VARIATION IN POTASSIUM AND SODIUM AS RELATED TO BODY COMPOSITION

Thesis for the Degree of Ph. D.

MICHIGAN STATE UNIVERSITY

Tedford A. Gillett

1966

THESIS

LIBRAR
Michigan St...
University

This is to certify that the

thesis entitled

VARIATION IN POTASSIUM AND SODIUM AS RELATED

TO BODY COMPOSITION

presented by

Tedford A. Gillett

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Food Science

Albert M. Pearson
Major professor

Date November 18, 1966

O-169

ROOM USE ONLY

ABSTRACT

VARIATION IN POTASSIUM AND SODIUM AS RELATED TO BODY COMPOSITION

by Tedford A. Gillett

Possible sources of error involved in predicting composition from sodium and potassium content were investigated using muscles from swine, cattle and sheep. Blood samples from the sheep were also examined to determine the relationship of high and low blood potassium to composition of individual muscles. In addition, whole pig bodies were obtained and divided into six compartments, including the shoulder, loin, side, ham, G.I. tract and head, and blood.

The sodium and potassium content of the muscles, the blood and the body compartments were determined by a flame photometric method utilizing a TCA extraction procedure, while fat, protein and moisture were measured by routine chemical methods. Variation in the potassium-muscle, potassium-lean, and potassium-protein ratios of various muscles and body compartments were examined by placing potassium on a wet basis, on a fat-free, moisture-free basis and on a protein basis.

On using data corrected for fat and moisture differences, the ranking of muscles by potassium concentration was generally the same for all species. There appeared to be more variation between muscles within a species than between the same muscles in different species. Since muscles high in connective tissue tended to be low in potassium content, it is suggested that some of the variation in muscle potassium may be due to the content of connective tissue. However, connective tissue content was not determined in this study so definite conclusions cannot be drawn.

Tedford A. Gillett

Although the number of sheep with high blood potassium values was small, the data indicated that the blood potassium level was not related ($P < .05$) to muscle potassium concentration. Differences in the potassium level of the blood and their effects on the estimates of composition are discussed.

Correlation coefficients relating potassium and sodium concentration to the fat, protein and moisture content of the individual compartments of the pig, the intact carcass and the entire animal were calculated. Correlation coefficients of -.93, 0.77 and 0.94 were obtained between total animal potassium and the percent fat, protein and moisture, respectively, for the whole animal. In general, the correlation coefficients between potassium and the various chemical components were highly significant, while those for sodium were quite low and few were significant.

Regression equations for predicting the composition of intact carcasses and whole animals from the total potassium and the potassium content of the ham are reported. Equations for estimating the chemical components of the whole animal from total animal potassium in grams (X) were as follows: percent fat = 70.22 - 18.38X, percent protein = 4.33X + 5.47, and percent moisture = 14.55X + 18.85. The corresponding standard errors of the estimate are 4.14, 0.55 and 0.82 percent, respectively. The standard errors of the regression cover such a large portion of the range in chemical components that they suggest a lack of accuracy in distinguishing between values for individual animals.

Muscle to muscle and compartment to compartment variation in sodium and potassium concentration was of considerable magnitude, regardless of

the basis of comparison. This suggests that at least part of the error involved in predicting composition from potassium was due to the lack of constancy between potassium and lean content. The lack of constancy in potassium content of data corrected for fat and moisture differences suggests that methods employing potassium are not sufficiently accurate for predicting composition.

VARIATION IN POTASSIUM AND SODIUM AS RELATED

TO BODY COMPOSITION

By

Tedford A. Gillett

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Food Science

1966

Ɖ 43163
4/5/67

ACKNOWLEDGEMENTS

The author wishes to express his gratitude to his committee chairman, Dr. A. M. Pearson, for his advice in the selection of course work and his constant interest and direction in the research project. Gratitude is also expressed to the other members of the author's guidance committee, Professor L. J. Bratzler and Dr. J. F. Price of the Food Science Department, Dr. E. P. Reineke, Professor of Physiology, and Dr. R. W. Luecke, Professor of Biochemistry. Thanks are expressed to Dr. W. T. Magee for his advice on statistical treatment and to Mr. Kenneth Kemp for assisting with the statistical analysis.

Gratitude is expressed to Mrs. Mildred E. Spooner and Vincent A. Cummings for assistance with the chemical analysis and to Doctors R. A. Merkel, D. M. Allen and V. M. Hix for providing some of the samples. Finally, the author wishes to thank his wife and children for their understanding, encouragement and assistance throughout his advanced studies.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX TABLES

Table		Page

Table | Page

INTRODUCTION

For a number of years medical and biological investigators have sought an accurate, non-destructive method for measuring gross body composition of animals. Such a method would find wide application in human medicine and in the livestock industry. It would be extremely useful to be able to predict the physical components (fat, muscle and bone) or the chemical components (ether-extract, water, protein and ash) of the body.

A non-destructive method which afforded accuracy would enable the animal breeder to select for muscling or meatiness. It would enable the nutritionist and physiologist to follow changes in composition throughout an experiment. It could be used by the livestock man to assess the degree of finish on animals, and thus enable him to time the marketing of animals to his advantage. The worth of livestock could also be determined on the basis of composition, and thus some of the subjectiveness of visual appraisal could be avoided. Meat processors could control the chemical components in their formulation and obtain more uniformity. Finally, in the research laboratory, the labor, expense and physical difficulties involved in direct analysis of meat could be reduced.

Rather thorough reviews have been compiled on the non-destructive methods of determining composition by Keys and Brozek (1953), Harrington (1958) and Brozek and Henschel (1961). Recently a new method has been proposed, the potassium-40 method, which appears to have many advantages for determining body composition (Anderson, 1959).

The rationale behind the use of K^{40} to predict composition is the assumption that the protein-potassium ratio (or lean-potassium ratio) is constant. If this was true, a determination of potassium would in effect measure the lean body mass of an animal (Anderson, 1959). The K^{40} method estimates potassium from the radio-activity of the naturally occurring gamma emitting isomer of potassium, K^{40}. Potassium from different sources is reported to vary by less than ± 0.5 percent in its K^{40} content (Vinogradov, 1957), so it should be an excellent index of total potassium and hence of lean body mass. Recent work, however, shows that the K^{40} method may lack the precision needed for practical application (Kirton and Pearson, 1963).

It was the purpose of this study to determine: 1) the accuracy with which composition can be predicted from potassium and sodium content, and 2) to examine some possible sources of error, particularly the constancy of the protein-potassium ratio.

REVIEW OF LITERATURE

Theoritical Basis for Predicting Composition from Total Potassium

Concentration differences in sodium and potassium exist between the intracellular and extracellular fluid. The differences are established and maintained through the metabolic work performed by the cell membranes (Guyton, 1956). Potassium, the main cation of the intracellular fluid, and sodium, the principle cation of the extracellular fluid, are present in a relatively constant proportion of these fluid compartments (Manery, 1954; Conway, 1957; Wolstenholme and O'Connor, 1958; Robinson, 1960).

In 1956, Moore *et al.* reported that almost 98 percent of the total potassium in the human body is in the skeletal muscle. They stated, "Since the skeletal muscle is the largest single component of the lean tissue of the body - excluding the skeleton - it is clear that the K_e (exchangeable potassium) is really a measure of the lean ... Theoretically, one should be able to translate the value for K_e into kilograms of wet muscle or lean tissue." The data of Forbes and Lewis (1956) have indicated that slightly over 60 percent of the potassium of the human body is located in the muscle. This figure appears much lower than that reported by Moore *et al.* (1956), however, the skeleton was included in the calculations of Forbes and Lewis (1956) as contrasted to the work of Moore *et al.* (1956).

Anderson (1959) also proposed the use of potassium content to predict the muscle mass of animals. His postulation was based on the assumption that the concentration of potassium in living cells was held constant by homeostatic processes, therefore, a determination of potassium would be equivalent to a determination of cellular mass. He also stated "There is no potassium in fat and very little in bone." He further suggested that total potassium content could be used to predict the lean body mass. Thus, those animals or cuts with a higher concentration of potassium would have a greater concentration of lean tissue or muscle.

There appears to be some controversy over Anderson's statement that "There is no potassium in fat and very little in bone." Kirton et al. (1961) reported that there was about half as much gamma activity in fresh bone and a quarter as much in fatty tissues as in muscular tissue. This would suggest that potassium was present in these tissues, since the radioactivity was measured from potassium-40. Archdeacon et al. (1961) reported 1500 - 2800 parts per million (ppm.) of potassium in the bone marrow of rabbits. On the separable bone of pigs, Pfau et al. (1961) making use of flame photometry and potassium-40 counts reported 1100 and 1290 ppm. of potassium, respectively, for the content of these bone samples by the two methods. Van Dilla et al. (1961) reported only a trace of potassium in pooled bone from cattle, while Blaxter and Rook (1956) reported the absence of potassium in the metacarpal bones from cattle.

Kirton (1962) suggested that the controversy might be due to differences in terminology. He explained that fat and bone most often meant fatty tissue and green bone (containing marrow and sometimes a little flesh), but fat and bone could be elaborated to mean "chemical fat" and "crystalline bone". Regardless of the terminology, the absence or low

content of potassium in fat and bone of animals and the high content in skeletal muscle suggests that a relationship does exist between the potassium content and composition.

Theoretical Basis for Predicting Composition by the Potassium-40 Method

According to Suttle and Libby (1955), potassium-40 theoretically comprises 0.0119 percent of the natural potassium isotopes, has a half life of 1.25×10^9 years and emits 10 beta particles for every gamma ray. Potassium isotopes from a natural mixture emit 2.96 gamma rays per second per gram with 1.45 Mev. of energy.

Anderson (1959) stated, "Isotopic fraction effects are very small because of the small mass differences, so that all potassium has essentially the same K-40 (potassium-40) content and hence the same radioactivity. A determination of the K-40 activity is therefore equivalent to a determination of total potassium."

