# QUANTITATIVE ESTIMATES OF CARCASS CHEMICAL COMPOSITION OF YEARLING CATTLE FROM SPECIFIC GRAVITY AND COOLER TRAITS

by

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# PREFACE

In 1975, a regional beef marketing project was developed to utilize the experimental facilities of the western states to study the "impact of relative price changes of feeds and cattle on the marketing of beef in the United States". This research is a joint venture between the agricultural economists and the animal scientists at the various experiment stations.

Through the combined efforts of the University of Arizona, New Mexico State University and Utah State University, research is underway which contributes to objectives 2 and 3 of this regional project.

The research data discussed herewithin is a partial contribution to the overall regional project. Its scope is limited to the compositional value of yearling steers which were slaughtered after a 10 month pasture feeding experiment. The data are used to establish the composition of yearling animals prior to their contemporary herd mates entering the feedlot phase of production.

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Finally, I would like to dedicate this thesis to my family; especially my father, Hwan-Chen Tsung, my mother, Pi-Hsia Chou Tsung, and my brother, Chun-Long Tsung; without their influence and help, I may not have obtained an education.

TABLE OF CONTENTS

## LIST OF TABLES

LIST OF TABLES--continued

## ABSTRACT

Forty 330 Kg yearling steers varying in genetic background but managed under similar environment were slaughtered off-grass. After 72 hrs. chill ($3^{\circ}C$), specific gravities of carcass left side, quarters and wholesale cuts were determined by hydrostatic weighing. The wholesale cuts were boned, and percent moisture, fat and protein determined on the soft tissue. These data were used to evaluate the predictive properties of specific gravity and cooler traits for carcass chemical composition.

The relationships between specific gravity and chemical composition were lower than those for fed cattle. Prediction equations using specific gravity and cooler traits as independent variables produced higher R values and lower standard errors than those equations containing specific gravity alone.

The relationship of chemical composition of wholesale cuts and composition of the carcass demonstrated that most of the wholesale cuts possessed similar predictive characteristics. Regression equations for predicting composition on weight or percentage basis from the chemical composition of the wholesale cuts as well as the cooler traits of carcasses produced higher coefficients of determination than those equations containing chemical composition alone. Equations using chemical composition of plate or rib with cooler traits accurately estimated the total carcass composition.

## INTRODUCTION

The increased demand for beef with more edible lean meat and less fat trim has caused increased interest in methods of accurately predicting the amount of muscle and fat in a carcass. Besides, nutritionists wish to know composition in order to properly evaluate nutrients; physiologists want to know composition as an aid in understanding body function; breeders wish an estimate of composition in order to bring about desired changes through selection programs; and the trade needs a reliable method for the classification of carcasses in commerce.

Numerous methods have been used in estimating carcass composition of domestic animals. The most accurate method to determine carcass composition by chemical analysis was developed by Hankins and Howe (1946), but this method is time consuming, expensive and renders the carcass inedible. Rapid and reliable methods of determining carcass composition would be useful to evaluate carcasses of various genetic and environmental sources.

A relationship between carcass specific gravity and body composition was first reported by Kraybill, Bitter and Hankins (1952). The specific gravity of fat is less than the other components (Behnke 1942), and hence the larger the proportion of fat, the lower will be the specific gravity of the carcass.

Most of the work using specific gravity to estimate carcass composition was conducted with fed cattle. Such carcasses are characterized by relatively high levels of ether extract or separable fat. Possibly, the method would not have the same application for the smaller and thinner cattle. Therefore, the major objectives of this study were: (1) to determine the relationship between specific gravity of the carcass and chemical composition of mixed breed, grass-fed animals with similar low degrees of fatness managed under similar systems, (2) to evaluate the predictive characteristics of ten specific gravity measurements, (3) to develop prediction equations using specific gravity measurements and easily obtainable carcass traits, and (4) to determine the correlation of the composition of wholesale cuts to that of the entire carcass.

# LITERATURE REVIEW

Increasing emphasis on yield of red meat has made the measurement and prediction of carcass composition more important in meat animal experimentation as well as throughout the meat animal industry. For the past 35 years a number of methods for predicting various measures of carcass composition have been reported. Methods are direct or indirect, destructive or non-destructive, costly or cheap, time consuming or rapid. The carcass prediction by carcass measurements, densitometric methods and part to whole will be examined in this review.

## Carcass Measurements

Measurements which are easily obtainable from a carcass and which have been tested for their usefulness in predicting carcass composition include weight of carcass, backfat thickness, ribeye area, weight of kidney fat, carcass length, carcass width and carcass depth.

Waldman, Tyler and Brungardt (1969) reported that shrunk live weight and left side weight were highly correlated with dissected fat and muscle weights in young Holstein calves. The body composition is almost entirely controlled by carcass weight (Reid et al. 1968). However, Berg and Butterfield (1976) pointed out that sex, breed and nutritional regime may influence composition at given weights. Hence, weight as a predictor of carcass composition could be useful within sex, breed, ration, etc.

Cole, Orme and Kincaid (1960) reported a correlation coefficient of .43 between ribeye area and kilograms of separable lean, but the correlation decreased to .04 when weight was held constant. Powell and Huffman (1973) indicated that ribeye area was of little value in estimating percent carcass composition ($R^2$= .06) when there is variation in carcass weight. However, because of the lack of better measures of muscling, it continues to be a predictor in estimating carcass composition.

Vance et al. (1971) reported that a single subcutaneous fat measurement was superior to ribeye area in its correlation with carcass chemical composition. Powell and Huffman (1973) indicated that backfat accounted for more variations in carcass lipid, protein and moisture (percent basis) than any of the yield grade factors for carcasses of uniform weight and composition as well as for carcasses varying greatly in weight and composition. Similar findings have been reported (Murphey et al. 1960; Ramsey, Cole and Hobbs 1962; Henderson, Goll and Kline 1966) in studies in which the composition of the carcass was determined as separable lean and fat.

Kidney fat has been shown to be correlated to carcass fat. In young and thin animals, it is probable that this relationship may be due to the contribution of that fat to the overall fat rather than a direct relationship with the components of the carcass. However, there is a general trend for the removal of kidney fat during slaughter (Berg and Butterfield 1976) which makes it unlikely that much attention will be given in the future to kidney fat as a predictor of fatness.

Width, length and depth have been evaluated as predictors of carcass composition. However, ratios of length, depth and width may describe the shape of the carcass, but have little predictive value in quantifying carcass composition (Everitt and Jury 1964; Busch, Dinckle and Minyard 1969; Fredeen, Martin and Weiss 1971).

## Densitometric Method

Density (D) of a substance is defined as its mass (M) per unit of volume (V) i.e., D=M/V, expressed for example as grams per cubic centimeter. The specific gravity of a carcass is defined as "the ratio of the mass of the carcass to that of an equal volume of a standard liquid". This is usually taken to be water. As both the density of the substance and water are expressed in the same units, specific gravity is an index, independent of the units of measurement, but both the temperature of the substance and of water must be specified.

The specific gravity of the carcass is the resultant of the densities of its components. The specific gravity of the body fat (.92) is considerably less than that of muscle (1.06) and bone (1.50) (Kraybill et al. 1952). For practical purposes the carcass could be considered a two-component system: (a) fat, which, while being of constant density, constitutes a highly variable portion of the whole body; and (b) the fat-free remainder (Murray 1922). However, as an animal matures, the density of each component may vary. Attention has been drawn to the reduction in water content accompanying the increased fattening of farm animals. Laws and Gilbert (1860) and Murray (1919) pointed out that the chemical composition became obvious in mature animals when the fat content was known, because the fat-free mass was constant in composition regardless of fatness. Moulton, Trowbridge and Haigh (1922) found similar results and reported that the water content of the fat-free body decreased rapidly from the time of conception to that of birth and thereafter decreased less rapidly until a relatively constant concentration of water was reached. In a later paper (Moulton 1923), the term "chemical maturity" was introduced which defined the age at which the concentration of water, protein and mineral matter in the fat-free mass became practically constant. This has led to the assumption that the water content of the fat-free body mass in a "chemical mature" animal is constant (Reid, Wellington and Dunn 1955) and consequently should have a stable density. Thus if the fat-free body mass remained relatively constant in composition, the density of the carcass would decrease with increasing levels of fatness.

A number of workers have applied bovine specific gravity as a predictor of body composition. Behnke et al. (1942) reported that variations in fat appeared to be the chief determinant of body specific gravity. Other investigators, including Kraybill et al. (1952), Orme (1958), Meyer, Lofgreen and Garrett (1960), Bieber, Saffle and Kamstra (1961), Cobb and Overjera (1965), Timon and Birhard (1965), Guenther et al. (1967) and Kelly et al. (1968), have supported the use of carcass density as a means of estimating the tissue composition of mature animals or those in a later stage of growth and development. Rathbun and Pace (1945), Bray et al. (1959), Cole, Backus and Orme (1960), Wedgewood (1963) and Waldman et al. (1969) have indicated that specific gravity is of little or no use in the estimation of body composition of carcasses from young animals or where carcass fat content is low. Kelly et al. (1968) reported that specific gravity was a poor estimator of carcass composition of steers when carcass ether extract was less than 20%. Further studies by Garrett and Hinman (1969), Gil et al. (1970) and Preston et al. (1974) have suggested that density becomes a less reliable estimator of carcass fat in carcasses containing less than 12% fat.

