat held constant) regression coefficients indicated a negative relationship between carcass grade and tenderness of the club steaks (b_1 = -0.0856 and -0.0657 for heifers and steers, respectively). The quadratic effect in the regression of tenderness of steaks from heifers on grade indicated that the relationship was curvilinear (b_2 = -0.1249). The difference in the relationship between grade and tenderness of roasts compared to that in steaks is difficult to explain. The l. dorsi was the muscle used for

TABLE IV

INFLUENCE OF USDA QUALITY GRADES AND FAT THICKNESS ON ORGANOLEPTIC PROPERTIES OF RIB ROASTS AND CLUB STEAKS

		Rib Roasts				Club Steaks			
		Taste Panel Tenderness	Warner-Bratzler Shear Value	Taste Panel Juiciness	Taste-Panel Flavor	Taste-Panel Tenderness	Warner-Bratzler Shear Value	Taste Panel Juiciness	Taste-Panel Flavor
Heifers									
	Mean	6.248	18.436	6.899	6.540	6.909	16.307	7.049	7.007
	S.D.[a]	1.361	3.444	5.522	0.544	1.128	3.814	0.575	0.549
Grade	b_1	0.2495*	-0.8787**	0.1229**	0.0218	-0.0856	-0.0803	0.1637**	-0.1041
	b_2	---	---	---	---	-0.1249*	0.3142	---	-0.0322
Fat thick.	b_1	-0.0140	-0.0915	-0.0240	0.0188	0.0281	-0.0513	0.0070	0.0059
	b_2	---	---	---	---	---	---	---	---
	R^2	0.07	0.22	0.11	0.04	0.12	0.11	0.22	0.04
Steers									
	Mean	5.994	19.321	6.741	6.668	6.774	18.406	7.068	7.143
	S.D.	1.208	5.048	0.544	0.510	1.141	4.156	0.557	0.589
Grade	b_1	0.3948**	-2.1037**	0.2325**	0.0579	-0.0657	-0.3317	0.0643	-0.0995*
	b_2	0.1310**	-0.3830*	---	---	---	-0.2753	---	---
Fat thick.	b_1	0.0038	-0.0043	-0.0138	-0.0038	-0.0086	-0.0140	-0.0174	0.0044
	b_2	---	---	---	---	---	---	---	---
	R^2	0.13	0.23	0.48	0.03	0.02	0.07	0.03	0.08

[a]S.D. = Standard deviation.

sensory evaluation in both cuts. Apparently, there is an interaction between cooking method and grade.

Marbling. When marbling and fat thickneww were fitted in the model (Table V), 5 percent of the variation in tenderness of roasts from heifers and 8 percent from steers was explained. Marbling was positively related to roast tenderness (b_1 = 0.244 and 0.732 for heifers and steers, respectively). Marbling, in conjunction with fat thickness, explained only a relatively small amount of the variation in tenderness of steak of steak also. The quadratic effect in the regression of tenderness of steak from heifers on marbling indicated that the relationship was significantly curvilinear (b_2 = -0.1962).

Percent ether extract (EE) of l. dorsi muscle. A section of the *l. dorsi* muscle one-inch thick taken at the 12th rib surface was extracted with ether to objectively measure the intramuscular fat content. When percent EE was fitted along with fat thickness in the model, the coefficients were similar to those obtained when marbling was fitted in the model (Table VI). The percent of the variation in tenderness of both roasts and steaks of steers and heifers which could be attributed to variation in percent EE and fat thickness was quite small in all cases. The partial regression coefficients, while positive, were small and not significant.

Subcutaneous fat thickness. The influence of fat thickness upon taste-panel tenderness score was assessed using three models in which fat thickness was fitted with either grade, marbling or percent EE of the *l. dorsi.* The partial regression coefficients, in all cases, were not significant and were very small, indicating that the thickness of the

TABLE V

INFLUENCE OF MARBLING AND FAT THICKNESS ON ORGANOLEPTIC PROPERTIES OF RIB ROASTS AND CLUB STEAKS

		Rib Roasts				Club Steaks			
		Taste-Panel Tenderness	Warner-Bratzler Shear Value	Taste-Panel Juiciness	Taste-Panel Flavor	Taste-Panel Tenderness	Warner-Bratzler Shear Value	Taste-Panel Juiciness	Taste-Panel Flavor
Heifers									
	Mean	6.248	18.436	6.899	6.540	6.909	16.307	7.049	7.007
	S.D.	1.361	3.444	0.522	0.544	1.128	3.814	0.575	0.549
Marbling[a]	b_1	0.2444	-0.8649**	0.1375**	0.0333	0.0219	-0.3339	0.1967**	-0.0899
	b_2	---	---	---	---	-0.1962*	0.5455	---	-0.0465
Fat thick.	b_1	-0.0098	-0.1060	-0.0240	0.0178	0.0320	-0.0634	0.0053	0.0077
	b_2	---	---	---	---	---	---	---	---
	R^2	0.05	0.18	-.11	0.04	0.11	0.10	0.24	0.05
Steers									
	Mean	5.994	19.321	6.741	6.668	6.774	18.406	7.068	7.143
	S.D.	1.208	5.048	0.544	0.510	1.141	4.156	0.557	0.589
Marbling	b_1	0.1732	-1.5680**	0.2556**	0.0538	0.0409	0.1124	0.1317*	-0.0788
	b_2	0.1529	-0.2938	---	---	0.0851	-0.4128	-0.0062	0.0498
Fat Thick.	b_1	0.0058	-0.0330	-0.0007	0.0006	-0.0079	0.0008	-0.0207	0.0048
	b_2	---	---	---	---	0.0029	---	0.0027	0.0005
	R^2	0.08	0.20	0.46	0.02	0.05	0.05	0.09	0.08

[a]Marbling was scored using a 10 point scale where 1 = devoid and 10 = abundant.

TABLE VI

INFLUENCE OF PERCENT ETHER EXTRACT OF EXCISED *L. DORSI* MUSCLE AND FAT THICKNESS ON ORGANOLEPTIC PROPERTIES OF RIB ROASTS AND CLUB STEAKS

		Rib Roasts				Club Steaks			
		Taste-Panel Tenderness	Warner-Bratzler Shear Value	Taste-Panel Juiciness	Taste-Panel Flavor	Taste Panel Tenderness	Warner-Bratzler Shear Value	Taste-Panel Juiciness	Taste-Panel Flavor
Heifers									
	Mean	6.248	18.436	6.899	6.540	6.909	16.307	7.049	7.007
	S.D.	1.361	3.444	0.522	0.544	1.128	3.814	0.575	0.549
% ether extract of *l. dorsi* muscle	b_1	0.1270	-0.4500*	0.0656*	0.0451	0.1410	-0.5604*	0.1010**	0.0092
	b_2	---	---	---	---	-0.0283	0.1180	---	-0.0009
Fat thick.	b_1	-0.0070	-0.1158	-0.0212	0.0122	0.0290	-0.0657	0.0062	-0.0013
	b_2	---	---	---	---	---	---	---	---
	R^2	0.04	0.17	0.07	0.07	0.10	0.12	0.22	0.001
Steers									
	Mean	5.994	19.321	6.741	6.668	6.774	18.406	7.068	7.143
	S.D.	1.208	5.048	0.544	0.510	1.141	4.156	0.557	0.589
% ether extract of *l. dorsi* muscle	b_1	0.1134	-0.8912**	0.1137**	0.0650*	0.0375	-0.2237	0.0503	-0.0508
	b_2	0.0096	0.0562	---	---	---	-0.0201	---	---
Fat thick.	b_1	-0.0263	0.0004	0.0068	-0.0055	-0.0273	0.1357	-0.0152	-0.0040
	b_2	---	---	---	---	---	---	---	---
	R^2	0.07	0.17	0.35	0.09	0.02	0.04	0.05	0.06

fat cover over the 12th rib has little, if any, influence on the tenderness of either roasts or steaks.