Kulwich et al. (1960) referring to the work of Vinogradov (1957) reported that potassium from different sources did not vary by more than ±0.5 percent in its potassium-40 content. On this basis they also concluded that a potassium-40 determination on a biological sample would be an excellent index of the total potassium. The work of Vinogradov (1957) indicated that about seven times as much radioactivity was emitted by potassium-40 as by the next most prevalent naturally occurring radioactive isotope, carbon-14.

Anderson (1958) described how to avoid counting errors due to the radioactivity of cesium-137, a product of nuclear weapon testing. Cesium

gamma
rays (
Contam
manner

Relatic

Ch
body po
have rep
potassiu
the edib
obtained
tent and
On groun

Kir
correlati
percent w
correlati
in the fr
were 13 p
Therefore
in compos
potassium

gamma rays have a lower energy level (0.66 Mev.) than potassium gamma rays (1.45 Mev.), which allows them to be counted on separate channels. Contamination due to other fallout products could be avoided in a similar manner (Anderson, personal communication as cited by Kirton, 1962).

Relationship of Total Potassium to Composition

Cheek and West (1953) reported a close correlation between total body potassium and lean body mass of rats. Kirton and Pearson (1963) have reported correlation coefficients of 0.94 and 0.81 between the potassium content and the percent protein and percent separable lean of the edible carcass and dressed carcasses of lamb, respectively. They obtained correlations of 0.997, -.996, and 0.986 between potassium content and the water, fat and protein, respectively, on ground pork samples. On ground lamb, their correlations were only slightly lower.

Kirton *et al*. (1963) in studies on 24 empty pig bodies reported correlations of 0.86, -.87 and 0.77 between percent potassium and the percent water, ether-extract and protein, respectively. Corresponding correlations of 0.87, -.88 and 0.78 were reported for the same components in the frozen carcasses. The standard errors of prediction from potassium were 13 percent for water and ether-extract, and 17 percent for protein. Therefore, Kirton *et al*. (1963) concluded that individual differences in composition between animals could not be accurately assessed by potassium determinations.

[illegible]

Relationship of Potassium-40 to Composition

Determination of the total potassium from potassium-40 counting offers an alternate nondestructive index for estimating composition (Zobrisky et al., 1959). The first measurements of body potassium by means of the radioactivity of potassium-40 were reported by Sievert (1951, 1956) and by Burch and Spiers (1953). Although the work of Sievert was not directed towards an estimate of body composition, he did explain age and sex differences in terms of composition.

In 1956 Woodward et al. plotted the total body gamma activity of 13 humans against calculated fat-free weight as determined by gross weight. They concluded that fat was the principle factor causing variation in the potassium content of the body. They also demonstrated that the radioactivity of potassium-40 was related to body water and hence to the lean body weight of the subjects.

Kulwich et al. (1958) studied the usefulness of potassium-40 as an index of the amount of lean in hams. They selected two groups of hams on the basis of fatness and measured their radioactivity at various stages of separation into their physical components. They reported a correlation coefficient of 0.983 between gamma rays per second per pound and the percentage of fat-free lean. A correlation coefficient of -.966 was also reported between gamma rays per second per pound and the percentage of fat.

In 1960 Kulwich et al. used beta instead of gamma rays to study the relationship of potassium-40 to the composition of ham samples. Using an ashing procedure, which released the carbon, they eliminated the

radioactivity of carbon-14 as a source of error. Errors due to the radioactivity of cesium-137 were also ruled out, since Laug and Wallace (1959) reported no significant amount of beta activity in the ash of meat products that could not be accounted for by the potassium content as measured by flame photometry. The samples used from portions of the ham were selected to have a wide range in chemical components and varied widely in ether-extract (13.0 - 78.6 percent), protein (5.2 - 21.6 percent), and moisture (16.1 - 64.7 percent). The wide range in chemical composition probably accounted for the high correlations reported. However, Kulwich et al. (1961a) working with intact hams reported a correlation of 0.96 between net counts per minute and the pounds of separable lean of the hams by measuring the gamma radiation due to potassium-40.

Kulwich et al. (1961b) related the gamma ray emission of beef rounds to their lean content and obtained correlation coefficients of -.865 and 0.798 between disintegrations per minute from potassium-40 and the percent of separable fat and lean, respectively.

Zobrisky et al. (1959) reported that the potassium-40 content of animals might be useful as a rapid nondestructive index for determining protein to fat ratios in live hogs. Kirton et al. (1960) working with live unwashed lambs reported correlations of -.79, 0.51 and 0.86 between the estimated potassium-40 content and the percent of carcass fat, lean and bone, respectively. They also reported that total lean was more accurately predicted from the live weight or carcass weight than from the potassium content. Correlations of 0.90 and 0.91 were reported between lean content and live weight and between lean content and carcass weight, respectively.

In 19

potassium

potassium-

more accur

accuracy t

A nu

tion from

accuracy.

1962), se

Allen *et*

al., 1961

1958), co

(Anderson

or potass

ditions (

Brown, 19

the pota

in the b

and will

Constanc

Con

the use

Anderson

constant

cial fi

In 1962 Kirton discussed the accuracy of estimating composition from potassium as determined by flame photometry or by the radioactivity of potassium-40. He concluded that although flame photometry appeared to more accurately indicate composition, neither approach offered sufficient accuracy to warrant practical application.

A number of possible sources of error exist in determining composition from potassium concentration, which could account for the lack of accuracy. Among the possible errors are individual variation (Kirton, 1962), sex and age (Spray and Widdowson, 1950; Anderson and Langham, 1959; Allen _et al._, 1960) and breed or race (Gillett _et al._, 1965; Zeidburg _et al._, 1961) differences. The inadequacy of instrumentation (Anderson, 1958), contamination from natural sources or from radioactive fallout (Anderson and Van Dilla, 1958), the effect of various levels of sodium or potassium in the diet (Smith and Meyer, 1962), and various disease conditions (Harrison and Darrow, 1938; Lade and Brown, 1963; Clancy and Brown, 1963) are also probable sources of error. Lack of constancy in the potassium-lean ratio and the effect of different levels of potassium in the blood may also be responsible for errors in predicting composition and will be discussed individually.

Constancy of the Potassium-Lean Ratio

Constancy in the potassium-lean body ratio is a basic assumption in the use of potassium as an index of lean body mass (Moore _et al._, 1956; Anderson, 1959). Barter and Forbes (1963) have also reported that a constant of 68.1 meq. of potassium per kg. of lean body weight is a crucial figure in the determination of body fat by their method. Woodward *et al*. (

in the p

stancy c

of potas

(Anderso

potassiu

mass and

Var

potassiu

1963) an

et al.,

indicate

sufficie

body mas

the fat-

reported

However,

membranc

breeds f

(1963) r

between

tical tr

Fro

sodium,

even bet

et al. (1956) reported that fat was the principle factor causing variation in the potassium content of the human body, which implied greater constancy of potassium on a fat-free basis. On a fat-free basis, the content of potassium has been reported to be independent of sex, age or weight (Anderson, 1957). However, Allen et al. (1960) found differences in potassium content due to sex and age after correcting their data for fat mass and bone mineral.

Various workers have questioned the degree of constancy between potassium and lean body mass (Moore et al., 1956; Miller and Remenchik, 1963) and between potassium and protein (Lawrie and Pomeroy, 1963; Pfau et al., 1963; Gillett et al., 1965; Flear et al., 1965). Moore (1956) indicated that there was some evidence that potassium concentration varied sufficiently to alter the validity of any relationship for expressing lean body mass on the basis of potassium content. Variation of potassium on the fat-free, moisture-free basis for different muscles of the pig were reported to be of considerable magnitude by Lawrie and Pomeroy (1963). However, Pfau et al. (1963) on comparing the potassium content of the semimembranosus and longissimus dorsi muscles from 60 pigs of two different breeds found the differences to be nonsignificant. Pfau and Kallistratos (1963) reported that there were no statistically significant differences between any of the muscles of a single pig, although the method of statistical treatment is not clear.

From human biopsies, Flear et al. (1965) reported variability in the sodium, potassium, chloride and water content of skeletal muscle, and even between different muscles in the same individual. The variability was not

(1963) s

body and

humans w

very dif

veloped

back mus

muscle o

estimati

Variatio

In

blood ty

al., 195

1963; Ka

reported

sheep was

fore attr

blood cel

potassium

high pota

low potas

ate allel

al. (1959

although

it did no

was not reduced on a fat-free, dry-weight basis. Miller and Remenchik (1963) stated that "potassium is not uniformly distributed through the body and the distribution varies from one 'package' to the next. Two humans with identical external anthropological measurements may have very different musculatures. The long distance runner may have well developed leg muscles while the laborer may have well developed chest or back muscles." Therefore, if potassium differences exist from muscle to muscle or from area to area, the validity of the potassium-40 method of estimating composition would appear to be questionable.

Variation in Potassium Levels of Sheep Blood and Muscles

In sheep, a number of researchers have noted high and low potassium blood types (Kerr, 1937; Evans, 1954; Evans and King, 1955; Kidwell *et al.*, 1959; Mounib and Evans, 1960; Howes *et al.*, 1961; Drury and Tucker, 1963; Kahattab *et al.*, 1964; Rasmusen and Hall, 1966). Evans *et al.* (1956) reported that the concentration of potassium in the plasma of British sheep was the same for those with low and high blood levels. They therefore attributed the differences noted in whole blood entirely to the red blood cells. They hypothesized that the two blood types (low and high potassium) were genetically controlled in a simple Mendelian manner. The high potassium type was homozygous for the recessive allele, while the low potassium group was either heterozygous or homozygous for the dominate allele (low potassium is dominant) (Evans *et al.*, 1956). Kidwell *et al.* (1959) in similar studies on sheep raised in America indicated that although their data didn't contradict the hypothesis of Evans *et al.* (1956), it did not lend strong support.

In 1966 Rasmusen and Hall studying the blood of 115 sheep confirmed Mendelian inheritance of high and low potassium in red blood cells. By typing blood for the presence or absence of factor M and determining the potassium concentration, they found that without exception all M-negative blood samples were from sheep of the low-potassium type. Furthermore, all animals known to be heterozygous for low potassium or homozygous for high potassium were M positive.