Probably the major advantage of the density method is that it is rapid and there is minimal carcass damage or monetary loss in its determination. Another potential advantage is that the experiments reported in the literature have tended to show that tissue density is independent of breed and sex (Kraybill et al. 1952; Garrett et al. 1971). With a trend in many countries towards bulls, steers and heifers all being slaughtered for beef, the subjective appraisal of carcass fatness is even less reliable and increases the potential usefulness of density measurements. Bone appears to have the most variable density and in general the older the animal the more dense its bones (Field et al. 1974). In addition, Fursey (1975) reported differences in the densities of bone taken from animals of the same age but of different breeds. Furthermore, Jones, Price and Berg (1987) have suggested that as an animal matures the density of each constituent may vary. No work was reported on the density of the fat depots changes with increased fattening. However, it should be noted that no large scale trial has been carried out to examine the effects of age, breed and sex on carcass density and further research is necessary.

Since density is the weight per unit volume, the major problem is the measurement of volume. This can be accomplished by determining the volume of either the gas or the water that is displaced (Pearson, Purchas and Reineke 1968). Measurement of volume of water displaced is relatively simple for eviscerated carcasses or cuts, where the major problem is the prevention of erroneous values due to trapping of air. However, measurement of volume with the intact animal is complicated by the sizeable volume of air in the lungs, intestinal tract and body cavity. The first successful attempts to measure body volume of intact animals by water displacement were achieved by Behnke et al. (1942) who made corrections for lung volume.

Application of hydrostatic weighing to estimate the density of eviscerated carcasses has been used extensively. Morales et al. (1945) provided the basic information that demonstrated the validity of the procedure and developed the fundamental equations for estimating fatness of the guinea pig and man from specific gravity. Little work appears to have been done to investigate alternative methods of measuring carcass density. Gas displacement methods appear to have only been examined in the measurement of the density of living animals (Pearson et al. 1968).

Jones et al. (1978) have pointed out the urgent need for research into the relationship between hot carcass density and carcass fatness, particularly with a view to its application to carcass grading.

Many researchers have relied heavily on the correlation coefficient as a measure of accuracy or usefulness of certain measurement techniques. Norton (1968) stated that the correlation coefficient is a comparatively meaningless and useless statistic. Many extremely high correlation coefficients result from analysis of data including ranges of animals from calves to old cows and from near zero percent separable fat to upwards 40 percent. Jones et al. (1978) stated that the size of a correlation coefficient is most influenced by the range in the data of the trait being predicted.

Norton (1968) suggested that testing the significance of the regression coefficient is equivalent to testing the significance of the corresponding correlation coefficient. This author suggests that the regression coefficient is more informative than the correlation coefficient because it has dimensions. Nie et al. (1975) developed a statistical procedure by which the significance of each regression coefficient and the significance of the intercept values can be tested.

Jones et al. (1978) have suggested that the value of any prediction equation can best be ascertained by examining the residual variation obtained by the difference between predicted and actual values of the characteristics being predicted. The statistic that measures the residual variation is the standard error of the estimate. If the standard error is listed as a percentage of the mean of the predicted variable, the resulting residual coefficient of variation gives a common method for comparing the predictive characteristics of equations.

The most realistic approach of evaluating the usefulness of regression equations is to test their accuracy of prediction with carcasses not included in the regression analysis. Marchello et al. (1979) have so far conducted the only study in which this type of evaluation was undertaken.

Garrett (1968) suggested that thermal effects could be responsible for the large variations in the slopes and intercepts of the regression equations associated with carcass fat and density. Thermal effects include not only the temperature of the carcass and the water, but also the expansivity of the soft tissues themselves. Jarvis (1971) found that the thermal coefficient of expansion of muscle was about twice that of water over the temperature range 5 to 30 C, and that of fatty tissue about nine times. This illustrates the importance of standardization of the procedure in the measurement of carcass density.

## Part to Whole Prediction

Lush (1926) observed the relationship between the ether extract in the edible portion of the wholesale rib cut and the ether extract of the entire animal to be linear and to have a very high coefficient of correlation. Chatfield (1926) found that for any given wholesale cut there is a close relationship between the content of fat determined as ether extract and that of the visible fat. Hopper (1944) also suggested the rib cut as a predictor of the whole.

Hankins and Howe (1946) developed prediction formula which were based on the physical separation of the 9-10-11th rib cut into muscle, fat and bone. Recently, Crouse and Dikeman (1974) used crossbred steers to develop prediction equations for carcass composition using cooler traits, carcass cut-out and 9-10-11 rib analysis. They concluded that the Hankins and Howe (1946) equation overestimated carcass moisture and protein, and underestimated carcass fat.

Butterfield (1962 and 1965) reported the shin (fore shank) is a possible predictor of carcass composition and developed equations using the weights of the radius and ulna and the weight of associated muscles. Harrington and King (1963), using Callow's (1962) data, found that the foreshin gave the most precise prediction and that there was little difference between equations from other joints with this equation.

Kelly et al. (1968) indicated the chemical composition of the chuck, round, rib, 9-10-11th rib, sirloin and short loin was highly correlated to the carcass composition of the cattle varying in fatness degree (0 - 40%). Kempster and Jones (1977) evaluated the lean content of wholesale cuts and overall lean content in steer carcasses and reported that the relative precision of joints for predicting carcass lean content differed to an important extent depending on whether or not joint weight was included in the prediction equation. When the prediction equation included joint weight or when percentage lean in the side was predicted from percentage lean in the joints, the shin and leg joints provided much less precise predictions than other joints.

Marchello et al. (1979) developed equations to predict carcass composition of cull range cows utilizing compositional values from the plate or rib in conjunction with carcass cooler traits. Equations from either the plate or rib were found to be accurate ($R^2$ = .72 to .99) in predicting the carcass composition of animals.

Weights have been favored on statistical grounds (Miller and Weill, 1963; Dinkel et al., 1965; Marchello et al. 1979) but percentages are often more convenient to use. Marchello et al. (1979) reported smaller standard errors associated with equations predicting percentages. Kempster and Jones (1977) observed little difference in precision between the use of weights and precentages for prediction equations not including the shin as independent variable.

## METHODS AND MATERIALS

### General Live Animal, Slaughtering, Cutting, Sampling

The animals in this study were a portion of Regional Beef Marketing Project W-145. Through the combined efforts of the University of Arizona, New Mexico State University and Utah State University steer calves of several breed types were pastured for 10 months then slaughtered for carcass evaluation. Twenty two ranches provided the calves for the two year study. The breed types of the experimental animals include Brangus, Angus, Okie, Hereford, Charolais X Hereford, Charolais X Angus, Angus X Hereford for Yearlings I,(1976); Hereford, Okie, Limousine Crosses, Santa Gertrudis, Santa Gertrudis Crosses, Beefmaster, Limousine X Hereford for Yearlings II (1977).

The 22 yearlings in Group I and the 18 yearlings in Group II were slaughtered off grass in the fall of 1976 and 1977, respectively. These animals were a random sample from each rancher cooperator's group before the feedlot phase of production was started.

Hot weights were obtained at the time of slaughter. All the carcasses were chilled for 24 hours, then the left side was quartered. The fore and hind quarters were separated by a cut that "burned" the 12th rib its full length. This cut severs the flank at a point level with the union of the 7th and 8th vertebrae (13th thoracic --

first lumbar) counting down from the pelvic arch. Quality grade and yield grade factors (cooler traits) were determined following USDA standard procedures. The separation of the chuck and brisket (including shank) from the wing (rib and plate) was accomplished by a cut between the 5th and 6th rib. The brisket was then removed from the chuck by a parallel cut to the brisket just above the bony rise (lateral condyle of humerus). The separation of the rib and plate was accomplished by a cut 15.2 cm from the chine bone and parallel to it.

In the breaking of the hind quarter, the flank was removed by cutting underneath the cod fat, then following the natural curve of the round and cutting to slightly expose lean in the sirloin tip area (the surface of Rectus femoris). This cut was continued through a point on the 13th rib that corresponds to the point of separation established between the rib and the plate.

The loin and round were broken on a line 2.5 cm anterior of the pelvic bone and just anterior of the head of the femur. This line crossed the 5th sacral vertebrae thus making the cut parallel to the cut made between the 12th and 13th ribs. The rump was not removed from the round; therefore, in this experiment any discussion of the round includes the rump.

The kidney, pelvic and heart fat was carefully removed and weighed. Each wholesale cut was then weighed and cut into retail cuts following the procedures outlined by Orts (1962). The retail cut-out data included the weights of: arm roast, blade roast, sirloin tip, round steak, heel of the round roast, rump roast, wedge bone sirloin steaks, t-bone steaks and rib steaks. Each retail cut was trimmed to a uniform fat thickness of approximately .5 cm.

The individual retail cuts and nonprimal wholesale cuts were then separated into bone and soft tissue. The fat trim obtained in the preparation of the retail cuts was added to the respective soft tissue. The weight of the bones was recorded and the soft tissue from each wholesale cut was ground through a 1.3 cm chopper and mixed throughly. A random .5 kg sample from the soft tissue of each wholesale cut was reground in a Hobart Model 10814 food cutter until a homogeneous mixture was obtained. All samples were placed in evacuated cryovac bags, wrapped with polyethylene coated freezer paper and stored at -25 C until chemical analyses were conducted.