Chemical Composition of Cooked Roasts and Steaks. The cores taken from the roasts for Warner-Bratzler shear (W-B) evaluation were retained after shearing and chemically analyzed to determine protein content and fat content. The combined effect of percent protein and percent EE of the cooked rib roasts on taste-panel tenderness was evaluated (Table VII). The resulting R^2 values of 0.09 for roasts from heifers and 0.10 for roasts from steers indicate that variation in these two variables had only a slight influence on taste-panel tenderness scores. The coefficient of partial regression (0.3109, $P < 0.05$) of tenderness on percent EE of cooked roasts from steers certainly indicates a positive relationship between these two variables. However, the corresponding relationship in roasts from heifers was not significant. Coefficients of partial regression of tenderness on protein content were negative but not significant.

The protein content and percent EE of the sheared cores of the cooked club steaks also were examined for their effect on taste-panel tenderness rating (Table VIII). R^2 values revealed that 18 percent of the variation in tenderness of steaks from heifers and 11 percent of the variation in tenderness of steaks from steers was explained by variation in these two components. The negative partial coefficients of regression of tenderness on percent EE of steaks from heifers ($b_1 = -0.0133$) and of steaks from steers ($b_1 = -0.0420$) indicate a weak relationship between fat content of cooked lean and taste-panel tenderness rating of broiled club steaks.

TABLE VII

INFLUENCE OF CHEMICAL COMPOSITION OF COOKED RIB ROASTS ON ORGANOLEPTIC PROPERTIES OF RIB ROASTS

		Taste-Panel Tenderness	Warner-Bratzler Shear	Taste-Panel Juiciness	Taste-Panel Flavor
Heifers					
	Mean	6.248	18.436	6.899	6.540
	S.D.	1.361	3.444	0.522	0.544
% Protein of cooked rib roast	b_1	-0.1681	1.0155*	-0.1777**	0.1462*
	b_2	---	0.0879	---	-0.0316
%Ether extract of cooked rib roast	b_1	0.0500	0.5657	-0.0243	0.1640*
	b_2	---	0.0454	---	0.0068
	R^2	0.09	0.31	0.20	0.13
Steers					
	Mean	5.994	19.321	6.741	6.668
	S.D.	1.208	5.048	0.544	0.510
% Protein of cooked rib roast	b_1	-0.0359	0.6291	-0.0970**	-0.0675
	b_2	-0.0012	0.1602	---	0.0047
%. Ether extract of cooked rib roast	b_1	0.3109*	-0.4931	0.0573**	0.0800
	b_2	0.0146	-0.0150	---	0.0043
	R^2	0.10	0.24	0.41	0.09

TABLE VIII

INFLUENCE OF CHEMICAL COMPOSITION OF BROILED CLUB STEAKS ON ORGANOLEPTIC PROPERTIES OF CLUB STEAKS

		Taste-Panel Tenderness	Warner-Bratzler Shear	Taste-Panel Juiciness	Taste-Panel Flavor
Heifers					
	Mean	6.909	16.307	7.049	7.007
	S.D.	1.128	3.814	0.575	0.549
% Protein of broiled club steak	b_1	-0.1678	0.8858**	-0.1752**	-0.0367
	b_2	0.0465	---	0.0187	0.0184
% Ether extract of broiled club steak	b_1	-0.0133	-0.0783	0.0059	0.0026
	b_2	-0.0132	---	-0.0034	0.0012
	R^2	0.18	0.22	0.31	0.04
Steers					
	Mean	6.774	18.406	7.068	7.143
	S.D.	1.141	4.156	0.557	0.589
% Protein of broiled club steak	b_1	-0.2573*	1.0533**	-0.2328**	-0.0736
	b_2	0.0265*	-0.0768	0.0146**	0.0140*
% Ether extract of broiled club steak	b_1	-0.0420	-0.1628	-0.0348	-0.0630
	b_2	0.0036	-0.0501	-0.0012	0.0019
	R^2	0.11	0.18	0.42	0.19

Warner-Bratzler Shear Value (W-B)

Grade. USDA carcass quality grade was fitted in a model along with fat thickness to study its influence on W-B of rib roasts (Table IV, p. 24). The R^2 values were 0.22 for roasts from heifers and 0.23 for roasts from steers. Grade had a significant negative effect on W-B for heifers and steers, indicating a significant decrease in shear value as grade increased.

For club steaks the R^2 values were smaller (0.11 for heifers and 0.07 for steers). The relationship between grade and W-B values for steaks was negative also but weaker for both sexes than was the case with roasts. The relationship was curvilinear (b_2 = 0.3142) for steaks from heifers.

Marbling. When marbling was substituted for grade in the model, the R^2 values were similar (Table V, p. 26). Coefficients of partial regression indicated a highly significant negative relationship between marbling and shear value of roasts from both sexes. The relationship between marbling and shear value of steaks was weaker. The partial regression coefficient involved was -0.3339 for steaks from heifers and 0.1124 for steaks from steers. The difference in the direction of the regression between heifers and steers is difficult to explain. Apparently, there is an interaction between marbling and cooking method which causes the results obtained with roasts and those with steaks to be different.

Percent Ether Extract of l. Dorsi Muscle. Percent EE of the *l. dorsi* muscle was combined with fat thickness to study its effect on shear value of both roasts and steaks (Table VI, p. 27). The R^2 values for roasts were the same (0.17) for both sexes. The negative relationship between percent EE of *l. dorsi* muscle and shear value was significant for heifers and steers.

Small R^2 values were obtained for steak tenderness in both sexes. The negative relationship between percent EE of the l. dorsi muscle and shear value was significant for steaks and heifers. The positive quadratic term, however, indicates a curvilinear effect. While these two parameters were negatively related in steers also, the regression was smaller and curvilinearity was not indicated.

Subcutaneous Fat Thickness. Carcass fat thickness was combined with either grade, marbling or percent EE of l. dorsi muscle to evaluate its effect on W-B (Tables IV, V, and VI, pp. 24, 26, and 27, respectively). Fat thickness did not have a significant effect on shear value of the roasts and steaks from either sex. Partial regression coefficients were small and inconsistent in sign.

Chemical Composition of Cooked Roasts and Steaks. The effects of both protein and percent EE on shear value (Table VII, p. 29). The coefficients of determination were relatively large (0.31 for heifers and 0.24 for steers). The relationship between percent protein and shear value of heifers was significant ($b_1 = 1.0155$). Shear value appeared to increase with increasing percent EE in roasts from heifers but to do the reverse in roasts from steers, but neither partial regression coefficient was significant.