A survey of the literature (Kerr, 1937; Mounib and Evans, 1958; Kidwell _et al_., 1959) on the magnitude of potassium differences in the blood of sheep indicates that the high potassium type erythrocytes have approximately three to five times as much potassium as the low potassium type. Mounib and Evans (1958) gave values of 23 and 83 meq. per liter for the potassium content of erythrocytes from the blood of sheep of the low and high potassium types, respectively. Khattab _et al_. (1964) used 30 meq. per liter as the dividing line in typing animals as low potassium or high potassium.

Since the blood is known to comprise approximately eight percent of the animal body (Dukes, 1955), Kirton (1962) concluded that the inclusion of both blood types (high and low potassium) would introduce some error in predicting composition from potassium content. He also suggested that if widely different potassium levels existed in sheep muscles that even larger errors could occur unless the different types were studied separately. Mounib and Evans (1960) found on studying a limited number of sheep that statistically significant differences between the two types (low and high blood potassium) did not occur in the skeletal muscle (_biceps_ femor

sligh

Relati

D

been u

the re

sodium

exchang

b; Berg

Zimmerma

Ede

in the b

1) free

sorbed b

crystall

that the

Toge

prises th

portion c

constant

Manery, 1

electroly

Such a re

Muldowney

femoris only). However, the potassium of the muscles did tend to vary slightly with the blood type.

Relationship of Sodium to Composition

Dilution techniques employing radioactive isotopes of sodium have been used to determine the extracellular fluid volume of animals, and the resulting dilution volume has been taken as an index of exchangeable sodium (Guyton, 1956). Exchangeable sodium plus a sizeable pool of slowly exchangeable bone sodium comprise the total body sodium (Edelman, 1954a, b; Bergstrom and Wallace, 1954; Forbes and Perley, 1951; Casey and Zimmerman, 1960).

Edelman (1961) described the complex nature of sodium distribution in the body by stating that bone sodium is found in three distinct phases: 1) free extracellular sodium (exchangeable), 2) exchangeable sodium absorbed by the surface of the crystalline bone, and 3) the sodium in the crystalline structure of bone (non-exchangeable). He further estimated that the total exchangeable sodium represented 70 percent of the total.

Together with the intracellular fluid the extracellular fluid comprises the total body water. Sodium comprises a relatively constant portion of the extracellular fluid while potassium comprises a relatively constant proportion of the intracellular fluid (Keys and Brozek, 1953; Manery, 1954). Due to their relative constancy, estimates of these electrolytes (sodium and potassium) should be related to total body water. Such a relationship has been established by Edelman et al. (1958) and Muldowney (1963). Both groups of workers found highly significant correlations between serum sodium and the ratio of total body water to the sum of exchangeable sodium plus the exchangeable potassium. Since body water has been shown to be related to composition (Babineau and Page, 1955), it appears that sodium should also be related to composition.

Kirton (1962) demonstrated that both sodium and potassium were highly related to composition. His work indicated that potassium was more closely related to composition than sodium. However, in light of the relationship between sodium and composition, further research in this area appears justified.

Experi

S

were us

and sod

the rel

ious co

barrows

used to

ments o

weight

barrows.

Cat

slaughte

carcasse

Shorthor

analyzed

overall

She

Universi

with an

No attem

4 Shrops

EXPERIMENTAL PROCEDURE

Experimental Animals

Swine. Two groups of swine from the Michigan State University farm were used. The first group was used to study the constancy of potassium and sodium in various muscles, while the second group was used to study the relationship of potassium and sodium to the composition of the various compartments of the pig body. Six Hampshire and six Yorkshire barrows with slaughter weights ranging between 84.3 and 99.8 kg. were used to study the variation in muscles. In the study on various compartments of the pig body, 25 crossbred Yorkshire-Hampshire hogs with a live weight of 81 to 108 kg. were used. Fourteen were gilts and 11 were barrows.

Cattle. Seven Angus, seven Hereford and two Shorthorn steers with slaughter weights between 232.2 and 344.3 kg. were used. The steer carcasses were purchased from local packers. The unavailability of the Shorthorns limited their number. Therefore, the Shorthorns were not analyzed separately as a breed, but values for them were included in the overall means.

Sheep. Twenty-five lambs were obtained from the Michigan State University farm with carcass weights ranging between 13.2 and 31.3 kg. with an average of 23.2 kg. Twenty-three were wethers and two were rams. No attempt was made to select for breed, however, there were 7 Suffolks, 4 Shropshires, 2 Hampshires, 2 Southdowns and 10 crossbred lambs. Six of the crossbreds were 5/8 Dorset-2/8 Suffolk-1/8 Western, three were 3/4 Dorset-1/4 Western, and one was 9/16 Dorset-6/16 Suffolk-1/16 Western.

Collection, Preparation and Storage of Samples

Since the procedures varied slightly, each will be discussed separately where appropriate and differences will be emphasized.

Muscle Potassium Variation Studies. Following conventional slaughter, the carcasses of the swine, cattle and sheep were aged for approximately 1 wk. at 3.3°C. Various muscles were then excised from the right side of each carcass. Each muscle was ground once through a 9.5 mm. plate and four times through a 1.6 mm. plate with mixing between each grinding. Samples of each muscle were then taken at random and placed in air tight sample jars, frozen and held at -29°C. for subsequent analysis. After thawing and just prior to analysis, the contents of each jar were thoroughly mixed with a plastic blade attached to a "Lightnin" stirrer.

In the first study on swine, the *longissimus dorsi*, *semimembranosus*, *semitendinosus*, *psoas major*, *biceps femoris* and *rectus femoris* muscles were utilized. The same muscles were also used in the cattle study, however, only the portion of the *longissimus dorsi* from the wholesale rib was utilized. In addition, the *triceps brachii* and *supraspinatus* muscles from the front quarter were used. For the sheep, only the portion of the *longissimus dorsi* between the 12th rib and the 5th lumbar vertebrae was used, while the *semimembranosus*, *semitendinosus* and *rectus femoris* muscles were used in their entirety.

In the lamb study, blood samples were also taken to determine if genetically different blood types (high and low potassium) would effect

muscle potassium concentration. Approximately 50 ml. of blood from each lamb was collected and placed in jars containing 1 gm. of reagent grade citric acid. The citric acid was used to prevent coagulation. The samples were then frozen and stored at -29°C. until analyzed.

Swine Body Compartment Study. In the second study on swine, the experimental animals were taken off feed approximately 24 hr. prior to slaughter and injected intramuscularly with approximately 3 ml. of Sernalan (phencyclidine-hydrochloride, 100 mg./ml.) prior to exsanguination. The blood was quantitatively collected and weighed in a plastic bag. Approximately 50 ml. samples of blood were also collected for analysis, while about 1 gm. of reagent grade citric acid was used to prevent coagulation. The blood samples were then frozen and stored at -29°C. for subsequent analysis.

The hogs were scalded, dehaired and washed in the conventional manner. The head and viscera, including the kidneys, were carefully removed, collected and quantitatively placed in plastic bags for weighing and freezing. This compartment was identified as the head and G. I. tract.

The carcass was weighed, split in half and placed in a cooler at 3.3°C. for 24 hours prior to cutting. The carcass was divided into four parts as follows: 1) the shoulder, which included the clear plate, jowl and fore foot, was that portion anterior to a cut made across the 3rd rib perpendicular to the vertebrae; 2) the ham, including the hind foot, was the entire portion posterior to a cut made across the 2nd and 3rd sacral

fatback

from th

major m

sparerib

illustra

cuts fro

Eac

and held

ments wi

4.0 mm.

through a

2.0 mm. p

divider w

grindings

equal por

sample we

placed in

After tha

thoroughly

Flame Phot

The p

they are d

sacral vertebrae perpendicular to the shank; 3) the loin, including the fatback, was the portion of the carcass dorsal to a straight cut made from the ventral edge of the blade bone to the ventral edge of the *psoas major* muscle on the ham end of the loin; and 4) the side, including the spareribs, was the remaining portion ventral to the loin. Figure 1 illustrates the division of the four compartments. In all cases, the cuts from both sides of the carcass were included.

Each compartment was then sealed in a separate plastic bag, frozen and held at -29°C. until removed for sawing and grinding. All compartments with the exception of the blood were sawed into strips approximately 4.0 mm. thick. They were then ground once through a 12.7 mm. plate, twice through a 6 mm plate, once through a 3.2 mm. plate, and twice through a 2.0 mm. plate. To reduce the quantity of substance to be ground, a divider was attached to the grinder head for the third and all subsequent grindings. The divider separated the components into two approximately equal portions. One portion was discarded after each grinding. A final sample weighing about 70 gm. was taken from each compartment of each pig, placed in sample jars, frozen and held at -29°C. until used for analysis. After thawing and before analysis, the contents of each sample jar were thoroughly mixed using a plastic stirring blade on an electric stirrer.

Flame Photometry

The procedures used for flame photometry varied slightly. Thus, they are described below with emphasis upon differences in methodology.

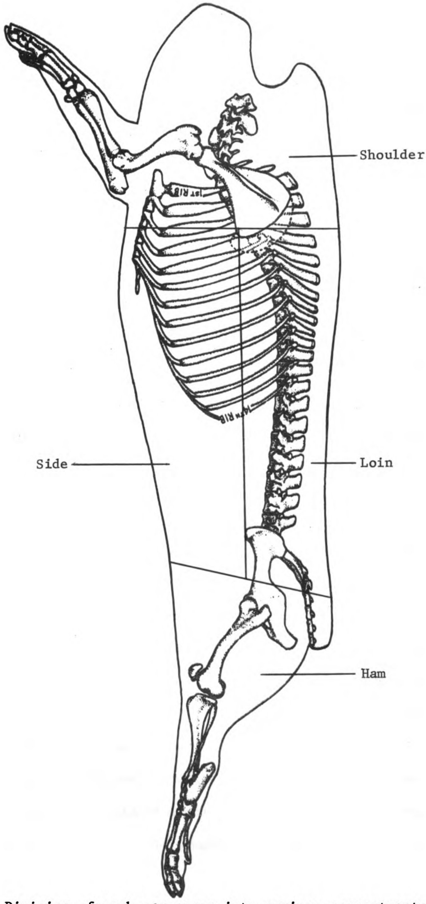

Figure 1. Division of pork carcasses into various compartments.