## Specific Gravity Determination

The quarters were chilled for 12 hours after trucking before specific gravity of the quarters and individual wholesale cuts were determined by hydrostatic weighing following the recommended procedure of Garrett (1968):

1. The deep tissue temperature of each cut was between 3 to 5 C.

2. Since the water temperature was different from the cut temperature, corrections were made in the calculated specific gravity as follows: cut specific gravity = weight in air/weight in air weight - weight in water x density of water

3. Precautions were taken so that trapped air was removed.

4. The underwater weighing was measured as rapidly as possible. The specific gravity of the side was determined by the hydrostatic weights of front quarter and hind quarter.

## Chemical Analysis

Chemical analyses were conducted to determine percent lipid, protein, and moisture. All analyses were performed using duplicate determinations and reruns were made when the values did not agree within one percent of the mean of duplicate determinations.

Crude protein in ground tissue was determined according to the Association of Official Agricultural Chemists (1965). Samples were also analyzed for total extractable lipid and total moisture content by chloroform: methanol extraction following the modified procedure of Ostrander and Dugan (1961) as outlined by Wooten et al. (1979). This procedure provided a means by which the total lipid and moisture content could be determined as separate steps of the same procedure.

## Statistical

Several regression analyses were conducted according to the procedures outlined by Nie et al. (1975). To further evaluate the predictive accuracy of the developed regression equations, the equations were used to predict the composition of the various cattle groups.

Equations using cooler traits (backfat thickness, hot weight, kidney fat, ribeye area and yield grade) and specific gravity measurements as independent variables with chemically determined lipid, protein and moisture as dependent variables were developed as follows: each specific gravity measurement was used in Step One; in Step Two, the cooler traits were used in addition to specific gravity measurements in a stepwise fashion in such a way that those variables contributing the most to the accuracy of the equation were first, left as independent variable if it met the following criteria: (a) the partial correlation coefficient between the independent and dependent variable was significant, (b) the variable significantly ($P < .05$) increased the multiple R value, and (c) the regression coefficient for that variable was significant ($P < .05$).

The compositional characteristics of each wholesale cut (lipid, protein, moisture and bone) were also evaluated for their accuracy as predictors of the entire side. The regression procedures were the same as those outlined for the specific gravity and carcass traits as predictors of chemical composition.

# RESULTS AND DISCUSSION

## General Characteristics

The steers in this study were thin yearlings of mixed breeding. Table 1 shows overall and group means for the carcass characteristics of the steers. Animals in Yearlings II were thinner than those in Yearlings I. Carcass chemical and specific gravity characteristics were different. According to ANOVA, significant difference was shown between Yearlings I and Yearlings II in cooler traits (ribeye area, kidney fat thickness, yield grade), chemical composition (lipid, protein and moisture percentage), and side specific gravity. The lower lipid percentage in Yearlings II was accompanied by higher moisture percentage, and the larger ribeye area was accompanied by higher protein percentage. The increase in carcass lipid content observed for Yearlings I was accompanied by a decrease in carcass specific gravity. In addition, the kidney fat in Yearlings II was heavier than in Yearlings I. These differences should be attributable to the fact that there were different breed types represented in each group of yearlings along with a few that were common to each group.

The physical and chemical characteristics of the carcasses used in this experiment are different in that they represent a thin, non-fed population of different breed types. Most research to estimate quantitative characteristics of beef carcasses has been conducted with either large animals or animals varying greatly in degree of fatness

Table 1. Group means of cooler traits and carcass composition of the steers.

| Item | Yearlings I | Yearlings II | Overall |
|---|---|---|---|
| Number of steers | 22 | 18 | 40 |
| Hot weight, Kg | 168.7 ± 16.0 | 158.66 ± 27.5 | 164.2 ± 22.2 |
| Fat thickness, cm | 0.18 ± .10 | 0.13 ± .03 | .16 ± .08 |
| Ribeye area, $cm^2$ | $53.2^d$ ± 8.7 | $66.0^e$ ± 10.5 | 59.0 ± 11.4 |
| Kidney fat, Kg | $1.3^d$ ± .4 | $1.6^e$ ± .5 | 1.4 ± .5 |
| Yield grade[a] | $1.8^d$ ± .4 | $1.1^e$ ± .5 | 1.5 ± .5 |
| Lipid percent[b] | $12.7^d$ ± 2.8 | $10.7^e$ ± 3.6 | 11.8 ± 3.3 |
| Protein percent[b] | $18.2^d$ ± 1.0 | $19.3^e$ ± 1.0 | 18.6 ± 1.1 |
| Moisture percent[b] | $66.9^d$ ± 2.3 | $68.8^e$ ± 3.3 | 67.8 ± 2.9 |
| Side SG[c] | $1.0812^d$ ± .0090 | $1.0951^e$ ± .0093 | 1.0874 ± .0114 |
| Front quarter bone percent | 26.25 | 27.60 | 26.86 |
| Hind quarter bone percent | 17.57 | 19.20 | 18.31 |

[a] USDA Yield Grade

[b] Boneless Basis

[c] Specific Gravity of the Left Side

d,e ANOVA shows significant difference

(Powell, Huffman and Patterson 1968; Kraybill et al. 1952; Gil et al., 1970; Meyer et al. 1960; Powell and Huffman 1973; Ferrel, Garrett and Hinman 1976). With the exception of Cole et al. (1960), Orme et al. (1958) and Waldman et al. (1969), most of the work using specific gravity to estimate carcass composition was conducted with carcasses of higher grades. Such carcasses are characterized by relatively high levels of ether extract or separable fat. Possibly, the method would not have the same application for the lower grades. Kelly et al. (1968) reported specific gravity was not correlated to carcass composition when ether extract of the carcass was less than 20 percent.

## Prediction of Carcass Chemical Composition by Specific Gravity and Cooler Traits

### Percent Prediction

Table 2 lists the simple correlation coefficients between cooler traits and carcass composition (percent basis). Yield grade and fat thickness were the cooler traits most highly correlated with the chemical composition in the overall group and with lipid and moisture composition of the Yearlings I. Vance et al. (1971) reported correlations ($P < .05$) of .62, -.56, and -.60 between fat thickness and carcass percent lipid, protein and moisture, respectively.

Thinner and rather different cattle in the Yearlings II group had only one factor, kidney fat, highly correlated with their carcass composition. Kidney fat was also highly correlated with lipid and moisture in the Yearlings I group and the overall group. However, it is possible that this relationship is due to the contribution of kidney fat to the overall total fat rather than to a direct relationship with the components of the carcass.

Hot carcass weight was not correlated ($P > .05$) with any chemical composition values. Ribeye area was not significantly ($P > .05$) correlated with chemical composition in the Yearlings I and II groups, but

Table 2. Simple correlation coefficients between carcass cooler traits and chemically determined carcass composition(%).[a]

| Trait | Yearlings I[b] | | | Yearlings II[b] | | | Overall[b] | | |
|---|---|---|---|---|---|---|---|---|---|
| | Lipid | Protein | Moisture | Lipid | Protein | Moisture | Lipid | Protein | Moisture |
| Hot Weight, Kg | -.29 | .10 | .32 | -.14 | .35 | .04 | -.11 | .08 | .05 |
| Fat Thickness, cm | .54** | -.30 | -.57** | .15 | -.03 | -.15 | .43** | -.33* | -.43** |
| Ribeye Area, $cm^2$ | -.25 | .06 | .29 | -.02 | .06 | .00 | -.27* | .32* | .26 |
| Kidney Fat, Kg | .61** | -.20 | -.61** | .71** | -.53** | -.65** | .48** | -.12 | -.45** |
| Yield Grade | .45** | -.15 | -.49** | .16 | -.10 | -.13 | .41** | -.38** | -.40** |

[a]Boneless Basis

[b]Yearlings I = 22 Steers; Yearlings II = 18 Steers; Overall = 40 Steers.

*P <.05

**P <.01

was correlated ($P < .05$) with lipid and protein composition in the overall group. Powell and Huffman (1973) indicated that ribeye area was of little value in estimating percent carcass composition when there is variation in carcass weight.

Most of the specific gravity measurements taken had higher correlation coefficients with the chemical components than those between the cooler traits and the chemical composition, except for flank and shank-brisket specific gravity values (Table 3). For both groups of Yearlings, specific gravity of the side, the plate, and the rib had the highest relationships with carcass chemical composition on a percentage basis (Table 3). It should be noted that for the second group of yearlings, several of the specific gravity measurements (front quarter, hind quarter, shank and brisket) taken were not significantly ($P > .05$) correlated with chemical composition or had low correlation coefficients. Kelley et al. (1968) reported when ether extract of the carcass was less than 20 percent, specific gravity was not correlated to carcass composition.