The effects of percent protein and percent EE of broiled steaks are shown in (Table VIII, p. 30). The R^2 values were 0.22 for heifers and 0.18 for steers. The positive relationship between percent protein and shear value was highly significant in both sexes, indicating that cooked steaks which were higher in protein were less tender as indicated by the shear. Percent EE had non-significant negative effects on shear values, but the direction of the regression would indicate that fat tends to have a desirable effect on shear value.

Juiciness

Grade. Grade was found to have a significant positive effect on the juiciness of rib roasts from both sexes (Table IV, p. 24). The R^2 values for roasts were 0.11 for heifers and 0.48 for steers when grade was fitted in the model along with fat thickness. The relationship between grade and juiciness was significant and positive for roasts from both sexes.

For steaks the R^2 values were 0.22 in the heifer analysis and 0.03 in the steer analysis. A significant positive relationship was found between grade and juiciness of heifer steaks. The association between these two variables in steers, while positive, was not significant.

Marbling. Marbling had almost the same effect on juiciness as did grade (Table V, p. 26). The R^2 values for roasts were 0.11 and 0.46 in the heifer and steer analyses, respectively. The relationship between marbling and juiciness was significant and positive in both heifers and steers. There was a significant positive relationship between juiciness and marbling for steaks also in both sexes. Thus, in all cases, marbling was found to have a beneficial effect on panel juiciness scores. However, the quadratic term indicates that this relationship in steers is curvilinear. The coefficients of determination (R^2) show that 24 percent of the variation in juiciness of club steaks of heifers but only 9 percent of the variation in juiciness of club steaks of steers can be explained by changes in marbling and fat thickness.

Percent Ether Extract. Percent EE of the l. dorsi muscle was significantly and positively related to juiciness of rib roasts from both heifers and steers (Table V, p. 26). The R^2 values were 0.07 for heifers and 0.35 for steers. The percent EE of the l. dorsi muscle had a significant positive effect on juiciness of roasts from heifers and steers.

For steaks the R^2 values were 0.22 for heifers and 0.05 for steers. A significant positive relationship was indicated for steaks from heifers and a smaller and non-significant positive relationship was shown for steaks from steers.

Subcutaneous Fat Thickness. Fat thickness was fitted with either grade, marbling or EE of the l. dorsi muscle in three models (Tables IV, V and VI, pp. 24, 26, and 27, respectively). The relationship between subcutaneous fat thickness and juiciness were small and not significant for both roasts and steaks in both sexes.

Chemical Composition of Cooked Roasts and Steaks. Percent protein and percent EE of the roasts were studied together to assess their effect on juiciness (Tables VII, p. 29 and VIII, p. 30). The resulting R^2 values for roasts were 0.20 for heifers and 0.41 for steers. The relationship between protein content and juiciness of roasts was significant in both sexes and indicated that an increase in protein content was associated with lower panel juiciness scores. A significant positive relationship was found between percent EE of roasts and juiciness of roasts from steers. The R^2 values were 0.31 for heifers and 0.42 for steers, indicating that changes in these two chemical components explained a relatively high percent of the variation in juiciness.

There was a significant negative relationship between protein content and juiciness of steaks, and this relationship was curvilinear in both sexes. There was a non-significant relationship between percent EE content and juiciness of steaks from both sexes.

Flavor

Grade. The combination of grade and fat thickness had only a slight effect on flavor of both roasts and steaks from both sexes (Table IV, p. 24). R^2 values in all cases were quite small.

There was a non-significant positive relationship between grade and flavor of roasts in heifers and steers. The coefficients of partial regression of flavor on grade in club steaks were negative. In the case of steaks from steers, this regression was significant (b_1 = -0.0995).

Marbling. Marbling had a positive but non-significant effect on flavor of rib roasts and a negative but non-significant effect on flavor of club steaks. This was true for both heifers and steers (Table V, p. 26).

A different effect appears to be produced by the presence of intramuscular fat when cuts are cooked by roasting as compared to that produced when they are broiled.

Percent Ether Extract. The percent EE of the l. dorsi muscle from the 12th rib section was found to have a positive effect on the flavor of rib roasts. In the case of steers this effect was significant (b_1 = 0.0650). However, because of the high correlation between percent EE and fat thiskness, in neither case when it was fitted with fat thickness in the model was much of the variation explained (7 percent in heifers and 9 percent in steers). The relationship of the percent EE content of the l. dorsi to steak flavor was not significant in either sex. However, it is interesting to note that the association between this variable and flavor in steaks from steers was negative.

Subcutaneous Fat Thickness. The regression coefficients indicating the effect of fat thickness on flavor were non-significant in all cases when fat thickness was fitted with either grade, marbling or percent EE of l. dorsi muscle.

Chemical Composition of Cooked Roasts and Steaks. The combination of percent protein and EE of cooked roasts explained 13 percent of the variation in flavor of roasts from heifers and 9 percent of the variation in flavor of roasts from steers (Table VII, p. 29). Percent protein was significantly related to flavor of roasts from heifers as was percent EE. Protein content of roasts from steers showed a negative but non-significant relationship with flavor while percent EE, although positively related was not significantly so.

The influence of percent protein and percent EE of the club steaks (Table VIII, p. 30) on flavor was small ($R^2 = 0.04$) for heifers and somewhat larger ($R^2 = 0.19$) for steers. The linear relationship between protein content and flavor of club steaks was negative in both sexes. The curvilinear relationship was positive in both sexes but significant only in steers. The relationship between percent EE and flavor of club steaks was not significant in either sex ($b_1 = 0.0026$ for heifers and 0.0630 for steers).

II. INFLUENCE OF INDEPENDENT VARIABLES ON PHYSICAL SEPARATION OF RIB ROASTS AND CLUB STEAKS

Percent Separable Fat

Grade. Carcass quality grades were fitted along with fat thickness in the model (Table IX). There was a positive but non-significant partial regression of percent separable fat on grade in the 9-10-11th rib roasts from heifers. This relationship was significant and positive for rib roasts from steers. Steaks from both heifers and steers showed a significant positive partial linear regression of separable fat on grade. No significant quadratic effects were observed.

Marbling. R^2 values obtained by combining marbling and fat thickness were similar to those found using grade and fat thickness (Table X). The linear relationship between marbling and percent separable fat was positive and not significant in roasts from heifers but significant in roasts from steers. In both cases the relationship was negatively curvilinear, but was significant only in roasts from steers. Positive relationships between marbling and percent separable fat of club steaks were indicated in both sexes.

Percent Ether Extract. Percent EE of the *l. dorsi* muscle (Table XI) exhibited the same pattern as observed for marbling and grade. The relationship between percent EE of the *l. dorsi* muscle and percent separable fat was significantly positive for roasts from heifers and positive but non-significant for roasts from steers. In the case of steaks, the relationship was significantly positive for heifers but only slightly positive and non-significant for steers.