Instrumentation. A Beckman, Model D. U., Spectrophotometer with a model 9200 flame attachment was connected to a dual pressure system, which controlled the flow of hydrogen and oxygen to the burner. The hydrogen pressure was regulated at 7 lb. per square inch and oxygen at 12 lb. per square inch as recommended by the manufacturer of the atomizer.

The photometer's power supply was set at a sensitivity of 5, while the selector switch on the photometer was set at 0.1. Potassium determinations were made on photo tube 1 with the filter in, at a wavelength of 768 mu and a slit width setting of 0.15 to 0.3. Sodium readings were made using a wavelength of 589 mu and a slit width of 0.01 - 0.03, while photo tube 2 was utilized with the filter in the out position. The operation and maintenance of the flame photometer is described in Beckman Instrument Manual 334-A.

Extraction, Filtration and Dilution of Samples. Sodium and potassium must be extracted from the tissues before flame photometry can be employed to measure concentration. The elements must be in solution, and free from all particles that might clog the fine atomizer tube of the burner.

Kirton (1962) compared four different methods of extraction and concluded that a modification of the TCA extraction procedure of Mounib and Evans (1957) offered better repeatability and was more readily adaptable. Thus, the TCA method was adopted for these studies. Following the procedure outlined by Kirton (1962), homogenous samples of ground muscle were weighed accurately into aluminum dishes and transferred by washing into aluminum blender jars. The samples were homogenized for 5 min. in

150 ml. of 2% TCA solution and transferred to 250 ml. Erlenmeyer flasks, which were stoppered and stored in a cooler at 3.3°C. for at least 2 hr. The solutions were then filtered through Whatman No. 40 filter paper into polyethylene bottles. Five ml. of the filtered solution was made up to a volume of 15 ml. by adding 10 ml. of 2% TCA with a pipette. Test tubes containing the diluted samples were covered with "Parafilm", mixed thoroughly and transferred to cuvettes for atomizing and reading.

To avoid possible errors encountered in transferring samples and in making a second dilution, the procedure used in the first study on swine was modified. Homogenous samples of ground tissue were weighed (1.5-3.0 gm.) on ashless filter paper and placed inside stainless steel jars (paper and sample). Then 200 ml. of 2% TCA solution was added using an automatic pipette and each mixture was blended for 4 min. with "VirTis" blender at high speed. Each mixture was stored for at least 2 hr. in a 250 ml. stoppered Erlenmeyer flask, then filtered and stored in a polyethylene bottle. The samples were read directly from the bottles by using a polyethylene tube connected to the atomizer-burner. This procedure appeared to reduce errors and was adopted for all other studies. Due to the fluid nature of the blood samples, however, they were transferred directly by washing from the aluminum dishes rather than by using filter paper.

Preparation of Standard Solutions. A stock solution containing 1000 ppm. potassium and 200 ppm. of sodium was prepared using analytical grade KCL and NaCl as suggested by Dean (1960). A 2% TCA solution prepared with de-ionized water was used for making up the stock solution. In the

first study on swine, 15 ml. of the stock solution was diluted to 500 ml. with 2% TCA solution. This gave a final concentration of 30 ppm. potassium and 6 ppm. sodium in the primary standard. A series of standards were then made from the primary standard by dilution with 2% TCA. The standards were used in plotting the standard curve and contained 30, 22.5, 15, 9, 3 and 0 ppm. of potassium and 6, 4.5, 3, 1.8, 0.6 and 0 ppm. of sodium.

In order to allow easier calculation of the concentration of the standards and to provide closer dilution intervals, the standard solutions were prepared differently for use in the sheep, steer and second swine study. Although the same stock solution was used, 50 ml. rather than 15 were made up to a volume of 500 ml. with 2% TCA. This gave a primary standard containing 100 ppm. potassium and 20 ppm. of sodium. Standards were then prepared from this primary standard by dilution with 2% TCA. The potassium concentration in this series of standards ranged from 0 to 65 ppm. at intervals of 5 ppm. to give 0, 5, 10, ...65 ppm. of potassium, while the sodium concentration ranged from 0 to 20 ppm. at intervals of 1 ppm.

Readings. All muscles from each animal were run concurrently with standards of similar strength. The same standard curve was employed to calculate the concentration of sodium or potassium in order to avoid possible daily fluctuations. As many compartments of the pig as possible (about six) were run concurrently with standards and utilized the same standard curve. Similar compartments from each pig were run simultaneously rather than all compartments from the same pig.

Calculations. A standard curve was made by plotting percent transmittance against the concentration of standard solutions of sodium and potassium. The sodium and potassium concentration for each sample was then determined from the standard curve using the necessary dilution factor. The formula for calculating the dilution factors in the last three studies was: $\frac{\text{ml. 2\% TCA + sample wt. (gm.)}}{\text{sample wt. (gm.)}}$
In the study on swine muscles, however, a factor of three was used to allow for the second dilution.

Chemical Analysis

The percent moisture was determined using the oven drying procedure outlined by Benne *et al.* (1956), except that 15 mm. deep aluminum cups without lids were used. The percent fat was determined on oven dried samples by an ether extraction procedure described by Hall (1953). Samples of 2.5-5.0 gm. were accurately weighed to the fourth place and used in these determinations. The protein determinations for the steer study and the first pig study were made following the procedure of Benne *et al.* (1956). With the sheep study and the second swine study, however, a micro-Kjeldahl procedure outlined by Brent (1965) was adopted. The samples varied in size from 1.3-1.6 gm. in the macro-Kjeldahl analysis and from 0.4-0.7 gm. in the micro-Kjeldahl analysis.

Statistical Analysis

After an analysis of variance was applied to the data as shown in the appendix tables, Duncan's multiple range test was used to test for significance between means (Duncan, 1955).

RESULTS AND DISCUSSION

Variation of Potassium in Pig Muscles

The data on the potassium content of different muscles of the pig are summarized in Table 1. For purposes of comparison, they are expressed on a wet basis (gm. of potassium per kg. of fresh muscle tissue), a fat-free, moisture-free basis (gm. of potassium per kg. of fat-free, moisture-free muscle) and on a protein basis (gm. of potassium per kg. of protein). Breed comparisons are also shown.

Table 1. Potassium content of different muscles of the pig.

Muscle	Mean[a] Yorkshire	Mean[a] Hampshire	Mean[a] Both	S.D.[b]	Range
		Wet tissue basis, gm./kg.			
Rectus femoris	4.05^{c}	4.17^{c}	4.11^{c}	0.14	3.78-4.23
Semimembranosus	$3.88^{c,d}$	3.96^{d}	3.92^{c}	0.13	3.61-4.10
Longissimus dorsi	$3.82^{d,e}$	$3.87^{d,e}$	3.85^{c}	0.13	3.54-3.96
Biceps femoris	$3.71^{d,e}$	3.85^{e}	$3.78^{c,d}$	0.17	3.34-3.95
Semitendinosus	3.65^{e}	3.71^{f}	$3.68^{d,e}$	0.10	3.49-3.82
Psoas major	3.64^{e}	3.60^{f}	3.62^{e}	0.18	3.35-3.93
		Fat-free, moisture-free basis, gm./kg.			
Rectus femoris	$17.30^{c,d}$	18.45^{c}	17.88^{c}	0.98	16.15-19.44
Semitendinosus	17.48^{c}	$17.84^{c,d}$	17.66^{c}	0.67	16.12-18.50
Biceps femoris	$16.85^{c,d,e}$	17.80^{d}	$17.32^{c,d}$	0.96	14.87-18.55
Semimembranosus	$16.22^{d,e}$	17.25^{d}	$16.74^{d,e}$	1.05	14.34-18.03
Longissimus dorsi	16.11^{e}	17.02^{d}	$16.56^{d,e}$	0.78	14.74-17.40
Psoas major	16.08^{e}	15.93^{e}	16.00^{e}	0.84	13.89-16.87
		Protein basis, gm./kg.			
Rectus femoris	19.01^{c}	20.92^{c}	19.96^{c}	1.21	18.00-22.42
Semimembranosus	17.70^{d}	$19.80^{c,d}$	$18.75^{c,d}$	1.37	16.23-20.42
Semitendinosus	$18.02^{c,d}$	$19.44^{d,e}$	$18.73^{c,d}$	1.18	16.25-20.45
Biceps femoris	17.66^{d}	$19.62^{d,e}$	$18.64^{c,d}$	1.31	15.76-20.65
Longissimus dorsi	17.00^{d}	$18.46^{e,f}$	$17.73^{c,d}$	1.28	16.13-19.65
Psoas major	17.03^{d}	17.54^{f}	17.28^{d}	1.13	14.65-18.30

[a]Means within treatment in the same column not bearing the same superscript are significantly ($P < .05$) different.
[b]Standard deviation of the overall mean.

Potassium variation on a wet basis. On a wet basis the rank of muscles in descending order of potassium content was as follows: *rectus femoris*, *semimembranosus*, *longissimus dorsi*, *biceps femoris*, *semitendinosus* and *psoas major*. The *rectus femoris* muscle contained the highest concentration of potassium with 4.11 gm. of potassium per kg. of muscle tissue. The *rectus femoris* muscle was followed by the *semimembranosus* and *longissimus dorsi* muscles, which contained 3.92 and 3.85 gm. of potassium per kg. of muscle, respectively. Lawrie and Pomeroy (1963) studying the variation of potassium in the muscles of bacon pigs (200 lb.) reported 0.37 and 0.34 percent for the potassium content of the *rectus femoris* and *longissimus dorsi* muscles, respectively. On changing the values of Lawrie and Pomeroy (1963) from percent to gm. per kg., it is apparent that the values are lower than those of this study. The potassium content of the *rectus femoris* was 3.7 vs. 4.11 gm., and the value for the *longissimus dorsi* muscle was 3.4 as compared to 3.85 for the present study.

The differences in the two studies might be attributed to different procedures for making potassium determinations. An ashing procedure utilizing hydrochloric acid was used by Lawrie and Pomeroy (1963), while a TCA extraction procedure was used in this study. It is more likely, however, that the differences between the two studies were due to actual differences between the two groups of pigs, since the pigs used were of different breeding. However, it is of interest to note that the *rectus femoris* muscle contained the highest concentration of potassium in both studies.