In general, the magnitude of the correlation coefficients between the various specific gravity measurements and carcass composition varied greatly between Yearlings I and Yearlings II (Table 3). This indicates that the relationship between specific gravity and chemical components may have been influenced by the breed type of the animal. Field et al. (1974), indicated that bone appeared to have the most variable specific gravity. Fursey (1975) reported differences in the densities of bone taken from animals of the same age but of different breeds. Both

Table 3. Simple correlation coefficients between specific gravity measurements and chemically determined carcass composition (%).[a]

| Trait | Yearlings I | | | Yearlings II | | | Overall | | |
|---|---|---|---|---|---|---|---|---|---|
| | Lipid | Protein | Moisture | Lipid | Protein | Moisture | Lipid | Protein | Moisture |
| Side SG[b] | -.63** | .35 | .64** | -.71** | .58** | .68** | -.69** | .61** | .68** |
| Front Quarter SG | -.58** | .54** | .52** | -.35 | .22 | .41** | -.48** | .47** | .51** |
| Hind Quarter SG | -.55** | .24 | .61** | -.20 | .27 | .21 | -.46** | .45** | .47** |
| Chuck SG | -.40* | .38* | .32 | -.63** | .58** | .56** | -.58** | .58** | .53** |
| Shank-Brisket SG | -.74** | .67** | .69** | -.18 | .21 | .15 | -.35* | .34* | .31* |
| Plate SG | -.78** | .60** | .72** | -.45* | .42* | .42* | -.63** | .57** | .58** |
| Rib SG | -.50** | .42* | .39* | -.66** | .54* | .62** | -.64** | .55** | .59** |
| Loin SG | -.37* | .17 | .39* | -.73** | .50* | .73** | -.58** | .53** | .60** |
| Round SG | -.49** | .46* | .43* | -.64** | .36 | .65** | -.61** | .54** | .58** |
| Flank SG | -.11 | .02 | .09 | -.38 | .49* | .31 | -.34* | .38* | .30 |

[a]Boneless Basis  *P < .05

[b]Specific Gravity  **P < .01

Garrett and Hinman (1969) and Gil et al. (1970) have indicated that specific gravity is less accurate in estimating the composition of thin cattle (e.g., less than 12 percent fat). One reason for this may be the increasing proportion of bone to soft tissue in thinner cattle as shown by Callow (1948). This was evident in the current study by the fact that the Yearlings II group possessed higher percent bone than did the Yearlings I (Table 1). The fact that significant correlations between chemical composition and density were reported by some workers (Orme et al. 1958; Cole et al. 1960) and not by others (Bieber et al. 1961; Kelly et al. 1968; Waldman et al. 1969) would justify investigation into this area.

Regression equations to predict carcass chemical composition (on a percentage basis) with specific gravity measurements and cooler traits as independent variables are listed in Tables 4, 5 and 6. These equations accounted for only a small percent of the total variation of the dependent variable. Because only a few of the cooler traits met the statistical criteria, most were not included in the equations. Hot carcass weight was not expected to be a part of the equations because it was not significantly correlated ($P < .05$) with any of the chemical components (Table 2). However, the remaining cooler traits were in fact highly correlated ($P < .01$) with the chemical components (Table 2) and still did not meet the statistical criteria or added little to the predictive accuracy when included in the regression equations. In the protein predicting equations, almost none of the cooler traits were part of the equations (Table 5). Mata-Hernandez (1979) explained this

Table 4. Regression equation[a] for predicting total carcass lipid (%)[b] using specific gravity measurements and cooler traits.

| Cut | Intercept | B values of the independent variables[c] | | | | | | R | SE[d] |
|---|---|---|---|---|---|---|---|---|---|
| | | SG | HCW | REA | BF | KF | YG | | |
| Side | 211.56** | -187.50** | - | - | - | 2.91** | - | .80 | 17.6 |
| Front Quarter | 88.06** | -70.88** | -.03* | - | 15.45** | 3.52** | - | .77 | 19.0 |
| Hind Quarter | 68.16* | -58.99* | - | - | 12.44* | 3.80** | - | .72 | 20.6 |
| Chuck | 132.26** | -116.36** | - | - | 16.12** | 2.99** | - | .76 | 19.0 |
| Shank-Brisket | 104.37** | -90.61* | - | - | - | 3.08** | 2.51** | .70 | 21.1 |
| Plate | 140.64** | -122.23* | - | -.06* | 14.10** | 3.59** | - | .86 | 15.1 |
| Rib | 117.01** | -98.24** | - | -.71* | 12.29** | 3.14** | - | .82 | 17.2 |
| Loin | 172.07** | -155.02** | - | - | 12.95** | 4.04** | - | .84 | 15.8 |
| Round | 221.32** | -196.64** | - | - | 15.28** | 3.26** | - | .80 | 17.6 |
| Flank | 47.00** | -43.21** | - | - | 15.83** | 4.31** | - | .75 | 19.5 |

[a]Includes all 40 steers. *P < .05

[b]Boneless basis **P < .01

[c]SG = specific gravity of the cut; HCW = hot carcass weigh (Kg); REA = ribeye area ($cm^2$) BF = backfat (cm); KF = kidney fat weight (Kg); YG = USDA yield grade.

[d]Standard error of estimates.

Table 5. Regression equation[a] for predicting total carcass protein (%)[b] using specific gravity measurements and cooler traits.

| Cut | Intercept | B values of the independent variables[c] | | | | | | R | SE[d] |
|---|---|---|---|---|---|---|---|---|---|
| | | SG | HCW | REA | BF | KF | YG | | |
| Side | -47.60** | 60.94** | - | - | - | - | - | .61 | 4.9 |
| Front Quarter | -13.87** | 29.65** | - | - | - | - | - | .46 | 5.4 |
| Hind Quarter | -15.13 | 31.27** | - | - | - | - | - | .45 | 5.5 |
| Chuck | -47.38** | 60.38** | - | - | - | - | - | .58 | 5.0 |
| Shank-Brisket | -18.97 | 34.98** | - | - | - | - | -.83** | .53 | 5.3 |
| Plate | -28.42* | 44.22** | - | - | - | - | -.60* | .64 | 4.8 |
| Rib | -28.83* | 41.84** | - | .03 | - | - | - | .62 | 4.9 |
| Loin | -37.93* | 52.20** | - | - | - | - | - | .53 | 5.2 |
| Round | -70.10** | 80.59** | - | - | - | - | - | .54 | 5.2 |
| Flank | -2.08 | 16.34* | - | - | - | - | - | .38 | 5.7 |

[a]Includes all 40 steers. *P < .05

[b]Boneless basis. **P < .01

[c]SG = specific gravity of the cut; HCW = hot carcass weight (Kg); REA = ribeye area ($cm^2$); BF = backfat thickness (cm); KF = kidney fat weight (Kg); YG = USDA yield grade.

[d]Standard error of estimates.

Table 6. Regression equation[a] for predicting total carcass moisture (%)[b] using specific gravity measurements and cooler traits.

| Cut | Intercept | B values of the independent variables[c] | | | | | | R | SE[d] |
|---|---|---|---|---|---|---|---|---|---|
| | | SG | HCW | REA | BF | KF | YG | | |
| Side | -105.97** | 162.89** | - | - | - | -2.38** | - | .77 | 2.8 |
| Front Quarter | -8.62 | 72.74** | - | - | - | -2.42** | - | .63 | 3.5 |
| Hind Quarter | -22.53 | 87.53** | - | - | - | -3.02** | - | .67 | 3.3 |
| Chuck | -64.31 | 122.47** | - | - | -11.98* | - | - | .62 | 3.5 |
| Shank-Brisket | -1.46 | 68.47* | - | - | - | -2.57** | -2.15* | .66 | 3.4 |
| Plate | -36.77 | 102.17** | - | - | -14.44** | -2.80** | - | .80 | 3.2 |
| Rib | -24.73 | 89.40** | - | - | - | -2.03* | -1.61* | .73 | 3.1 |
| Loin | -75.96** | 138.62** | - | - | -11.09** | -3.37** | - | .83 | 2.5 |
| Round | -108.04* | 165.06** | - | - | -13.44** | -2.71** | - | .77 | 2.9 |
| Flank | 41.86** | 32.74* | - | - | -14.25** | -3.55** | - | .71 | 3.2 |

[a]Includes all 40 steers. *P < .05

[b]Boneless basis. **P < .01

[c]SG = specific gravity of the cut; HCW = hot carcass weight (Kg); REA = ribeye area ($cm^2$); BF = backfat thickness (cm); KF = kidney fat weight (Kg); YG = USDA yield grade.

[d]Standard error of estimates.

discrepancy in terms of the correlations found between specific gravity measurements and cooler traits. Many of the specific gravity measurements were highly correlated ($P < .01$) with ribeye area, backfat, thickness, kidney fat, and yield grade. Similar relationships between specific gravity and cooler traits have been reported by Powell and Huffman (1973). Similar results were found in this study. This indicates that specific gravity and cooler traits explain the same portion of the variation in carcass chemical composition when the composition is expressed on a percent basis.