TABLE IX

INFLUENCE OF USDA QUALITY GRADE AND FAT THICKNESS ON PHYSICAL SEPARATION OF 9-10-11TH RIB ROASTS AND CLUB STEAKS

		Roasts		Steaks	
		% Separable Fat	% Separable Lean	% Separable Fat	% Separable Lean
Heifers	Mean	38.963	45.669	22.970	60.270
	S.D.	5.849	4.808	6.638	7.968
Grade	b_1	0.4377	-0.3566	1.6037*	-0.7763
	b_2	---	---	-0.0920	---
Fat thick.	b_1	0.5157**	-0.3961**	0.2020	-0.1988
	b_2	---	---	---	---
	R^2	0.24	0.22	0.24	0.05
Steers	Mean	35.701	46.488	23.393	57.838
	S.D.	9.313	7.852	7.346	10.048
Grade	b_1	1.4967**	0.0559	1.1046*	-1.7546*
	b_2	---	-0.5931*	---	---
Fat thick.	b_1	0.7026**	-0.3913*	0.4212**	-0.3383
	b_2	---	---	---	---
	R^2	0.53	0.48	0.36	0.25

TABLE X

INFLUENCE OF MARBLING AND FAT THICKNESS ON PHYSICAL SEPARATION OF 9-10-11TH RIB ROASTS AND CLUB STEAKS

		Roasts		Steaks	
		% Separable Fat	% Separable Lean	% Separable Fat	% Separable Lean
Heifers					
	Mean	38.963	45.669	22.970	60.270
	S.D.	5.849	4.808	6.638	7.968
Marbling	b_1	0.2899	-0.4054	1.9247**	-1.3332
	b_2	-0.7502	---	-0.0959	---
Fat thick.	b_1	0.4826**	-0.3953**	0.2035	-0.1422
	b_2	---	---	---	---
	R^2	0.28	0.22	0.24	0.08
Steers					
	Mean	35.701	46.488	23.393	57.838
	S.D.	9.313	7.852	7.346	10.048
Marbling	b_1	1.4188*	-1.0738	0.9595	-1.8337*
	b_2	-1.3834**	0.8386	---	---
Fat thick.	b_1	0.5546**	-0.4577**	0.5119**	-0.4478*
	b_2	---	---	---	---
	R^2	0.57	0.44	0.34	0.24

TABLE XI

INFLUENCE OF PERCENT ETHER EXTRACT OF EXCISED L. DORSI MUSCLE AND FAT THICKNESS ON PHYSICAL SEPARATION OF 9-10-11TH RIB ROASTS AND CLUB STEAKS

		Roasts		Steaks	
		% Separable Fat	% Separable Lean	% Separable Fat	% Separable Lean
Heifers					
	Mean	38.963	45.669	22.970	60.270
	S.D.	5.849	4.808	6.638	7.968
% ether extract of *l. dorsi* muscle	b_1	0.7243*	-0.5647*	1.3637**	-0.6372
	b_2	-0.0681	---	-0.0934	---
Fat thick.	b_1	0.4439**	-0.3247**	0.1863	-0.1693
	b_2	---	---	---	---
	R^2	0.29	0.27	0.26	0.06
Steers					
	Mean	35.701	46.488	23.393	57.838
	S.D.	9.313	7.852	7.346	10.048
% ether extract of *l. dorsi* muscle	b_1	0.6410	-0.2638	0.1103	-0.0865
	b_2	0.0404	-0.0717	---	---
Fat thick.	b_1	0.8435**	-0.6701**	0.5984**	-0.6362**
	b_2	---	---	---	---
	R^2	0.51	0.40	0.31	0.19

Subcutaneous Fat Thickness. The relationship between fat thickness and percent separable fat was significant and positive in all three models (Tables IX, X and XI, pp. 38, 39, 40 respectively) for roasts from both heifers and steers. This was as expected since subcutaneous fat is the greatest contributor to the total separable fat of the 9-10-11th rib section. In club steaks the relationship of fat thickness to percent separable fat was positive in all cases but the coefficient of partial regression of percent separable fat on subcutaneous fat thickness was significant only in steers. Apparently, the contribution of fats, other than subcutaneous fat, to the total separable fat of the club steak was greater in heifers than in steers.

The regression of percent separable fat on grade and on subcutaneous fat thickness are illustrated in Figures 1, 2, 3 and 4 which contain scatter diagrams of these variables as measured in roasts from both steers and heifers.

The curvilinearity of the regression of percent separable fat on grade is clearly shown in Figures 1 and 2. If a curvilinear function were actually fitted to these data, the curve describing it would undoubtedly have a maximum point in the vicinity of 12 (low choice) on the grade scale. Linear relationship is apparent in Figures 3 and 4 in which percent separable fat is plotted against fat thickness. That fat thickness has more influence on percent separable fat than does grade is quite apparent.

Percent Separable Lean

Grade. Both steers and heifers had a decreasing percentage of separable lean in the 9-10-11th rib as carcass grade increased, although these negative relationships were not significant (Table 9, p. 38). These

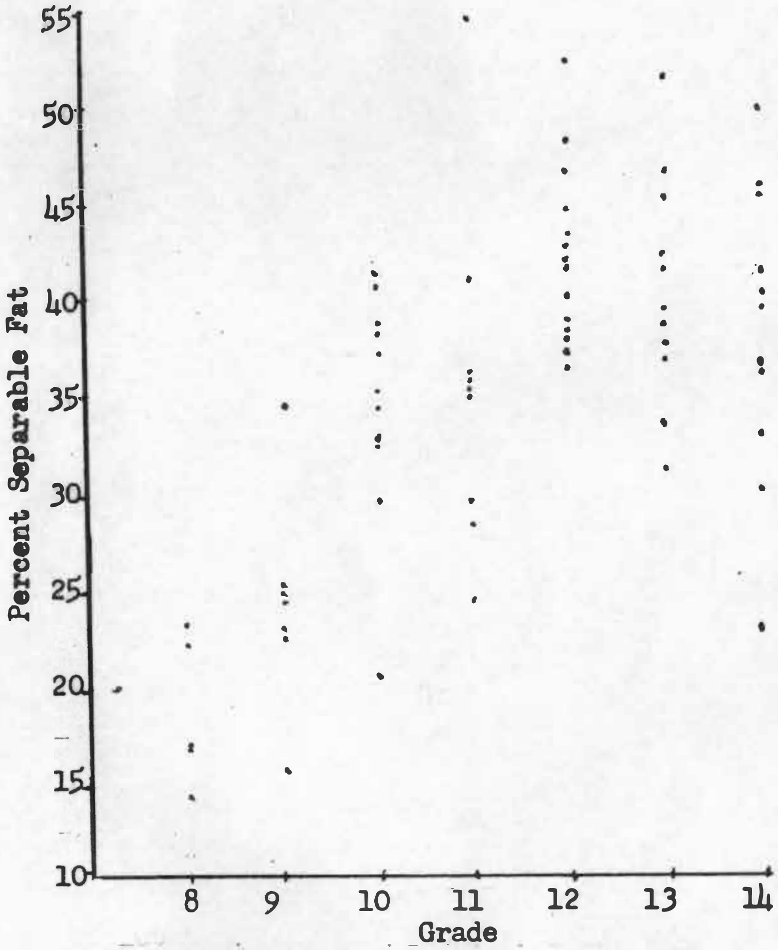

Figure 1. The relationship between USDA quality grade and separable fat of 9-10-11th rib roasts from steers.