There was no statistically significant difference in the present study among the four highest muscles (*rectus femoris*, *semimembranosus*, *longissimus dorsi* and *biceps femoris*), yet all were significantly higher in potassium than the *psoas major* muscle. The *biceps femoris* was intermediate in potassium content (3.78 gm. K/kg. wet muscle) and did not differ significantly from the *semitendinosus*, which had a mean of 3.68 gm./kg. The two lowest muscles in potassium content were the *semitendinosus* (3.68 gm./kg.) and the *psoas major* (3.62 gm./kg.), which did not differ significantly ($P < .05$) from each other. Although the *psoas major* ranked lowest in potassium content in this study and second highest in the work of Lawrie and Pomeroy (1963), the potassium content for the *psoas major* was the same in both studies. It should be pointed out that the actual ranking of the muscles in the two studies was of little importance since the same muscles were not used in both studies. Lawrie and Pomeroy used only three of the muscles which were common to this study (*longissimus dorsi*, *rectus femoris* and *psoas major*) and two others which were not (*lateral head triceps* and *extensor capri radialis*). The percent decrease in potassium ($\frac{\text{concentration high muscle-concentration low muscle}}{\text{concentration high muscle}}$ X 100) between the mean values for the *rectus femoris* (highest) and the *psoas major* (lowest) muscle was 11.9. This is lower than the percent decrease from extreme mean values reported by Lawrie and Pomeroy (1963), who found a 30 percent decrease between the potassium content of the *rectus femoris* and the *extensor carpi radialis* muscles. As the *extensor carpi radialis* muscle was not used in the present study, the greater percent decrease reported by Lawrie and Pomeroy (1963) can probably be attributed to differences in the muscles studied. It should also be pointed out that the percent decrease reported above was based upon iiffe

nuscl

ıas b

:onte

:at-f

ıuscl

. emit

: soas

! ajor

: emor

ᵢ mea

ł etwe

l owes

r spe

F ilu

a ree

p tas

f om

f can

d ffe

c mpa

t ato

differences between means, thus the maximum error between different muscles may be even larger.

Potassium variation on a fat-free, moisture-free basis. Since fat has been reported to account for some of the variation in potassium content (Woodward et al., 1956), the data in Table 1 are presented on a fat-free, moisture-free basis. On this basis of comparison, the rank of muscles in descending order of potassium content was the rectus femoris, semitendinosus, biceps femoris, semimembranosus, longissimus dorsi and psoas major. The rank of the rectus femoris (highest) and the psoas major (lowest) was not changed from that on the wet basis. The rectus femoris had a mean value of 17.88 gm of potassium and the psoas major had a mean value of 16.00 gm./kg., which represents a 10.5 percent decrease between the means for two muscles.

The semimembranosus and longissimus dorsi muscles were next to the lowest in potassium content, with mean values of 16.74 and 16.56 gm., respectively. The difference between the two muscles was not significant. Failure to find a significant difference between the two muscles was in agreement with the results of Pfau et al. (1963), who compared the potassium content of the semimembranosus and longissimus dorsi muscles from two different breeds of pigs and found the difference was not significant. However, results of the present study showed that significant differences did exist between other muscles, while Pfau et al. (1963) compared only the two muscles. In a subsequent study, Pfau and Kallistratos (1963) determined the potassium content of all muscles of a single

pig. They concluded that the potassium content was relatively constant, although the method of statistical treatment was not clear. This was in contrast to the variable results obtained in this study.

The rectus femoris (17.88 gm.) and the semitendinosus (17.66 gm.) contained significantly more potassium than the three lowest muscles (semimembranosus, longissimus dorsi and psoas major), yet they were not significantly different from the biceps femoris. The biceps femoris muscle was intermediate in potassium content with a mean value of 17.32 gm./kg.

The results on a fat-free, moisture-free basis are in general agreement with those of Lawrie and Pomeroy (1963), who reported a large difference in the potassium content of different muscles. Calculation of the percent decrease in potassium between the rectus femoris (highest) and extensor carpi radialis (lowest) muscles in the study of Lawrie and Pomeroy (1963) gave a value of 17.6 as compared to 10.5 percent between extreme mean values in this study. These values represent an important source of error in the potassium lean ratio and are of considerable importance since they are corrected for the effects of fat and moisture.

Potassium variation on a protein basis. On a protein basis, i.e., grams of potassium per kilogram of protein, the ranking of mean values for the different muscles remained the same as on a fat-free, moisture-free basis, except for the semimembranosus, which shifted from fourth to second highest. Expressing the potassium content on a protein basis reduced the variation between most muscles. Only the highest and lowest muscles showed significant differences in their potassium content. The rectu

psoas

betwe

on ei

the p

cies

mus c

Calcu

and s

that

study

conta

whila

potas

and b

potas

potas

taine

major

potas

that

free

rectus femoris was highest with a mean value of 19.96 gm./kg., and the psoas major was lowest with a value of 17.28 gm./kg. The percent decrease between the two muscles was 13.4, which was greater than that reported on either a wet or a fat-free, moisture-free basis. The difference in the potassium-protein ratio among muscles could contribute to inaccuracies in the determination of body composition from potassium.

In 1963, Pfau et al., compared the potassium content of the longissimus dorsi and semimembranosus muscles of 60 pigs on a protein basis. Calculation of the mean content of potassium in the longissimus dorsi and semimembranosus muscles of the barrows (male castrates) indicated that the values were lower for the two muscles than those in the present study. The semimembranosus muscles from the study of Pfau et al. (1963) contained 16.0 gm. of potassium compared to 18.75 gm. in this study, while the longissimus dorsi contained 16.1 gm. compared to 17.73 gm. of potassium per gm. of protein in the present study. The semitendinosus and biceps femoris muscles in this study were both intermediate in potassium content, with 18.73 and 18.64 gm./kg. of protein, respectively.

Potassium variation among breeds. Table 1 compares the average potassium content for all six muscles on a breed basis. Hampshire contained more potassium than Yorkshires in all muscles, except the psoas major, regardless of the basis of comparison. The mean content of potassium of the psoas major muscle from the Hampshires was lower than that from the Yorkshires on both a wet basis and a fat-free, moisture-free basis, but not on a protein basis.

When the statistical analysis was carried out on the total potassium content of all muscles combined together on a protein basis, highly significant differences occurred between breeds. The Hampshire had a mean value of 19.29 gm. of potassium per kg. of protein compared to 17.51 gm. for the Yorkshires. Thus, the constancy of the potassium-protein relationship between breeds becomes questionable when the differences are based on the total potassium per unit of protein for all six muscles. Regardless of whether or not the animals used are indicative of the breed as a whole, the variation between individual animals and strains appears to be real and shows that the potassium content per unit of protein is not constant.

Variation of Sodium in Muscles of the Pig

Table 2 summarizes the data on the sodium content of different muscles from the pig. For purposes of comparison, the gm. of sodium per kg. of tissue are expressed on a wet basis, fat-free, moisture-free basis and on a protein basis. The mean content of muscles by breed are also shown for comparison.

Sodium variation on a wet basis. The sodium content of the six muscles studied was relatively constant on a wet basis. Only the *longissimus dorsi* muscle was significantly different from all other muscles studied. The mean ranking of muscles in descending concentration of sodium was as follows: the *semitendinosus*, *biceps femoris*, *psoas major*, *rectus femoris*, *semimembranosus* and *longissimus dorsi*. The *semitendinosus* and *biceps femoris* muscles were highest in sodium content, each having a mean of 0.51 gm. per kg. of wet tissue. The lowest muscle, the *longissimus dorsi*, had a

Table 2. Sodium content of different muscles of the pig.

Muscle	Mean[a] Yorkshire	Hampshire	Both	S.D.[b]	Range
		Wet tissue basis, gm./kg.			
<u>Semitendinosus</u>	0.53[c]	0.49[c]	0.51[c]	0.05	0.42-0.62
<u>Biceps femoris</u>	0.52[c]	0.50[c]	0.51[c]	0.03	0.47-0.56
<u>Psoas major</u>	0.50[c]	0.49[c]	0.49[c]	0.04	0.42-0.56
<u>Rectus femoris</u>	0.49[c]	0.47[c]	0.48[c]	0.04	0.42-0.56
<u>Semimembranosus</u>	0.50[c]	0.46[c,d]	0.48[c]	0.04	0.44-0.55
<u>Longissimus dorsi</u>	0.45[d]	0.42[d]	0.43[d]	0.03	0.41-0.51
		Fat-free, moisture-free basis, gm./kg.			
<u>Semitendinosus</u>	2.54[c]	2.37[c]	2.45[c]	0.23	2.00-2.86
<u>Biceps femoris</u>	2.34[c,d]	2.31[c,d]	2.32[c,d]	0.16	2.06-2.63
<u>Psoas major</u>	2.22[d,e]	2.16[c,d]	2.19[d,e]	0.22	1.67-2.60
<u>Rectus femoris</u>	2.11[e]	2.08[d,e]	2.09[e]	0.19	1.88-2.42
<u>Semimembranosus</u>	2.08[e,f]	1.99[e]	2.04[e]	0.14	1.83-2.33
<u>Longissimus dorsi</u>	1.88[f]	1.84[e]	1.86[f]	0.11	1.71-2.12
Mean	2.19**	2.12			

[a]Means within treatment in the same column not bearing the same superscript are significantly ($P < .05$) different.
[b]Standard deviation of the overall mean.
**$P < .01$.

mean sodium content of only 0.43. The difference between the two highest muscles (<u>semitendinosus</u> and <u>biceps femoris</u>) and the lowest muscle amounted to a 15.7 percent decrease. The <u>rectus femoris</u> and <u>semimembranosus</u> muscles each contained 0.48 gm. of sodium, while the <u>psoas major</u> contained only slightly more (0.49 gm./kg.).