The predictive characteristics of the various specific gravity measurements for carcass chemical composition are listed in Table 7. The total number of independent variables is not listed because it varied depending upon which chemical component of the carcass was being predicted. The R values for those equations in which none of the cooler traits meeting the previously prescribed statistical criteria are not listed. Specific gravity of certain of the wholesale cuts gave very similar predictive characteristics as the specific gravity of the entire side. Kelly et al. (1968) reported significant ($P < .05$) but low correlations between specific gravity of wholesale cuts and the chemical composition of those cuts in the low fatness thinly finished cattle (10 to 20%). With the exception of the studies by Kraybill et al. (1952) and Mata Hernandez (1979) few reports have examined the relationship between specific gravity of wholesale cuts and the chemical composition of the entire carcass. The present study showed that the multiple R values (.70 to .85) were lower than those values (.85 to .90) reported by Kraybill et al. (1952) and Mata-Hernandez

Table 7. Multiple R values[a] of regression equations using specific gravity and cooler traits as predictors of carcass chemical composition (%).

| Independent Variables[b] | Yearlings I | | | Yearlings II | | | Overall | | |
|---|---|---|---|---|---|---|---|---|---|
| | Lipid | Protein | Moisture | Lipid | Protein | Moisture | Lipid | Protein | Moisture |
| Side SG | .76 | - | .77 | .79 | - | - | .80 | - | .77 |
| Front Quarter SG | .72 | - | .78 | - | - | - | .77 | - | .63 |
| Hind Quarter SG | .80 | - | .84 | - | - | - | .72 | - | .67 |
| Chuck SG | - | - | - | .63 | - | - | .76 | - | .62 |
| Shank-Brisket SG | .92 | .76 | .81 | - | - | - | .70 | .53 | .66 |
| Plate SG | .90 | .60 | .80 | .90 | .84 | .75 | .86 | .64 | .80 |
| Rib SG | .66 | - | - | .88 | - | .76 | .82 | .62 | .73 |
| Loin SG | - | - | - | .87 | - | .84 | .84 | - | .83 |
| Round SG | .70 | - | .67 | .64 | - | .75 | .80 | - | .77 |
| Flank SG | - | - | - | .81 | .73 | - | .75 | - | .71 |

[a]R values are not listed whenever regression coeffiecient not significant (P > .05)

[b]Total number of independent variables not listed

(1979). It should be pointed out that these workers derived prediction equations using data from fed cattle and on the basis of weight instead of percentage. However, the information presented here suggests that specific gravity of the entire side may not be needed in order to use the predictive value of specific gravity measurements, and the predictive value of the specific gravity is less in the young cattle compared to that in mature or fed cattle.

The various specific gravity measurements presented different predictive characteristics depending on the group of cattle in which the regression analysis was conducted (Table 7). Specific gravity of the side and plate gave higher multiple R values than the specific gravity of other wholesale cuts in predicting the chemical components for all groups of yearlings. The specific gravity measurements of the plate and rib gave the same predictive characteristics when both groups of yearlings were pooled in the regression analysis. Possibly, the specific gravity method of estimating composition has effectiveness only when a cut has a certain fat level. Table 8 gives a summary of the regression equations for estimating percentage of the chemical components using cooler traits as independent variables and the specific gravity of the plate. There was not any constancy in each group of equations.

To further evaluate the predictive accuracy of the regression equations (Table 8), the equation were used to predict the chemical composition of the various cattle groups (Table 9) and examined by the paired T-test (Nie et al. 1975). The prediction equations derived from Yearlings I and Yearlings II showed that they are not able to

Table 8. Regression equations possessing the best predictive characteristics for estimating carcass chemical composition (%).

| Carcass Component | Source of Equation[b] | Intercept | B values for the independent variables[a] | | | | | | R | SE[c] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | HCW | BF | REA | KF | YG | Plate SG | | |
| Lipid, % | Yearlings I | 119.63** | - | 12.68** | - | 3.13** | - | -104.73** | .90 | 10.3 |
| | Yearlings II | 111.04** | -.05** | - | - | 6.26** | - | -93.71** | .90 | 16.6 |
| | Overall | 140.64** | - | 14.10** | -.06* | 3.59** | - | -122.23** | .86 | 15.1 |
| Protein, % | Yearlings I | -43.61* | - | - | - | - | - | 57.17** | .60 | 4.6 |
| | Yearlings II | -7.31 | .02** | - | - | -1.44** | - | 23.61** | .84 | 3.0 |
| | Overall | -28.42* | - | - | - | - | -.60* | 44.22** | .64 | 4.8 |
| Moisture, % | Yearlings I | -72.56* | - | -8.44* | - | - | - | 130.47** | .80 | 2.2 |
| | Yearlings II | -14.37 | - | - | - | -4.47** | - | 82.89* | .75 | 3.4 |
| | Overall | -36.77 | - | -14.44** | - | -2.80** | - | 102.77** | .80 | 3.2 |

[a]HCW = hot carcass weight (Kg); REA = ribeye area (cm); KG = kidney fat weight (Kg): BF = back fat thickness (cm); YG = USDA yield grade

[b]Yearlings I = 22 steers; Yearlings II = 18 steers; Overall = 40 steers.

[c]Standard error of the estimates.

*P < .05

**P < .01

Table 9. Correlation coefficients and T-test values between actual and predicted[a] chemical composition[b].

| Carcass Component | Source of Equation | Predicted Group[c] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Yearlings I | | | | Yearlings II | | | | Overall | | | |
| | | Actual | Predicted | R | T[d] | Actual | Predicted | R | T | Actual | Predicted | R | T |
| Lipid | Yearlings I | 12.75 | 12.75 | .91 | .99 | 10.69 | 12.26 | .83 | .01 | 11.82 | 12.52 | .83 | .02 |
| | Yearlings II | 12.75 | 9.40 | .78 | .00 | 10.69 | 11.06 | .90 | .35 | 11.82 | 10.15 | .68 | .00 |
| | Overall | 12.75 | 12.50 | .90 | .40 | 10.69 | 11.17 | .85 | .32 | 11.82 | 11.90 | .86 | .77 |
| Protein | Yearlings I | 18.17 | 18.17 | .60 | .97 | 19.27 | 18.67 | .42 | .02 | 18.66 | 18.39 | .57 | .08 |
| | Yearlings II | 18.17 | 19.12 | .37 | .00 | 19.27 | 19.28 | .84 | .98 | 18.66 | 19.52 | .35 | .00 |
| | Overall | 18.17 | 18.32 | .52 | .43 | 19.27 | 19.10 | .51 | .40 | 18.66 | 18.67 | .64 | .98 |
| Moisture | Yearlings I | 66.93 | 66.93 | .80 | .99 | 68.75 | 68.44 | .69 | .65 | 67.75 | 67.61 | .66 | .69 |
| | Yearlings II | 66.93 | 69.45 | .73 | .00 | 68.75 | 68.76 | .75 | .99 | 67.75 | 69.14 | .65 | .00 |
| | Overall | 66.93 | 68.10 | .90 | .00 | 68.75 | 68.76 | .77 | .99 | 67.75 | 68.39 | .80 | .03 |

[a]Equations are listed in Table 8.

[b]Percentage on a boneless basis.

[c]Yearlings I -- 22 steers; Yearlings II -- 18 steers; Overall -- 40 steers.

[d]Two tail T-test probability.

accurately predict the carcass composition of cattle in the various groups. Only the moisture prediction equations derived from Yearlings I accurately predicts moisture composition in every group. The equations derived from the overall group were useful in predicting lipid and protein components of cattle in various groups, but the moisture equation could not accurately estimate moisture percentage of cattle in Yearlings I and overall group.

## Total Weight Prediction

The relationships between various physical and chemical carcass variables on a weight basis are listed in Table 10. Hot carcass weight had the highest correlation coefficients with the lipid and protein components for all groups of cattle. Kidney fat was only correlated ($P < .01$) with the lipid component in Yearlings I and the overall group. Ribeye area tended to be more correlated with protein and moisture than with lipid in Yearlings I and the overall group. Yield grade and fat thickness were positively correlated ($P < .05$) with total carcass lipid in overall group, while in the Yearlings I they were negatively correlated ($P < .01$) with protein and moisture.

Table 11 listed the simple correlation coefficients between specific gravity measurements and chemically determined carcass composition (Kg). Only specific gravity of the side and the hind quarter were significantly correlated ($P < .05$) with all three of the chemical components. Specific gravity measurements were generally significantly correlated with total carcass lipid but not with protein and moisture for all groups of cattle.

Table 10. Simple correlation coefficients between carcass cooler traits and chemically determined carcass composition (Kg).[a]

| Trait | Yearlings I[b] | | | Yearlings II[b] | | | Overall[b] | | |
|---|---|---|---|---|---|---|---|---|---|
| | Lipid | Protein | Moisture | Lipid | Protein | Moisture | Lipid | Protein | Moisture |
| Hot weight, Kg | .15 | .90** | .93** | .36 | .98** | .98** | .34 | .95** | .96** |
| Fat thickness, cm | .33 | -.45* | -.47* | .22 | .09 | .07 | .34* | -.20 | -.20 |
| Ribeye area, $cm^2$ | .03 | .61** | .65** | .19 | .45 | .46 | -.15 | .38** | .33* |
| Kidney fat, Kg | .72** | -.04 | -.10 | .83** | .21 | .21 | .52** | .08 | -.00 |
| Yield Grade | .24 | -.52** | -.58** | .13 | -.11 | -.13 | .38** | -.17 | -.13 |

[a]Boneless basis

[b]Yearlings I = 22 steers; Yearlings II = 18 steers; Overall = 40 steers

*P < .05

** P < .01

Table 11. Simple correlation coefficients between specific gravity measurements and chemically determined carcass composition (Kg).[a]

| Trait | Yearlings I | | | Yearlings II | | | Overall | | |
|---|---|---|---|---|---|---|---|---|---|
| | Lipid | Protein | Moisture | Lipid | Protein | Moisture | Lipid | Protein | Moisture |
| Side SG[b] | -.52** | .40* | .40 | -.64** | .12 | .15 | -.67** | .14 | .08 |
| Front Quarter SG | -.74** | .04 | -.06 | -.38 | -.14 | -.12 | -.57** | .13 | -.18 |
| Hind Quarter SG | -.32 | .50** | .54** | -.06 | .21 | .21 | -.37** | .22 | .18 |
| Chuck SG | -.48* | .08 | .00 | -.55** | .21 | .21 | -.60** | .11 | .02 |
| Shank-Brisket SG | -.77** | .27 | .16 | -.21 | .03 | .06 | -.37** | .05 | .00 |
| Plate SG | -.74** | .42* | .33 | -.40* | .08 | .08 | -.60** | .16 | .10 |
| Rib SG | -.52** | .19 | .11 | -.62** | .02 | .04 | -.63** | .05 | .00 |
| Loin SG | -.23 | .35 | .37* | -.54* | .38 | .47* | -.53** | .20 | .19 |
| Round SG | -.40** | .41** | .31 | -.70** | -.10 | -.03 | -.61** | .09 | .03 |
| Flank SG | .07 | .31 | .30 | -.07 | .67** | .68** | -.17 | .38 | .32 |

[a]Boneless basis.