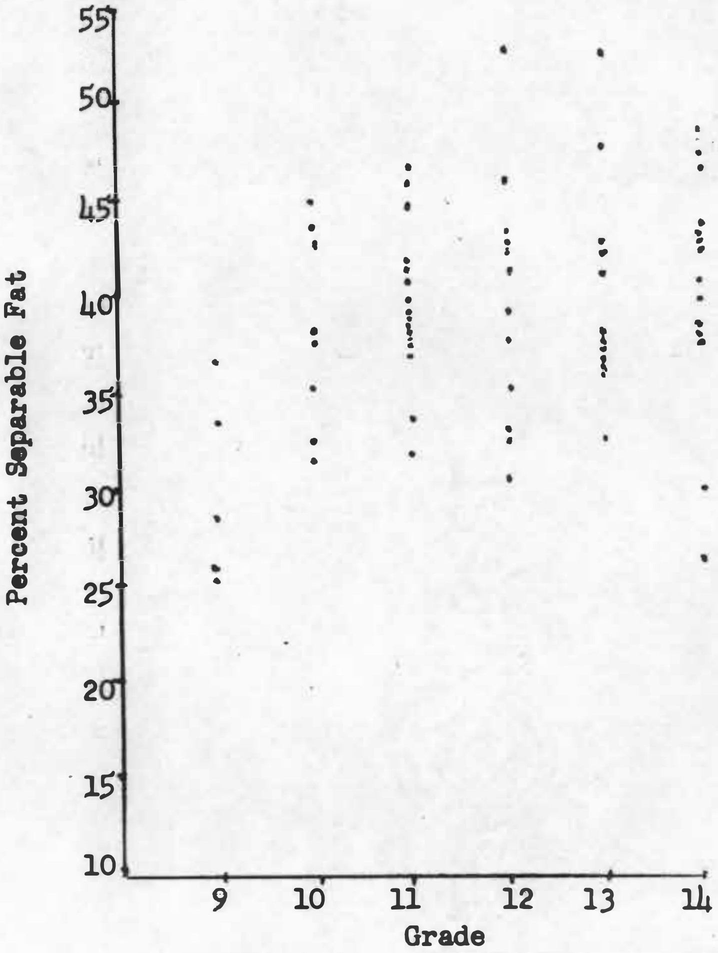

Figure 2. The relationship between USDA quality grade and separable fat of 9-10-11th rib roasts from heifers.

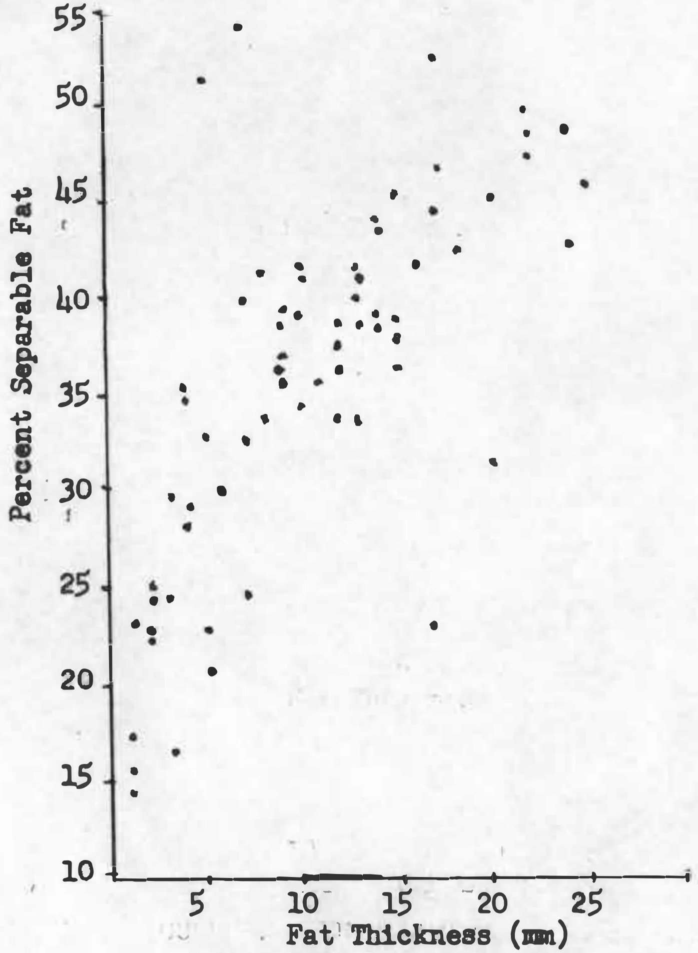

Figure 3. The relationship between fat thickness (mm) and separable fat of 9-10-11th rib roasts from steers.

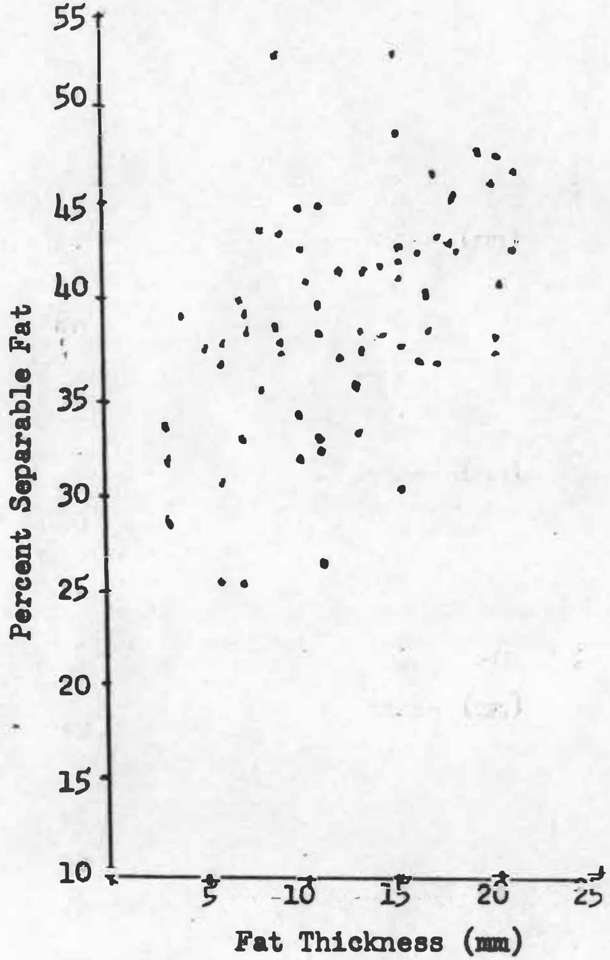

Figure 4. The relationship between fat thickness (mm) and separable fat of 9-10-11th rib roasts from heifers.

relationships were negative also for steaks from both sexes, with steers showing a significantly greater decrease in percentage of separable lean as grade increased. In roasts from steers, there was a significant curvilinear effect.

Marbling. Since marbling plays such a prominent role in determining carcass quality grade, the results obtained when marbling was fitted in the model were almost identical to those with grade as an independent variable in the model in place of marbling (Table X, p. 39). The coefficients of linear regression of percent separable lean on grade and on marbling were negative in all cases, but the only significant one was that of percentage separable lean on marbling in steaks from steers.