After converting the mean sodium values from the studies of Lawrie and Pomeroy (1963) from percent to gm./kg., a comparison with the values of this study is possible. In both studies, the concentration of sodium in three muscles was determined, namely: the <u>psoas major</u>, <u>rectus femoris</u> and the <u>longissimus dorsi</u>. Values for these three muscles were 0.49, 0.48 and 0.43 gm., respectively, in the present study, while Lawrie and

Pomero

muscle

S

moistu

betwee

rankin

placin

maine

by the

while

T

nifica

the l

and th

2.19,

major.

fat-fr

cantly

betwee

a fat-

This

when

that

and le

Pomeroy (1963) reported a value of 0.50 gm./kg. for each of the three muscles.

Sodium variation on a fat-free, moisture-free basis. On a fat-free, moisture-free basis, a larger number of significant differences existed between the sodium content of muscles than on the wet basis. The mean ranking of muscles according to sodium concentration was not altered by placing them on a fat-free, moisture-free basis. The *semitendinosus* remained highest with a mean value of 2.45 gm. of sodium per kg. followed by the *biceps femoris*, *psoas major*, *rectus femoris* and *semimembranosus*, while the *longissimus dorsi* ranked last with a mean value of 1.86 gm.

The sodium content of the *semitendinosus* and *biceps femoris* was significantly higher than that of the *rectus femoris*, *semimembranosus* and the *longissimus dorsi*. However, the difference between the *biceps femoris* and the *psoas major* was not significant. Mean sodium values of 2.32, 2.19, 2.09 and 2.04 gm./kg. were obtained for the *biceps femoris*, *psoas major*, *rectus femoris* and *longissimus dorsi* muscles, respectively, on a fat-free, moisture-free basis. The *longissimus dorsi* contained significantly ($P < .05$) less sodium than all other muscles. The percent decrease between the means of the *longissimus dorsi* and *semitendinosus* was 24.1 on a fat-free, moisture-free basis compared to 15.7 percent on a wet basis. This difference is larger than that for potassium, and was also increased when placed on a fat-free, moisture-free basis. It therefore appears that the sodium-lean ratio is even more inconsistant than that of potassium and lean.

sodi

less

was r

highl

The m

kg. c

a fat

compa

large

the s

they

used

Conte

six p

perce

(5.05

membr

of 1.

fican

dinos

six m

<u>Sodium variation among breeds</u>. In every case, the mean content of sodium from the Hampshires was lower than that of the Yorkshires regardless of the basis of comparison. However, the difference between breeds was not significant when each muscle was analyzed separately, but was highly significant when all muscles of each breed were considered together. The mean sodium content of all muscles from the Hampshires was 0.47 gm./kg. compared to 0.50 gm. for Yorkshires on a wet tissue basis, while on a fat-free, moisture-free basis, the Hampshires averaged 2.13 gm./kg. compared to 2.20 for the Yorkshires. These breed differences are not as large as those for potassium, yet they indicate a lack of constancy in the sodium-lean ratio between the breeds and/or strains studied. However, they may not be indicative of the breeds as a whole since the numbers used were small.

<u>Content of Fat, Protein and Moisture in Pig Muscles</u>

Table 3 shows the mean percent of fat, moisture and protein of the six pig muscles studied. The <u>semitendinosus</u> muscle ranked highest in percent fat with a mean value of 6.03, followed by the <u>biceps femoris</u> (5.05), the <u>longissimus dorsi</u> (4.76), the <u>psoas major</u> (2.77) and the <u>semimembranosus</u> (2.70), while the <u>rectus femoris</u> ranked last with a mean value of 1.29 percent. The <u>semimembranosus</u> and <u>rectus femoris</u> contained significantly less fat than the <u>longissimus dorsi</u>, <u>biceps femoris</u> and <u>semitendinosus</u>, but did not differ significantly from the <u>psoas major</u>.

The protein content did not differ significantly between any of the six muscles, while only the <u>rectus femoris</u> and <u>longissimus dorsi</u> muscles

Table 3. Percent fat, moisture and protein in muscles of the pig.

Muscle	Mean[a] Fat	Moisture	Protein
Semitendinosus	6.03^{b}	73.13^{b,c}	19.68^{b}
Biceps femoris	5.05^{b}	73.11^{b,c}	20.32^{b}
Longissimus dorsi	4.76^{b}	72.01^{c}	21.52^{b}
Psoas major	2.77^{b,c}	74.59^{b,c}	20.99^{b}
Semimembranosus	2.70^{c}	73.80^{b,c}	20.99^{b}
Rectus femoris	1.29^{c}	75.69^{b}	20.61^{b}

[a]Means in the same column not bearing the same superscript are significantly ($P < .05$) different.

differed in moisture content ($P < .05$). The mean moisture content of the rectus femoris (highest) was 75.69 percent, while the longissimus dorsi (lowest) muscle contained 72.01 percent. The mean percentage of protein in the longissimus dorsi (highest) was 21.52 percent, while the percent protein in the semitendinosus (lowest) muscle was 19.68.

Variation of Potassium in Steer Muscles

Table 4 summarizes the data on the variation of potassium in different steer muscles. The mean content of potassium and the ranges are reported on a wet-basis, on a fat-free, moisture-free basis and on a protein basis in order that comparisons might be made.

Potassium variation on a wet basis. On a wet basis (gm. potassium/kg. muscle) the overall mean ranking of muscles in order of descending concentration of potassium was as follows: semitendinosus, semimembranosus, rectus femoris, biceps femoris, psoas major, longissimus dorsi, triceps brachii and supraspinatus. The semitendinosus was highest in potassium

Table 4. Potassium content of various steer muscles.

Table 4. Potassium content of various steer muscles.

Muscle	Potassium, gm./kg. of tissue					
	Wet basis		Fat-free, moisture-free basis		Protein basis	
	Overall		Overall		Overall	
	Mean^{a}	Range	Mean^{a}	Range	Mean^{a}	Range
Semitendinosus (ST)	3.95^{b}	3.81-4.27	17.17^{b}	15.94-18.11	18.60^{b}	17.65-19.54
Semimembranosus (SM)	3.87^{c}	3.70-4.06	16.37^{de}	15.58-17.32	18.10^{c}	17.09-20.16
Rectus femoris (RF)	3.79^{d}	3.57-4.06	17.27^{b}	16.10-18.72	18.47^{b}	16.83-19.71
Biceps femoris (BF)	3.78^{d}	3.53-4.26	16.41^{cd}	15.57-17.37	17.98^{c}	16.76-19.23
Psoas major (PM)	3.69^{e}	3.43-3.98	16.68^{c}	15.08-18.12	17.98^{c}	16.65-19.60
Longissimus dorsi (LD)	3.68^{ef}	3.51-3.87	16.04^{e}	14.97-17.31	17.14^{d}	15.99-18.70
Triceps brachii (TB)	3.62^{f}	3.44-3.94	16.27^{de}	15.65-16.86	17.39^{d}	16.36-18.16
Supraspinatus (SS)	3.44^{g}	3.31-3.66	16.30^{de}	15.29-16.84	17.44^{d}	15.90-18.18
Average (all muscles)	3.73	3.31-4.27	16.57	14.97-18.72	17.89	15.90-20.16
Standard error[h]	20.29		92.14		127.57	

[a]Means within treatment in same column not bearing the same superscript are significantly different ($P < .05$).
[h]Square root of variance of the treatment mean, where the error mean square is the interaction between muscles and animals.

with a mean value of 3.95 gm./kg. It contained significantly more potassium than all other muscles studied. The semimembranosus ranked second in potassium with a mean content of 3.87 gm./kg., which was significantly higher than all muscles except the semitendinosus.

The significant difference between the mean content of potassium in the semimembranosus (3.87 gm./kg.) and the longissimus dorsi (3.68 gm./kg.) was in contrast to the work of Pfau et al. (1963) and Gillett et al. (1965) who compared the potassium content of the same muscles from the pig and found the differences were not statistically significant ($P < .05$). The rectus femoris (3.79 gm./kg.) and biceps femoris (3.78 gm./kg.) were not significantly different in their content of potassium, yet both contained significantly more potassium than the psoas major, longissimus dorsi, triceps brachii and supraspinatus.

The content of potassium in the longissimus dorsi (3.68 gm./kg.) did not differ significantly from that of the psoas major (3.69 gm./kg.) nor the triceps brachii (3.62 gm./kg.), while the supraspinatus contained significantly less potassium than all other muscles studied (3.44 gm./kg.). The supraspinatus and triceps brachii, which are both located in the front quarter, were the two lowest muscles in potassium content. This suggests that differences in the location and/or function of muscles may have a bearing on their potassium content. Lawrie and Pomeroy (1963) in studying pig muscles suggested that variation in the content of connective tissue of different muscles may have caused the differences that they found in the potassium content of muscles. They further speculated that the difference might be related to the function of the muscles.

the

<u>branc</u>

a mea

in co

local

ive t

in co

tion

tissu

betwe

McCla

as "l

<u>brach</u>

<u>sus</u> a

colla

ratio

tissu

(3.95

was 1

with m

of the

and Po

the me

of the

McClain et al. (1965) reported highly significant differences between the alkali-insoluble collagen content of the triceps brachii, semimembranosus and longissimus dorsi muscles. As alkali insoluble collagen is a measure of total connective tissue, there appears to be a difference in connective tissue content of different muscles. If potassium ions are localized in contractile protein as reported by Nesterov (1964), connective tissue would be low in potassium. This being the case, differences in connective tissue content would be responsible for some of the variation in potassium content between muscles. Thus, variation in connective tissue content may account for some of the variation in potassium content between the triceps brachii and semimembranosus of the present study. McClain et al. (1965) working with bovine muscles, which they classified as "less tender" reported 4.98 percent of the protein of the triceps brachii was alkali-insoluble collagen and 3.14 percent of the semimembranosus and only 2.20 percent of the longissimus dorsi was alkali insoluble collagen. This would suggest that the variation in the potassium-protein ratio can at least partially be explained by differences in the connective tissue content.