[b]Specific gravity

*P < .05

**P < .01

Most of the correlation coefficients between specific gravity measurements and carcass composition calculated in the present study were lower than those reported by various workers for fed animals which varied greatly in composition (Powell and Huffman 1968, 1973; Ferrel et al. 1976). Kelly et al. (1968) found that specific gravity was a poor estimator of carcass composition of steers when carcass ether extract was less than 20 percent. Jones, Price and Berg (1978) pointed out that the size of a correlation coefficient is most influenced by the variation of the trait being predicted. It should be noted that the predicting total carcass composition in this study was on just composition of left side.

The prediction equations reported in this portion of the study include specific gravity measurements and carcass cooler traits as independent variables. The addition of the cooler variables in the regression model only slightly increased the predictive characteristics of the equations. The standard error of estimates was high (15.2 - 22.2%).

Regression equations for predicting total carcass lipid (Kg) from specific gravity measurements and cooler traits are listed in Table 12. Specific gravity of the wholesale cuts and quarters presented the same predictive characteristics as the specific gravity of the entire side. The regression coefficients for the cooler traits were very similar for all of the equations. In general the regression coefficient for the specific gravity measurement varied in magnitude for the various equations. This was expected because the magnitude of the correlation

Table 12. Regression equations[a] for predicting total carcass lipid (Kg)[b] using specific gravity measurements and cooler traits.[c]

| Cut | Intercept | B values of the independent variables | | | | | R | SE[d] |
|---|---|---|---|---|---|---|---|---|
| | | SG | HCW | BF | KF | YG | | |
| Side | 130.51** | -120.08** | .03** | - | 1.99** | - | .84 | 17.2 |
| Front Quarter | 48.18** | -44.81** | .02* | 9.16** | 2.27** | - | .79 | 19.8 |
| Hind Quarter | 60.04** | -56.86** | .03* | - | 2.43** | - | .72 | 22.2 |
| Chuck | 89.55** | -83.62** | .03* | 8.95** | 1.94** | - | .81 | 18.8 |
| Shank-Brisket | 71.11** | -62.45** | - | - | 2.25** | 1.59** | .72 | 22.2 |
| Plate | 81.44** | -78.52** | .03** | 7.14** | 2.16** | .87* | .89 | 15.2 |
| Rib | 83.14** | -73.27** | - | - | 1.83** | 1.17* | .78 | 20.2 |
| Loin | 107.31** | -102.06** | .03** | 7.19** | 2.66** | - | .87 | 15.8 |
| Round | 149.18** | -137.39** | .03** | 8.44** | 2.15** | - | .85 | 17.1 |
| Flank | 21.74* | -26.04** | .04** | 9.42** | 2.78** | - | .77 | 20.6 |

[a]Includes all 40 steers.

[b]Boneless basis.

[c]SG = specific gravity of the cut; HCW = hot carcass weight (Kg); BF = back fat thickness (cm); KF = kidney fat weight (Kg); YG = USDA yield grade

[d]Standard error of estimate

*P < .05

**P < .01

coefficient between the specific gravity measurements and the chemical composition also varied (Table 11). Mata-Hernandez (1979) pointed out that the accuracy of estimation for carcass lipid, protein and moisture was higher on a kilogram basis than on a percent basis. This was not observed in this study. Because the standard error of the estimate (SE) is expressed as percent of the mean, those equations having higher SE values possess less accurate predictive characteristics regardless if presented on a kilogram or percentage basis (Tables 4 and 12). How-ever, the cattle in that study were feedlot fed and had much higher fat content (25.5 ± 3.9%) than in this study. The predicting ability of specific gravity was very similar for lipid composition both on a kilogram basis and percentage basis.

Part to Whole Prediction

Table 13 gave the simple correlation coefficients between the chemical components of the beef carcass and the chemical components of the wholesale cuts. For all groups of cattle the correlation coefficients between the carcass chemical compositions and those of the wholesale cut were very similar and ranged from .46 to .93. It should be noted that little variation was encountered in the correlation coefficients between the chemical composition of the individual cuts and that of the entire carcass. This suggests that all of the wholesale cuts possess similar predictive characteristics.

Hopper (1944) found that the composition of the whole and edible portions of the wholesale and 9-10-11 rib cut was indicative of carcass fatness. This work was extended by Hankins and Howe (1946) who

Table 13. Simple correlation coefficients between the chemical composition[a] of the beef carcass and its cuts for the various groups[b] of cattle.

| Item | Yearlings I | | | Yearlings II | | | Overall | | |
|---|---|---|---|---|---|---|---|---|---|
| | Lipid | Protein | Moisture | Lipid | Protein | Moisture | Lipid | Protein | Moisture |
| Chuck | .83** | .77** | .76** | .92** | .85** | .91** | .87** | .81** | .83** |
| Shank-Brisket | .80** | .50* | .73** | .31 | .81** | .30 | .59** | .72** | .52** |
| Plate | .84** | .60** | .66** | .92** | .63** | .89** | .90** | .69** | .82** |
| Rib | .86** | .46* | .79** | .83** | .48* | .77** | .86** | .58** | .78** |
| Loin | .74** | .67** | .66** | .91** | .73** | .89** | .84** | .77** | .82** |
| Round | .77** | .70** | .63** | .91** | .53* | .93** | .86** | .68** | .83** |
| Flank | .84** | .57** | .75** | .89** | .81** | .86** | .87** | .72** | .82** |

[a]Percentage on a boneless basis.

[b]Yearlings I -- 22 steers; Yearlings II -- 18 steers; Overall -- 40 steers.

* $P < .05$

** $P < .01$

determined that the chemical composition and separable physical components of 9-10-11 rib cut of steers was highly associated with the composition of the entire carcass. The correlation coefficients listed in Table 13 suggest that there is not a single cut whose chemical composition is more related to carcass composition than any of the other wholesale cuts. This was true regardless of the group being analyzed. Marchello et al. (1979) found the same result in developing accurate predictors of carcass chemical composition of cull range cow carcasses.

The regression equations for predicting carcass composition from the chemical components based on percentage in the wholesale cuts are listed in Table 14. Multiple correlation coefficients were similar for equations obtained from the plate and rib regardless of the carcass component being predicted. In general, equations using the shank-brisket as independent variables had the lowest coefficients of determination. Standard errors of estimate for prediction of lipid were higher (12 - 21%) than for prediction of protein (4%) or moisture (2.1 - 3.3%).

Prediction of carcass composition on a percentage basis possessed very similar coefficients of determination to those on a weight basis (Tables 14 and 15). Equations predicting percentage had smaller standard errors than predicting weight, especially for protein and moisture. Kempster and Jones (1977) reported little difference in precision between the use of weights and percentages for prediction equations not including the shin as independent variable. Marchello et al. (1979) pointed out smaller standard errors associated with equations predicting percentages.

Table 14. Regression equations[a] for predicting carcass composition (%)[b] from the chemical composition (%)[b] of the wholesale cuts.

| Carcass Component | Cut | Intercept | B values[c] for the independent variables | | | R | SE |
|---|---|---|---|---|---|---|---|
| | | | Lipid | Protein | Moisture | | |
| Lipid | Chuck | 16.77** | .78** | -.62** | - | .91 | 12.2 |
| | Shank & Brisket | 27.00** | .40** | -1.05 | - | .68 | 21.2 |
| | Plate | 4.71** | .58** | - | - | .90 | 12.5 |
| | Rib | 5.17** | .66** | - | - | .85 | 14.9 |
| | Loin | 2.29* | .96** | - | - | .84 | 15.6 |
| | Round | 3.24** | 1.12** | - | - | .85 | 14.9 |
| | Flank | 5.27** | .42** | - | - | .87 | 14.0 |
| Protein | Chuck | 9.49** | -.10** | .53** | - | .85 | 3.2 |
| | Shank & Brisket | 5.46** | - | .70** | - | .72 | 4.2 |
| | Plate | 20.59** | -.16** | - | - | .72 | 4.3 |
| | Rib | 16.87** | -.16** | .18** | - | .75 | 4.2 |
| | Loin | 11.96** | -.16** | .43** | - | .82 | 3.5 |
| | Round | 15.22** | -.25** | .27** | - | .85 | 3.3 |
| | Flank | 9.79** | - | .25** | .07* | .75 | 4.1 |

Table 14,--continued.

| Carcass Component | Cut | Intercept | B values[c] for the independent variables | | | | |
|---|---|---|---|---|---|---|---|
| | | | Lipid | Protein | Moisture | R | SE[d] |
| Moisture | Chuck | 67.63** | -.71** | .34* | - | .88 | 2.1 |
| | Shank & Brisket | 58.02** | -.37** | .74* | - | .66 | 3.3 |
| | Plate | 73.59** | -.47** | - | - | .84 | 2.4 |
| | Rib | 73.50** | -.57** | - | - | .84 | 2.4 |
| | Loin | 4.40 | - | - | .92** | .82 | 2.5 |
| | Round | 85.23** | -1.11** | -.46** | - | .88 | 2.2 |
| | Flank | 73.19** | -.35** | - | - | .82 | 2.5 |

[a]All 40 steers were included

[b]Boneless percentage

[c]Regression coefficients not listed if not significant at the .05 level.