Percent Ether Extract. The ether extractable portion of the excised *l. dorsi* muscle should reflect objectively the degree of marbling observed in the intact cut and therefore be correlated with carcass quality grade. Thus, as expected, the coefficients of linear regression of all measures of separable lean on percent EE of the *l. dorsi* were negative (Table XI, p. 40). However, the only one which was large enough to be significant was that of separable lean of 9-10-11th rib soasts of heifers on percent EE of the *l. dorsi*.

Subcutaneous Fat Thickness. Subcutaneous fat thickness was fitted along with either grade, marbling or percent EE of the excised *l. dorsi* muscle as an independent variable in three models (Tables IX, X, and XI, pp. 38, 39, and 40 respectively). The relationship between fat thickness and percent separable lean was significantly negative for roasts in all three models for both sexes. It appears that subcutaneous fat thickness has a stronger negative influence on percent separable lean of steaks from steers than on that of steaks from heifers since the coefficients of linear regression of separable lean on fat thickness were significant in steaks from steers when fat thickness was fitted with marbling or percent EE of the l. dorsi muscle, but no significance was observed for this influence in steaks from heifers in any of the models used.

III. CHEMICAL COMPOSITION OF RAW CUTS

Influence of Grade, Marbling and Percent Ether Extract of L. Dorsi Muscle on Percent Protein of Club Steak and L. Dorsi Muscle

When either grade, marbling or percent EE of the l. dorsi muscle was combined with fat thickness, each had a significant negative effect on percent protein of the club steak in both sexes (Tables XII, XIII and XIV). Thus when grade was higher, that is, when marbling was more profuse or content of ether extractable materials increased, the protein fraction of the mixed separable fat and lean of the one-inch thick club steak decreased significantly. The variables determined by chemical analysis of the rib-eye muscle had similar relationships to these variables. There was a decrease in the percent protein as grade, marbling or percent EE increased. All these relationships were significant except that between percent EE and percent protein of rib eyes of heifers.

Influence of subcutaneous Fat Thickness on Percent Protein of Club Steak and L. Dorsi Muscle

As in the case of the percentage of physically separable components (fat and lean), there was a stronger correlation of subcutaneous fat thickness with the chemically determined protein fraction of the club steaks from steers than with that of club steaks from heifers. As fat thickness

TABLE XII

INFLUENCE OF USDA QUALITY GRADES AND FAT THICKNESS ON CHEMICAL COMPOSITION OF UNCOOKED CLUB STEAKS AND EXCISED *L. DORSI* MUSCLE

		Steaks			L. Dorsi		
		% Protein	% Ether Extract	% Moisture	% Protein	% Ether Extract	% Moisture
Heifers							
	Mean	17.219	24.491	56.640	21.827	4.422	71.181
	S.D.	1.598	6.132	4.592	1.102	2.338	1.763
Grade	b_1	-0.4383**	1.7351**	-1.5656**	-0.3243**	1.1552**	-0.7634**
	b_2	---	-0.2889	---	-0.0950	---	-0.0481
Fat thick.	b_1	-0.0744	0.3221*	-0.2717**	-0.0558*	0.0550	-0.0435
	b_2	---	---	---	0.0119*	---	-0.0170*
	R^2	0.32	0.51	0.50	0.27	0.68	0.49
Steers							
	Mean	17.651	22.956	58.519	21.753	3.971	72.094
	S.D.	1.594	7.043	5.566	0.699	2.626	2.141
Grade	b_1	-0.3868**	1.9078**	-1.1049**	-0.3909**	1.1453**	-0.9601**
	b_2	---	---	---	-0.0691**	---	---
Fat thick.	b_1	-0.0988**	0.4599**	-0.3980**	0.0141	-0.0198	-0.0019
	b_2	0.0045	---	---	---	---	-0.0184**
	R^2	0.67	0.72	0.58	0.36	0.60	0.61

TABLE XIII

INFLUENCE OF MARBLING AND FAT THICKNESS ON CHEMICAL COMPOSITION OF UNCOOKED CLUB STEAKS AND EXCISED *L. DORSI* MUSCLE

		Steaks			L. Dorsi		
		% Protein	% Ether Extract	% Moisture	% Protein	% Ether Extract	% Moisture
Heifers							
	Mean	17.219	24.491	56.640	21.827	4.422	71.181
	S.D.	1.598	6.132	4.592	1.102	2.338	1.763
Marbling	b_1	-0.4571**	2.1745**	-1.7288**	-0.2947**	1.3736*	-0.8526**
	b_2	---	-0.7555*	---	-0.0429	---	-0.0880
Fat thick.	b_1	-0.0785*	0.3129*	-0.2747**	-0.0416	0.0452	-0.0378
	b_2	---	---	---	0.0105*	---	-0.0167*
	R^2	0.29	0.50	0.48	0.27	0.71	0.52
Steers							
	Mean	17.651	22.956	58.519	21.753	3.971	72.094
	S.D.	1.594	7.043	5.566	0.699	2.626	2.141
Marbling	b_1	-0.4404**	2.1263**	-1.2714**	-0.3026**	1.4227**	-1.0482**
	b_2	---	---	---	-0.0703	---	---
Fat thick.	b_1	-0.1184**	0.5641**	-0.4539**	0.0059	0.0265	-0.0556
	b_2	0.0056*	---	---	---	---	-0.0152*
	R^2	0.68	0.71	0.58	0.34	0.67	0.61

TABLE XIV

INFLUENCE OF PERCENT ETHER EXTRACT OF L. DORSI MUSCLE AND FAT THICKNESS ON CHEMICAL COMPOSITION OF UNCOOKED CLUB STEAKS AND EXCISED L. DORSI MUSCLE

		Steaks			L. Dorsi	
		% Protein	%Ether Extract	% Moisture	% Protein	% Moisture
Heifers						
	Mean	17.219	24.491	56.640	21.827	71.181
	S.D.	1.598	6.132	4.592	1.102	1.763
% ether extract of l. dorsi muscle	b_1	-0.3403**	1.7810**	-1.1942**	-0.1058	-0.5806**
	b_2	---	-0.0892	---	-0.0206	-0.0118
Fat thick.	b_1	-0.0618	0.2866**	-0.2315**	-0.0454	-0.0091
	b_2	---	---	---	0.0117*	-0.0130*
	R^2	0.37	0.58	0.56	0.26	0.70
Steers						
	Mean	17.651	22.956	58.519	21.753	72.094
	S.D.	1.594	7.043	5.566	0.699	2.141
% ether extract of l. dorsi muscle	b_1	-0.1663**	0.8213**	-0.3684	-0.1649**	-0.6955**
	b_2	---	---	---	-0.0058	---
Fat thick.	b_1	-0.1352**	0.6491**	-0.5275**	0.0170	-0.0401*
	b_2	0.0095**	---	---	---	-0.0060*
	R^2	0.63	0.64	0.53	0.37	0.85

increased, there was a significant decrease in the percentage of protein according to analyses based on all of the statistical models, (Tables XII, XIII, and XIV, pp. 46, 47, and 48, respectively). There was also a significant curvilinear effect indicated by the quadratic term in the models used in the analyses of data from steers. The only b_1 value which attained significance for this independent variable in heifers was when it was fitted with marbling in the model, and although it was significant, it was smaller than the corresponding regression coefficients found in the analyses of data from steers. No indication of curvilinearity was found in the data from heifers.