The percent decrease between the mean values of the semitendinosus (3.95 gm./kg. - highest) and the supraspinatus (3.44 gm./kg. - lowest) was 12.91 percent on a wet basis. These results are in general agreement with mean differences reported by Gillett et al. (1965) on six muscles of the pig, but somewhat lower than values for the pig reported by Lawrie and Pomeroy (1963). These workers found the percent decrease between the means of the longissimus dorsi and the extensor carpi radialis muscles of the pig to be 30 percent.

ture

conte

free

indic

conte

reduc

betwe

(long

fat-f

basis

semit

kg.,

but w

The ps

conta

spinat

the ps

(16.41

conter

(16.37

(16.27

three

than a

Potassium variation on a fat-free, moisture-free basis. Since moisture and fat may contribute to some of the variation in the potassium content of different muscles, they were compared on a fat-free, moisture-free basis (gm. potassium/kg. fat-free, moisture-free tissue). Results indicate that fat and moisture contributed to the variation in potassium content, since the number of means showing significant differences were reduced on correcting the data for fat and moisture. The percent decrease between means of the highest (rectus femoris - 17.27 gm./kg.) and lowest (longissimus dorsi - 16.04 gm./kg.) muscles was reduced to 7.85 on the fat-free, moisture-free basis.

Although the variation was reduced on a fat-free, moisture-free basis, significant differences still occurred. The rectus femoris and semitendinosus muscles had mean potassium values of 17.27 and 17.17 gm./kg., respectively. They were not significantly different from each other, but were significantly higher in potassium than all other muscles studied. The psoas major ranked third in potassium content (16.68 gm./kg.) and contained significantly more potassium than the semimembranosus, supraspinatus, triceps brachii and the longissimus dorsi muscles. However, the psoas major was not significantly different from the biceps femoris (16.41 gm./kg.). Although the longissimus dorsi was lowest in potassium content (16.04 gm./kg.), the differences between it and the semimembranosus (16.37 gm./kg.), the supraspinatus (16.30 gm./kg.) and the triceps brachii (16.27 gm./kg.) were not statistically significant ($P < .05$). The latter three muscles were, however, significantly lower in potassium content than all other muscles, except for the longissimus dorsi and biceps femoris.

ment

(196

mois

of P

free

cons

pota

valu

tassi

agree

The r

was a

the p

spina

fall

semit

than

respe

were

and 1

media

other

The variation in the potassium content of steer muscles is in agreement with the results of Gillett et al. (1965) and Lawrie and Pomeroy (1963), who compared the potassium content of pig muscles on a fat-free, moisture-free basis. The results are, however, in contrast to the work of Pfau and Kallistratos (1963), who concluded that the fat-free, moisture-free potassium content of all muscles from a single pig were relatively constant. Since the literature contains little information on the potassium content of bovine muscles, it was not possible to compare the values for cattle with those from other studies.

Potassium variation on a protein basis. The concentration of potassium on a protein basis (gm. potassium/kg. protein) was in close agreement with the values obtained on a fat-free, moisture-free basis. The ranking of means in order of descending concentration of potassium was as follows: the semitendinosus, rectus femoris, semimembranosus, then the psoas major, biceps femoris (both the same), followed by the supraspinatus, triceps brachii and longissimus dorsi. The muscles seemed to fall into three groups with regard to their potassium content. The semitendinosus and rectus femoris were significantly higher in potassium than all other muscles studied with values of 18.60 and 18.47 gm./kg., respectively. The semimembranosus, biceps femoris and psoas major muscles were intermediate in potassium content, with mean values of 18.10, 17.98 and 17.98 gm. of potassium per kg. of protein, respectively. This intermediate group of three muscles did not differ significantly from each other, but they did have significantly less potassium than the two highest mu

pc

Th

otl

val

wer

<u>dor</u>

Gil

musc

fron

on a

was

fewe

the p

was s

gm. c

<u>longi</u>

on a

still

This

and c

for p

is bas

indiv

muscles, i.e., *semitendinosus* and *rectus femoris*, and significantly more potassium than the *supraspinatus*, *triceps brachii* and *longissimus dorsi*. The latter three muscles were significantly lower in potassium than all other muscles, but they did not differ from each other ($P < .05$). Mean values of 17.44, 17.39 and 17.14 gm. of potassium per kg. of protein were obtained for the *supraspinatus*, *triceps brachii* and *longissimus dorsi*, respectively.

In contrast to the work reported on pig muscles (Pfau *et al*., 1963; Gillett *et al*., 1965), where the *semitendinosus* and *longissimus dorsi* muscles did not differ significantly from each other, the same muscles from the steers did differ significantly in potassium content ($P < .05$) on a protein basis. The variation in potassium content between muscles was reduced when the data were placed on a protein basis. There were fewer muscles showing significant differences than on the wet basis, and the percent decrease between the means of the highest and lowest muscles was smaller (6.91 percent). The *semitendinosus* was highest with 18.60 gm. of potassium per kg. of protein compared to 17.14 gm./kg. for the *longissimus dorsi* - the lowest muscle. Although variation was reduced on a protein basis or when corrected for fat and moisture, differences still existed in the potassium-protein ratio and the potassium-lean ratio. This indicates a lack of constancy in the potassium-protein relationship, and could represent an important source of error in the use of potassium for predicting the composition of cattle. Since the lack of constancy is based on mean values, even larger differences would be expected between individual animals.

than

lack

pred

test

bree

cont

were

sign

on a

(P <

did

perc

that

tein

low

ence

ation

furth

<u>Varia</u>

muscl

Variation in potassium among the steer muscles appeared to be less than that of the pigs in the present investigation, yet constancy was lacking in both cases. This indicates a general lack of accuracy in predicting composition from total potassium or potassium-40 counts.

Potassium variation among breeds. The error mean square used for testing breed differences was obtained by removing the effects of muscle, breed and the muscle x breed interaction. Breed differences in potassium content of Hereford and Angus steers did not exist when individual muscles were analyzed. On considering all eight muscles together, however, significant breed differences occurred in the total potassium content on a protein basis ($P < .01$) and on a fat-free, moisture-free basis ($P < .05$), but not on a wet basis. This indicates that fat and moisture did not contribute to the variation between breeds in this study. The percent decrease between the potassium content of the Angus muscles and that of the Herefords only amounted to 2.13 and 1.79 percent on a protein basis and on a fat-free, moisture-free basis, respectively. Such low values for percent decrease between breeds indicate that the difference in potassium content between breeds was not an important consideration in the potassium-protein or potassium-lean ratio for cattle and, furthermore, the breed difference was less for cattle than for pigs.

Variation of Sodium in Steer Muscles

Table 5 summarizes the data on the sodium content of the steer muscles. The sodium content of all eight muscles are listed on a wet

Table 5. *Sodium content of various steer muscles*

Table 5. Sodium content of various steer muscles

Muscle	Sodium gm./kg. of tissue					
	Wet basis		Fat-free, moisture-free basis		Protein basis	
	Mean[a]	Range	Mean[a]	Range	Mean[a]	Range
Supraspinatus (SS)	0.64[b]	0.50-0.81	3.03[b]	2.37-3.81	3.25[b]	2.53-4.07
Biceps femoris (BF)	0.54[c]	0.44-0.68	2.35[cd]	2.06-2.71	2.57[cd]	2.22-3.04
Rectus femoris (RF)	0.54[c]	0.47-0.68	2.45[c]	2.10-3.02	2.62[c]	2.20-3.24
Triceps brachii (TB)	0.54[c]	0.42-0.67	2.40[c]	2.01-3.07	2.56[cd]	2.13-3.28
Psoas major (PM)	0.50[d]	0.37-0.64	2.27[de]	1.72-2.80	2.44[cd]	1.80-3.01
Semitendinosus (ST)	0.50[d]	0.42-0.57	2.17[e]	1.83-2.52	2.34[e]	1.99-2.62
Semimembranosus (SM)	0.46[e]	0.38-0.55	1.95[f]	1.61-2.30	2.16[f]	1.78-2.48
Longissimus dorsi (LD)	0.44[e]	0.33-0.54	1.94[f]	1.44-2.43	2.07[f]	1.51-2.56
Average (all muscles)	0.52	0.33-0.81	2.36	1.44-3.81	2.50	1.51-4.07
Standard error[g]	7.706		37.558		43.347	

[a]Means within treatment in same column not bearing the same superscript are significantly different ($P < .05$).

[g]Square root of variance of the treatment mean where the error mean square is the interaction between muscles and animals.

basi

of c

of m

kg.

foll

and t

psoas

the s

highe

the m

next

brach

was o

conte

four

being

kg.

lower

per k

from

(supra

percen

relati

basis, fat-free, moisture-free basis and on a protein basis for purposes of comparison. Ranges are also included on each muscle as an indication of maximum variation within and between muscles.

Sodium variation on a wet basis. On a wet basis (gm. of sodium per kg. of wet tissue) the ranking of muscles from highest to lowest was as follows: the supraspinatus (highest); the biceps femoris, rectus femoris and triceps brachii (all containing the same amount); followed by the psoas major and semitendinosus (each with the same amount); and finally the semimembranosus and longissimus dorsi. The supraspinatus was much higher than the other muscles ($P < .05$) in sodium content. By comparing the mean of the supraspinatus (0.64 gm./kg.) with the mean values of the next three muscles, i.e., the biceps femoris, rectus femoris and triceps brachii (each with 0.54 gm. of sodium per kg.) a 15.4 percent decrease was obtained. The latter three muscles were significantly higher in sodium content than all other muscles except the supraspinatus. The remaining four muscles fell into two pairs with the psoas major and semitendinosus being intermediate in sodium concentration and each containing 0.50 gm./kg. The semimembranosus and longissimus dorsi muscles were significantly lower than all other muscles and contained 0.46 and 0.44 gm. of sodium per kg., respectively. These two muscles did not differ significantly from each other. The large variation between the means of the highest (supraspinatus) and lowest (longissimus dorsi) muscles amounted to a 30.7 percent decrease. Variation of such a magnitude in the sodium-muscle relationship would undoubtedly be reflected in estimates of composition c

s

e

re

pr

mo

der

lar

mai

the

brac

gm./

kg.),

per k

signi

more

mus do

cantl

sodiu

major

signi

T

spinat

on using sodium concentration as an index of composition. Lack of constancy in the sodium-lean relationship accounts for at least part of the error involved and explains why Kirton and Pearson (1963) found the relationship between sodium content and composition to be too low for practical use.