[d]Standard error of estimates.

*$P < .05$

**$P < .01$

Table 15. Regression equations[a] for predicting carcass composition (Kg)[b] from the chemical composition (Kg)[b] of the wholesale cuts.

| Carcass Component | Cut | Intercept | B values[c] for the independent variables | | | R | SE[d] |
|---|---|---|---|---|---|---|---|
| | | | Lipid | Protein | Moisture | | |
| Lipid | Chuck | 5.74** | 3.22** | - | - | .84 | 16.9 |
| | Shank & Brisket | 13.05** | 7.80** | -3.16* | - | .71 | 22.3 |
| | Plate | 8.24** | 6.54** | - | - | .83 | 17.5 |
| | Rib | 6.94** | 9.81** | - | - | .82 | 17.7 |
| | Loin | 2.68* | 7.05** | - | - | .86 | 15.9 |
| | Round | 4.04** | 4.14** | - | - | .84 | 16.7 |
| | Flank | 8.24** | 4.96** | - | - | .98 | 13.8 |
| Protein | Chuck | 6.67** | - | 1.50** | .33** | .88 | 7.8 |
| | Shank & Brisket | 11.41** | - | 6.98** | - | .70 | 11.6 |
| | Plate | 9.60** | - | - | 2.48** | .76 | 10.5 |
| | Rib | 8.31** | - | - | 2.67** | .74 | 10.9 |
| | Loin | 3.17 | - | 2.76* | .90* | .91 | 6.8 |
| | Round | 2.61 | - | 1.55** | .41** | .94 | 5.8 |
| | Flank | 11.40** | -1.07* | 8.90** | - | .78 | 10.2 |

Table 15, -- continued.

| Carcass Component | Cut | Intercept | B values[c] for the independent variables Lipid | Protein | Moisture | R | SE[d] |
|---|---|---|---|---|---|---|---|
| Moisture | Chuck | 22.80** | - | - | 2.72** | .92 | 6.2 |
| | Shank & Brisket | 35.89** | 6.99* | 23.94** | - | .77 | 10.2 |
| | Plate | 40.28** | - | - | 8.15** | .71 | 11.0 |
| | Rib | 28.61** | - | - | 9.95** | .78 | 9.8 |
| | Loin | 12.57 | - | - | 6.02** | .89 | 7.1 |
| | Round | 10.76* | - | - | 2.99** | .94 | 5.4 |
| | Flank | 41.81** | - | 28.57** | - | .75 | 10.3 |

[a]All 40 steers were included.

[b]Boneless basis.

[c]Regression coefficients not listed if not significant at the .05 level.

[d]Standard error of the estimates.

*P < .05

**P < .01

The prediction equations listed in Table 15 suggest that all of the wholesale cuts possess similar predictive characteristics. In addition, equations having the same number and types of independent variables were very similar in intercept values, regression coefficients, R values and standard errors of estimates.

Table 16 lists the regression equations for predicting composition (%) from the chemical composition(%) of the wholesale cuts and the cooler traits of carcasses. Cooler traits contributed greatly in predicting lipid and moisture, especially backfat thickness and kidney fat weight. Only a few cooler traits met statistical criteria in the protein predicting equations.

Regression equations for predicting composition (Kg) from the chemical composition (Kg) of the wholesale cuts and the cooler traits of carcasses are shown on Table 17. The equations possessed higher coefficients than those with chemical composition alone (Table 15) and improved accuracy in predicting ability. The hot carcass weight was the major factor in improving protein and moisture predicting equations. Table 10 showed a high correlation relationship (.90 to .98) between hot carcass weight and the protein as well as moisture on a weight basis.

The prediction equations for each dependent variable include the composition (Kg) of the plate or the rib or the loin together with cooler traits were selected to further evaluate the predictive accuracy of these regression equations (Table 17). The paired T-test (Nie et al. 1975) is used as a measure of predictive accuracy for individual animals. The results of using these equations are shown in Table 18. The actual value

Table 16. Regression equations for predicting composition (%)[a] from the chemical composition (%)[b] of the wholesale cuts along with the cooler traits of carcasses.

| Carcass Components | Cut | Intercept | B values[c] for the independent variables | | | | | | | | R | SE[d] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Lipid | Protein | Moisture | HCW | REA | BF | KF | YG | | |
| Lipid | Chuck | -16.48** | .71** | -.58** | - | -.02* | - | - | 2.02** | - | .95 | 9.5 |
| | Shank & Brisket | 24.61** | .28** | -.94** | - | -.03* | - | 11.76** | 3.26** | - | .85 | 15.9 |
| | Plate | 6.69** | .51** | - | - | - | -.06** | - | 1.81** | - | .94 | 10.0 |
| | Rib | -26.62* | .83** | - | .36* | - | - | 10.34** | 2.22** | - | .93 | 11.3 |
| | Loin | 1.57 | .89** | - | - | -.02* | - | 15.19** | 2.50** | -1.07** | .96 | 8.9 |
| | Round | .61 | 1.04** | - | - | - | - | - | 2.31** | - | .91 | 12.1 |
| | Flank | 3.91** | .40** | - | - | - | - | - | - | 1.19* | .89 | 13.1 |
| Protein | Chuck | 9.48** | -.10** | .53** | - | - | - | - | - | - | .85 | 3.2 |
| | Shank & Brisket | 6.53** | - | .68** | - | - | - | -3.56* | - | - | .76 | 4.0 |
| | Plate | 19.15** | -.15** | - | - | - | .23* | - | - | - | .75 | 4.1 |
| | Rib | 16.87** | -.16** | .18** | - | - | - | - | - | - | .75 | 4.2 |
| | Loin | 11.96** | -.16** | .43** | - | - | - | - | - | - | .82 | 3.5 |
| | Round | 15.22** | -.25** | .27** | - | - | - | - | - | - | .85 | 3.3 |
| | Flank | 9.79** | - | .25** | .07* | - | - | - | - | - | .75 | 4.1 |

Table 16, continued

| Carcass Components | Cut | Intercept | B values[c] for the independent variables | | | | | | | | R | SE[d] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Lipid | Protein | Moisture | HCW | REA | BF | KF | YG | | |
| Moisture | Chuck | 76.34** | -.71** | - | - | - | - | - | -1.63** | - | .90 | 2.0 |
| | Shank & Brisket | 62.67** | -.24** | .70* | - | - | - | -11.12* | -2.60** | - | .80 | 2.8 |
| | Plate | 76.14** | -.40** | - | - | - | - | - | -1.29* | -1.07* | .88 | 2.1 |
| | Rib | 76.25** | -.46** | - | - | - | - | -8.96** | -1.68** | - | .90 | 2.0 |
| | Loin | 44.60** | -.41** | - | .44* | - | - | -12.80** | -1.77** | .91* | .92 | 1.8 |
| | Round | 40.97** | -.45** | - | .47* | - | - | - | -1.94** | - | .91 | 1.8 |
| | Flank | 74.41** | -.33** | - | - | - | - | - | - | -1.07* | .85 | 2.4 |

[a]All 40 steers were included

[b]Boneless percentage.

[c]Regression coefficients not listed if not significant at the 0.05 level.

[d]Standard error of estimates.