The association between subcutaneous fat thickness and protein content of the excised l. dorsi muscle was examined (Tables XII, XIII, and XIV). In heifers the regression of percent protein content on fat thickness was negative in all cases but not significant. However, a significant curvilinear effect was indicated in all models. Very small and non-significant values were obtained for the coefficients of partial linear regression of protein content of rib eye from steers on fat thickness.

Influence of Grade, Marbling and Percent Ether Extract of L. Dorsi Muscle on Percent Ether Extract of Club Steak

The results of combining either grade, marbling or percent EE of the l. dorsi muscle with fat thickness as independent variables in models to study their effects on percent EE of club steaks are presented in Tables XII, XIII, and XIV. Combining any one of these three variables with fat thickness explained a high percentage of the variation in the chemically determined percentage in club steak. There was a significant positive partial linear regression of percent EE on each of these variables which, on a priori grounds, would be expected to be strongly influenced by fatness. In heifers the association appeared to be curvilinear.

Influence of Grade and Marbling on Percent Ether Extract of L. Dorsi Muscle

The influence of grade or marbling on the percent EE of the l. dorsi muscle was significant in both sexes (Tables XII and XIII, pp. 47 and 48). The partial linear regression coefficients indicate that for each one-third of a qulaity grade increase in heifers, the fat content of the rib eye increased about 1.16 percent. In steers one-third grade increase caused the fat content of the rib eye to increase about 1.15 percent. Marbling scores showed vary similar relationships to the chemically extractable fat of the rib eye. In heifers one unit increase in marbling score was accompanied by about 1.37 percent increase in percent EE of the l. dorsi while in steers the corresponding increase was about 1.42 percent.

Influence of Subcutaneous Fat Thickness on Percent Ether Extract of Club Steaks and of L. Dorsi Muscle

Subcutaneous fat had a significant influence on the percent EE of the mixed separable fat and lean from the club steaks of both heifers and steers (Tables XII, XII, and XIV, pp. 46, 47 and 48).

Fat thickness also was combined with either grade of marbling to study its effect on percent EE of l. dorsi muscle (Tables XII and XIII). Fat thickness had a small positive effect on percent EE of the l. dorsi muscle in both models for heifers and steers.

Influence of Grade, Marbling, Percent Ether Extract of L. Dorsi Muscle and Subcutaneous Fat Thickness on Percent Moisture of Both Club Steak and L. Dorsi Muscle

In the meat animal carcass there is an inverse relationship between fat and moisture. This relationship is borne out in the results of this study by the finding of a negative regression of moisture content on any variable which reflects the fatness of the carcass (Tables XII, XIII and IV, pp. 46,47, and 48).

IV. INFLUENCE OF INDEPENDENT VARIABLES ON CHEMICAL COMPOSITION OF COOKED CUTS (RIB ROASTS AND CLUB STEAKS)

Percent Protein Content

Grade, Marbling and Precent Ether Extract of the L. Dorsi muscle. When either grade, marbling or percent EE of the *l. dorsi* muscle was combined with fat thickness in a model to study their influence on protein content of cooked roasts, such an influence of these three variables was found to be significant (Tables XV, XVI and XVII). The relationship of the above-mentioned variables with protein content of the cooked roasts was negative for both heifers and steers.

The influence of either grade, marbling or percent EE of the *l. dorsi* muscle on protein content of cooked steaks when combined as independent variables in a model with fat thickness showed the same significant negative influence as was observed in the case of cooked roasts.

Subcutaneous Fat Thickness. Fat thickness was combined, as stated above, as an independent variable in a model with either grade, marbling or percent EE of the *l. dorsi* muscle to study its effect on protein content of cooked roasts and steaks (Tables XV, XVI and XVII).

TABLE XV

INFLUENCE OF USDA QUALITY GRADES AND FAT THICKNESS ON CHEMICAL COMPOSITION OF COOKED RIB ROASTS AND CLUB STEAKS

		Rib Roasts			Club Steaks		
		% Protein	% Ether Extract	% Moisture	% Protein	% Ether Extract	% Moisture
Heifers							
	Mean	28.864	9.039	60.210	28.913	7.809	61.140
	S.D.	1.556	3.576	2.862	1.870	3.596	3.406
Grade	b_1	-0.5691**	2.0148**	-1.2077**	-0.3414*	1.3587**	-1.0242**
	b_2	---	0.1840	---	---	---	---
Fat thick.	b_1	-0.0343	0.0747	-0.0267	-0.0521	0.1573*	-0.1142
	b_2	---	---	---	---	---	---
	R^2	0.39	0.67	0.46	0.13	0.50	0.31
Steers							
	Mean	29.382	8.404	60.082	29.553	7.054	61.129
	S. D.	1.796	4.049	3.155	2.331	2.960	2.883
Grade	b_1	-0.5172**	1.4735**	-1.3257**	-0.6125*	1.1206**	-0.7099**
	b_2	---	---	-0.1681	-0.1225	---	---
Fat thick.	b_1	-0.0092	0.0796	-0.0859	-0.0167	0.0363	-0.0408
	b_2	---	---	---	---	---	---
	R^2	0.31	0.58	0.44	0.10	0.57	0.27

TABLE XVI

INFLUENCE OF MARBLING AND FAT THICKNESS ON CHEMICAL COMPOSITION OF COOKED RIB ROASTS AND CLUB STEAKS

		Roasts			Steaks		
		% Protein	% Ether Extract	% Moisture	% Protein	% Ether Extract	% Moisture
Heifers							
	Mean	28.864	9.039	60.210	28.913	7.809	61.140
	S.D.	1.556	3.576	2.862	1.870	3.596	3.406
Marbling	b_1	-0.6961**	2.0229**	-1.3159**	-0.4760**	1.6104**	-1.1316**
	b_2	---	0.1090	---	---	---	---
Fat thick.	b_1	-0.0271	0.0625	-0.0311	-0.0406	0.1465*	-0.1161
	b_2	---	---	---	---	---	---
	R^2	0.42	0.64	0.42	0.16	0.52	0.30
Steers							
	Mean	29.382	8.404	60.082	29.553	7.054	61.129
	S.D.	1.796	4.049	3.155	2.331	2.960	2.883
Marbling	b_1	-0.6078**	1.8917**	-1.2896**	-0.4959*	1.4035**	-0.8363**
	b_2	---	---	-0.1727	-0.1159	---	---
Fat thick.	b_1	-0.0340	0.1323*	-0.1116	-0.0198	0.0803*	-0.0745
	b_2	---	---	---	---	---	---
	R^2	0.32	0.65	0.49	0.10	0.63	0.28

TABLE XVII

INFLUENCE OF PERCENT ETHER EXTRACT OF L. DORSI MUSCLE AND FAT THICKNESS ON CHEMICAL COMPOSITION OF COOKED RIB ROASTS AND CLUB STEAKS

		Roasts			Steaks		
		% Protein	% Ether Extract	% Moisture	% Protein	% Ether Extract	% Moisture
Heifers							
	Mean	28.864	9.039	60.210	28.913	7.809	61.140
	S.D.	1.556	3.576	2.862	1.870	3.596	3.406
% ether extract of excised l. dorsi muscle	b_1	0.3458**	1.2377**	-0.9511**	-0.2884**	1.0837**	-0.8089**
	b_2	---	0.0377	---	---	---	---
Fat thick.	b_1	-0.0385	0.0251	0.0107	-0.0373	0.1124	-0.0821
	b_2	---	---	---	---	---	---
	R^2	0.34	0.76	0.59	0.17	0.62	0.38
Steers							
	Mean	29.382	8.404	60.082	29.553	7.054	61.129
	S.D.	1.796	4.049	3.155	2.331	2.960	2.883
% ether extract of excised l. dorsi muscle	b_1	-0.2912**	1.1369**	-0.7919**	-0.3447*	0.8447**	-0.4380**
	b_2	---	---	-0.0004	0.0032	---	---
Fat thick.	b_1	-0.0478	0.1327**	-0.0765	0.0097	0.0804*	-0.0867
	b_2	---	---	---	---	---	---
	R^2	0.28	0.74	0.56	0.14	0.72	0.27

The regressions, for the most part, were negative, small and non-significant in both roasts and steaks from both sexes. The one exception is the small but positive relationship between fat thickness and the protein content of the steaks from steers when fat thickness was fitted into a model with percent EE of the uncooked _l. dorsi_ muscle.

Percent Ether Extract Content

Grade, Marbling and Percent Ether Extract of l. Dorsi Muscle. There was a significant positive relationship between either carcass quality grade, marbling or percent EE of the rib eye and chemically determined fat content of cooked roasts and steaks from both sexes (Tables XV, XVI and XVII, pp. 52, 53 and 54, respectively). Thus, cuts which had a higher degree of fat in the raw muscle, whether by subjective appraisal or by chemical determination, had the higher fat content on the "as eaten" basis.

Subcutaneous Fat Thickness. Fat thickness was combined in models with either grade, marbling or percent EE of the _l. dorsi_ muscle to study its effect on percent EE of cooked roasts and club steaks (Tables XV, XVI and XVII). The association between fat thickness and fat content of the cooked product was positive. In general, the regressions reflecting these relationships were significant.

Percent Moisture Content

Grade, Marbling and Percent Ether Extract of l. Dorsi Muscle. Observations which reflect a higher fat content of the raw product were shown to have a significant negative influence on moisture content of the cooked product, whether cooking was by roasting or broiling (Tables XV, XVI, XVII, pp. 52, 53 and 54, respectively). Comparisons between the mean fat and moisture contents of uncooked l. dorsi and cooked samples taken from roasts as well as steaks show that upon cooking there was an increase in the percentage of fat in the muscle and a decrease in the moisture content. There was slightly more fat and less moisture in roasts than in steaks.

Subcutaneous Fat Thickness. Subcutaneous fat thickness, when fitted as an independent variable in the model with either grade, marbling or percent EE of the rib eye, did not have a significant effect on moisture content of either cooked roasts or steaks (Tables XV, XVI and XVII). It should be reiterated here that, upon fabrication and prior to cooking, the subcutaneous fat was trimmed to a uniform thickness. However, the fat thickness used in the statistical analysis was that taken on the carcass over the 12th rib surface when the carcasses were selected in the packing company's coolers.

V. CONCLUSIONS

Because of various striking inconsistencies in the results of the many analyses conducted, relatively few definite conclusions can be drawn with confidence from the research reported herein. However, there was sufficient consistency with respect to certain points to permit concluding that USDA quality grade and marbling cannot be used effectively to predict the degree of eating satisfaction experienced by the consumer. Subcutaneous fat thickness had little or no effect on beef eating quality. Thus, on the basis of the results obtained in this study, it definitely appears unnecessary and unwarranted to feed cattle beyond the "finish" point of cattle presently graded "good." Carcasses from such cattle provide beef which is not only of acceptable eating quality but also of higher protein content than beef from carcasses grading higher on the present USDA grading scale. Grading procedures should be revised so that if adjectives such as "good" or "choice" are used to describe the grades, they would pertain also to the eating quality of beef from the carcasses so graded.

CHAPTER V

SUMMARY

Sixty-eight steer carcasses and 67 heifer carcasses from a local packing plant were used to study the relationship of amount of intramuscular and subcutaneous fat to various physical and chemical properties and eating qualities of beef. Steer carcasses ranging in USDA grade from high choice to high standard and heifer carcasses ranging from high to low good were included. One to 9 carcasses of each one-third grade class in each sex representing the subcutaneous fat range normally found in each one-third grade class were selected. The left side of each carcass was studied.

The combination of subcutaneous fat thickness fitted as an independent variable in a model along with either grade, marbling or percent ether extract (EE) of the _l. dorsi_ muscle explained only a relatively small amount of the variation in the properties of rib roasts and club steaks. These variables tended to be more highly associated with variation in juiciness than with any other organoleptic property studied. Increases in grade, marbling or percent EE of _l. dorsi_ muscle had a beneficial, though slight and somewhat inconsistent, effect on practically all aspects of eating quality. The strongest relationships were found between these variables and juiciness while the relationships between the tenderness of steaks and these variables were only slight. Fat Thickness had no significant effect on the eating quality of beef. In roasts from both sexes, percent separable fat was influenced more by fat thickness than by grade.

Marbling, grade or percent EE of _l. dorsi_ muscle tended to have a significant negative effect on both percent protein and moisture content of cooked roasts and steaks.

The analyses of chemical composition variables of cooked roasts showed, in general, a negative relationship between taste-panel scores and percent protein and a positive relationship between taste-panel scores and percent ether extract. In broiled steaks these relationships were inconsistent.

It was concluded that USDA quality grade and marbling cannot be used effectively to predict the degree of eating satisfaction experienced by the consumer.

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LITERATURE CITED

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VITA

Kadhim Abdul Ruhman Khalil was born in Mosul, Iraq, on July 1, 1945. He graduated from Al-Sharkia High School in June, 1961. The following fall he entered the Agricultural College of the University of Baghdad located in the capital city of Iraq. On June 22, 1966, he received his Bachelor of Science Degree with a major in Animal Husbandry. In November 1966, he joined the staff of the Animal Science Department of the University of Mosul. During this two-year period as an instructor and research associate, he published two studies, "A Preliminary Study of Wool Characteristics of Awasi Rams in Iraq," and "A Study on the Effect of Feeding Dried Beet Pulp on Growth Rate of Friesian Calves," in *Mesopotamia,* the Journal of Agriculture and Forestry Research for the University of Mosul.

On August 23, 1968, he arrived in Knoxville, Tennessee to begin work toward the Master of Science Degree in Animal Husbandry with Beef Production being his field of special interest. While in Graduate School he also worked at the University of Tennessee's Blount Farm, Knoxville, and as an assistant in the departmental meat lab. In December, 1969, he received his Master of Science Degree. He decided to continue working toward his Doctor of Philosophy Degree and as a result he began this study in the Winter Quarter of 1970 and in June, 1972 he will receive the Ph. D. Degree with emphasis on Meat Processing. During this time he became a member of the Honor Society of Agriculture. In 1971, he received a fellowship from the Graduate School of the University of Tennessee. He also received a special award from the U-T Block and Bridle Club for his service in the Club activities.