*P < .05

**P < .01

Table 17. Regression equations for predicting composition (Kg)[a] from the chemical composition (Kg)[b] of the wholesale cuts along with the cooler traits of carcasses.

| Carcass Component | Cut | Intercept | B values[c] for independent variables | | | | | | | | R | SE[d] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Lipid | Protein | Moisture | HCW | REA | BF | KF | YG | | |
| Lipid | Chuck | -.35 | 1.38** | -.93** | .28** | - | - | - | 1.65** | - | .95 | 10.3 |
| | Shank & Brisket | .07 | 2.47** | - | - | - | - | 7.31** | 2.17** | - | .81 | 18.8 |
| | Plate | -16.83** | 2.21** | - | -.37* | - | .26** | - | - | 5.99** | .93 | 12.3 |
| | Rib | -2.98* | 3.49** | - | - | .02** | - | - | 1.28** | .92** | .91 | 13.3 |
| | Loin | -3.02** | 2.86** | - | - | - | .02* | 7.65** | 1.56** | - | .95 | 10.3 |
| | Round | -.14 | 1.71** | - | - | - | - | - | 1.72** | - | .91 | 13.0 |
| | Flank | -.66 | 1.83** | - | - | .02* | - | - | .96** | .77** | .94 | 11.1 |
| Protein | Chuck | -1.22* | -.27** | .66** | -.15** | .08** | - | - | - | - | .98 | 3.1 |
| | Shank & Brisket | -.52 | - | 2.05** | -.42** | .07** | - | - | - | -.34* | .96 | 4.5 |
| | Plate | -1.16 | -.51** | - | .31** | .07** | - | - | - | - | .97 | 4.2 |
| | Rib | -.95 | -.80** | - | - | .08** | - | - | - | - | .96 | 4.5 |
| | Loin | -.63 | -.43** | .62** | - | .07** | - | -1.87* | - | - | .97 | 3.8 |
| | Round | -.89 | -.22** | .39** | - | .06** | - | - | - | - | .97 | 4.0 |
| | Flank | -1.35* | -.43** | - | - | .08** | - | - | - | - | .97 | 4.2 |

Table 17, continued.

| Carcass Component | Cut | Intercept | B values[c] for independent variables | | | | | | | | R | SE[d] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Lipid | Protein | Moisture | HCW | REA | BF | KF | YG | | |
| Moisture | Chuck | -1.48 | -.77** | - | .40** | .22** | - | - | - | - | .98 | 2.9 |
| | Shank & Brisket | -1.34 | - | - | .69** | .25** | - | -7.22* | -1.79** | - | .98 | 3.1 |
| | Plate | -3.75 | -1.36** | - | - | .29** | - | - | - | - | .97 | 4.1 |
| | Rib | -3.15 | -2.08** | - | .75* | .26** | - | - | - | - | .97 | 3.8 |
| | Loin | -.59 | -.98* | - | - | .29** | - | -8.55** | -1.58** | - | .98 | 3.5 |
| | Round | -.33 | - | - | .47** | .20** | - | -6.64* | -1.35** | - | .98 | 2.9 |
| | Flank | -3.02 | -.88** | - | - | .29** | - | - | -1.07* | - | .97 | 3.8 |

[a]All 40 steers were included.

[b]Boneless basis.

[c]Regression coefficients not listed if not significant at the 0.05 level.

[d]Standard error of estimates.

*P < .05

**P < .01

Table 18. Correlation coefficients[a] and T-test values between actual and predicted chemical composition.[b]

| Carcass Component | Source of Chemical Composition in the Equation | Predicted Group[c] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Yearlings I | | | | Yearlings II | | | | Overall | | | |
| | | Actual | Predicted | R | T | Actual | Predicted | R | T | Actual | Predicted | R | T |
| Lipid | Plate | 8.14 | 8.14 | .90 | .98 | 6.28 | 6.76 | .94 | .02 | 7.30 | 7.52 | .93 | .13 |
| | Rib | 8.14 | 7.28 | .90 | .00 | 6.28 | 5.92 | .90 | .15 | 7.30 | 6.72 | .91 | .00 |
| | Loin | 8.14 | 7.75 | .94 | .01 | 6.28 | 6.17 | .94 | .56 | 7.30 | 7.04 | .95 | .03 |
| Protein | Plate | 11.68 | 11.86 | .92 | .13 | 11.39 | 11.50 | .99 | .20 | 11.50 | 11.70 | .97 | .05 |
| | Rib | 11.68 | 11.69 | .94 | .89 | 11.39 | 11.13 | .98 | .04 | 11.55 | 11.44 | .96 | .19 |
| | Loin | 11.68 | 12.20 | .95 | .00 | 11.39 | 11.92 | .99 | .00 | 11.55 | 12.08 | .98 | .00 |
| Moisture | Plate | 43.08 | 43.42 | .93 | .43 | 40.51 | 40.79 | .99 | .34 | 41.92 | 42.24 | .97 | .24 |
| | Rib | 43.08 | 43.45 | .95 | .33 | 40.51 | 41.11 | .99 | .05 | 41.92 | 42.40 | .97 | .06 |
| | Loin | 43.08 | 42.62 | .96 | .17 | 40.15 | 40.27 | .99 | .43 | 41.92 | 41.57 | .98 | .11 |

[a] Equations are listed in Table 17.

[b] Kg on a boneless basis.

[c] Yearlings I = 22 steers, Yearlings II = 18 steers, Overall = 40 steers.

[d] Two tail T-test probability.

of each dependent variable is shown for each group together with the predicted values. Considering the difference for chemical composition between groups in this study, the significance of the T-test for equations derived from the chemical composition of the plate or the rib along with the cooler traits show a fairly accurate individual animal prediction of the chemical composition of the whole carcass. In general, the equation using plate composition indicated that it is more suitable for prediction for all the dependent variables. Besides, the plate has the advantage of being a low cost wholesale cut that is readily obtainable from the packing plant. Therefore, the composition of the plate together with cooler traits is highly recommended to be used as independent variables in the prediction equations.

## Conclusion

Quantitative estimates of beef carcass chemical composition have been developed using mixed breed, non-fed yearlings with low and similar degrees of fatness. The correlated but lower relationship of specific gravity with carcass composition found in this study is in agreement with earlier reports. Rathbun and Pace (1945) found body density to be an accurate indicator of body composition but cautioned against the use of this technique with very young animals or in the case of marked variation in skeletal proportion. As pointed out in other sections of this work, bone density is not constant and thus a correction factor may have to be applied to density measurements to remove bias which this may introduce. This may explain the different correlation coefficients found between Yearlings I and Yearlings II.

The poor accuracy of estimation for carcass lipid was found both on a weight and on a percent basis. It was observed that specific gravity of certain wholesale cuts possessed the same predictive characteristics as the specific gravity of the entire side.

The R values for the prediction equations derived from all groups of animals were rather low. Regression analysis using specific gravity together with cooler traits as independent variables did not provide very accurate workable equations to estimate carcass composition.

Estimates of carcass composition on a part to whole basis demonstrated that very small differences exist in the accuracy of prediction of the various cuts (Tables 14 and 15). It seems logical to support the suggestion of Hankins and Howe (1964) that the chemical composition of the 9-10-11th rib would be a good indicator of carcass composition. Regression equations for predicting composition on a weight basis or percentage basis from the chemical composition of the wholesale cuts along with the cooler traits of carcasses produced higher coefficients of determination than those equations containing chemical composition alone. Similar results were found by Marchello et al. (1979) in developing accurate predictors of carcass chemical composition of cull range cows. The prediction equations using the chemical composition (Kg) of the plate or the rib along with the cooler traits showed fairly accurate predictions of the total chemical composition on a weight basis. In view of these results the smaller, less expensive and more accessible cuts, such as the plate, are recommended for use as predictors of carcass composition.

The regression equations using chemical composition of wholesale cuts with cooler traits had higher multiple R values than the equations using specific gravity with cooler traits as independent variables (Tables 8 and 17). Possibly, it is because the young, thin animal had not reached "chemical maturity". Therefore, the adipose tissue composition in soft tissue of the young animal is quite variable and more precise chemical determination of the wholesale cuts composition other than specific gravity is needed.

## SUMMARY

Data from 40 non-fed yearlings (USDA Yield Grade 1.4 ± .5) varying in genetic background, but pastured on the same range for 10 months were utilized to determine the relationships of specific gravity measurements and cooler traits (hot carcass weight, backfat thickness, ribeye area and kidney fat) to carcass chemical composition. In addition, the compositional characteristics of the various wholesale cuts were evaluated for their accuracy as predictors of carcass chemical composition.

The mean and standard deviations for the chemical composition (%) of the soft tissue portion of the left side were: lipid, 11.8 ± 3.3; protein, 15.5 ± .9; and moisture, 57.0 ± 3.2. Most specific gravity measurements were significantly ($P < .05$) correlated with the various chemical components (%) of the carcass. Prediction equations using specific gravity and cooler traits had slightly higher coefficients of determination than those equations containing specific gravity alone. Most cooler traits could not meet the statistical criteria in the regression equation for predicting total carcass protein.

Multiple R values for predicting protein and moisture (%) were .80 with standard errors of estimate of 4% or lower. Multiple R values for predicting percent of lipid were higher (.90) with higher corresponding standard errors of estimate (16%). Specific gravity of some wholesale cuts (plate and rib) demonstrated the same predictive

characteristics as the specific gravity of the entire side. However, only the prediction equation of lipid and protein composition derived from overall group was able to predict the composition accurately on various groups. This suggests that the specific gravity and cooler traits as poor predictors for predicting chemical composition in young animals.

The relationship between specific gravity and carcass composition on weight basis were not significantly correlated ($P > .05$) except in the case of lipid composition. The accuracy of estimation for carcass lipid was similar on a Kg basis and on a percent basis.

Since correlation between the chemical composition of the carcass and wholesale cuts was highly significant in nearly every case, it seems logical to support the suggestion of Hankins and Howe (1964) that the chemical composition of the 9-10-11th rib would be a good indicator of carcass composition, and the smaller, inexpensive and more accessible cuts (the plate) are recommended for use as predictors of carcass composition. Regression equations for predicting total carcass compositions on a weight and percentage basis using chemical composition of the wholesale cuts and cooler traits of the carcasses had higher coefficients of determination than those equations containing chemical compositions alone. Therefore, the prediction equations using the chemical compositions of the plate together with the cooler traits of the carcass as independent variables were recommended in predicting the total chemical composition on weight basis of yearling cattle.

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