Sodium variation on a fat-free, moisture-free basis. On a fat-free, moisture-free basis, the variation between muscles was greater as evidenced by more differences between individual muscles ($P < .05$) and larger differences between extreme means. The supraspinatus muscle remained significantly higher in sodium content than all other muscles of the study. It was followed by the rectus femoris (2.45 gm./kg.), triceps brachii (2.40 gm./kg.), biceps femoris (2.35 gm./kg.), psoas major (2.27 gm./kg.), semitendinosus (2.17 gm./kg.) and the semimembranosus (1.95 gm./kg.), while the longissimus dorsi was lowest with only 1.94 gm. of sodium per kg. of fat-free, moisture-free tissue.

The rectus femoris, triceps brachii and biceps femoris did not differ significantly in sodium content, however, each of these muscles contained more sodium ($P < .05$) than the semitendinosus, semimembranosus and longissimus dorsi muscles. The biceps femoris and psoas major were not significantly different, while the semitendinosus contained significantly more sodium than the semimembranosus and longissimus dorsi. Although the psoas major contained more sodium than the semitendinosus the difference was not significant ($P < .05$).

The percent decrease between extreme means for the highest (supraspinatus - 3.03 gm./kg.) and the lowest (longissimus dorsi - 1.94) muscles

w
s
s
me
wa

ca
qu
al.
con
inv

sodi
prot
fat-
mean
mus
to th
moist
prote
large
perce

on a

was 36.0 percent. Such variation represents a lack of constancy in the sodium-lean ratio of considerable magnitude, and thus suggests that sodium is not a good index of composition. These studies are in agreement with the work of Kirton and Pearson (1963), who found that potassium was more closely related to composition than sodium.

On comparing the ranking of muscles for potassium and sodium, it can be observed that the *supraspinatus* muscle was highest in sodium, but quite low in potassium. This is in agreement with the work of Flear *et al*. (1965), who observed an inverse relationship between sodium and potassium concentration in human muscle biopsies. However, they indicated that the inverse relationship was not quantitative for all muscles.

Sodium variation on a protein basis. When the concentration of sodium among muscles was compared on a protein basis (gm. sodium per kg. protein), the ranking was quite similar to that on a wet basis or on a fat-free, moisture-free basis. The extreme variation between the highest mean (3.25 gm./kg. - *supraspinatus*) and the lowest (2.07 gm./kg. - *longissimus dorsi*) amounted to a 36.3 percent decrease. This was almost identical to the 36.0 percent decrease found on the same muscles on a fat-free, moisture-free basis. The variation between muscles was increased on a protein basis compared to the wet basis as evidenced by the fact that a larger number of muscles showed significant differences and a greater percent decrease occurred between extreme means.

The mean ranking of muscles in descending concentration of sodium on a protein basis was as follows: *supraspinatus* (3.25 gm./kg.), *rectus*

femoris (2.62 gm./kg.), *biceps femoris* (2.57 gm./kg.), *triceps brachii* (2.56 gm./kg.), *psoas major* (2.44 gm./kg.), *semitendinosus* (2.34 gm./kg.), *semimembranosus* (2.16 gm./kg.) and the *longissimus dorsi* (2.07 gm./kg.). The *supraspinatus* had significantly more sodium than all other muscles, while the *semimembranosus* and *longissimus dorsi* had less than all other muscles (P < .05). The *rectus femoris, biceps femoris, triceps brachii* and *psoas major* were relatively high in sodium and did not differ significantly from each other. The *semitendinosus* was significantly higher than the two lowest muscles (the *semimembranosus* and *longissimus dorsi*), but lower than all other muscles on a protein basis.

The extreme variation in sodium on any basis of comparison suggests that sodium would be a rather poor index of composition and errors of considerable magnitude might be expected. Constancy does not exist in the sodium-muscle, sodium-lean, or sodium-protein ratio, which makes the use of sodium as an index of composition impractical.

Sodium variation among breeds. Differences in sodium content of various muscles from Angus and Hereford steers were not significant on any basis of comparison (P < .05). This suggests that breed differences were not an important consideration in predicting composition from sodium content. The fact that breed differences were small and unimportant in this study does not necessarily eliminate the possibility that larger differences may exist between breeds as only two breeds were compared and the number of animals in each was small. Furthermore, the animals may not have been representative of the breeds studied.

Content of Fat, Protein and Moisture in Steer Muscles

Table 6 shows the percent fat, moisture and protein for individual muscles. As might be expected, large differences occurred in percent fat between muscles and between individual steers. The psoas major was highest with a mean value of 7.40 percent, and contained significantly more fat than all other muscles.

Table 6. Percent fat, moisture and protein in various steer muscles

	Mean[a]		
Muscles	Fat %	Moisture %	Protein %
Psoas major (PM)	7.40^{b}	70.48^{d}	20.53^{e}
Longissimus dorsi (LD)	6.21^{c}	70.83^{d}	21.50^{b}
Rectus femoris (RF)	5.80^{cd}	72.26^{c}	20.52^{e}
Supraspinatus (SP)	5.45^{d}	73.41^{b}	19.77^{f}
Triceps brachii (TB)	5.42^{d}	72.31^{c}	20.84^{de}
Biceps femoris (BF)	4.46^{e}	72.52^{c}	21.05^{cd}
Semitendinosus (ST)	3.57^{ef}	73.41^{b}	21.26^{bc}
Semimembranosus (SM)	3.18^{f}	73.18^{b}	21.40^{bc}
Average (all muscles)	5.18	72.30	20.86
Standard error[g]	4.29	.1823	.1351

[a]Means within treatment in same column not bearing the same superscript are significantly different ($P < .05$).
[g]Square root of variance of the treatment mean where the error mean square is the interaction between muscles and animals.

The longissimus dorsi and rectus femoris were not significantly different from each other, nor were the rectus femoris, supraspinatus

and _triceps brachii_ or the _semitendinosus_ and the _semimembranosus_ ($P < .05$). The _semitendinosus_ and _semimembranosus_ with mean values of 3.57 and 3.18 percent fat, respectively, were lower in fat than all muscles except the _biceps femoris_ ($P < .05$). The _biceps femoris_ contained significantly less fat than the _psoas major_, _longissimus dorsi_, _rectus femoris_, _supraspinatus_ and _triceps brachii_ but significantly more than the _semimembranosus_. The _longissimus dorsi_ contained significantly more fat than the _supraspinatus_, _triceps brachii_, _biceps femoris_, _semitendinosus_, and _semimembranosus_, but less than the _psoas major_.

The _supraspinatus_ and _semitendinosus_, both with mean values of 73.41 percent, and the _semimembranosus_ with a mean value of 73.18 percent contained more moisture ($P < .05$) than all other muscles. The _psoas major_ and _longissimus dorsi_ with mean values of 70.48 and 70.83 percent, respectively, contained significantly less moisture than all other muscles studied. The _biceps femoris_, _triceps brachii_ and _rectus femoris_ muscles with mean values of 72.52, 72.31 and 77.26 percent moisture, respectively, were intermediate in moisture content. They did not differ from each other ($P < .05$), but they were significantly different from all other muscles.

The mean ranking of muscles in percent protein from highest to lowest was as follows: the _longissimus dorsi_ (21.50 percent), _semimembranosus_ (21.40 percent), _semitendinosus_ (21.26 percent), _biceps femoris_ (21.05 percent), _triceps brachii_ (20.84 percent), _psoas major_ (20.53 percent), _rectus femoris_ (20.52 percent) and the _supraspinatus_ with only 19.77 percent protein. The three highest muscles (_longissimus dorsi_, _semimembranosus_ and _semitendinosus_) did not differ in percent protein ($P < .05$),

but they contained significantly more protein than the psoas major, rectus femoris, supraspinatus and triceps brachii.

Significant differences did not occur between the semimembranosus, semitendinosus, and biceps femoris nor between the biceps femoris and triceps brachii. Similarly, the triceps brachii, psoas major and rectus femoris did not differ significantly in protein concentration. The supraspinatus with a mean protein content of 19.77 percent contained less protein than all other muscles. It was followed by the rectus femoris and psoas major muscles, which had significantly less protein than all muscles except the supraspinatus and triceps brachii. The percent decrease between the muscle highest in protein (longissimus dorsi - 21.50 percent) and the lowest (supraspinatus - 19.77 percent) was 8.0 percent. This indicates an unusually large amount of variation in the protein content of various muscles. However, the effects of variation in protein were presumably removed by calculating the potassium-protein and sodium-protein ratios.

Variation of Potassium in Sheep Muscles

Table 7 summarizes the data on the potassium content of various lamb muscles. The mean potassium concentration of the four muscles studied are shown along with ranges for the muscles. To provide a comparison, all muscles are shown on a wet tissue basis, a fat-free, moisture-free basis and on a protein basis.

Table 7. Potassium content of various lamb muscles.

Fat-free

Table 7. Potassium content of various lamb muscles.

Muscle	Wet basis		Fat-free moisture-free basis		Protein basis	
	Mean[a]	Range	Mean[a]	Range	Mean[a]	Range
Semitendinosus	3.87[b]	3.28-4.48	17.86[b]	14.84-21.34	18.97[b]	14.46-18.64
Rectus femoris	3.78[c]	3.25-4.31	17.61[b]	14.76-20.60	18.90[b]	15.37-20.10
Semimembranosus	3.64[d]	3.11-4.06	16.25[c]	14.16-18.93	17.56[c]	16.67-21.88
Longissimus dorsi	3.56[e]	3.16-4.29	15.58[d]	13.63-17.15	16.67[d]	16.23-21.14
Overall average	3.71		16.58		18.03	
$S_{\bar{x}}$[f]	0.0179		0.1112		0.0918	

[a]Means within treatment in the same column not bearing the same superscript are significantly ($P < .05$) different.

[f]Square root of variance of the treatment mean where the error mean square is the interaction between muscles and animals.

per

conc

<u>femo</u>

signi

and c

was s

and w

<u>dorsi</u>

of 3.6

<u>longis</u>

kg. (P

A

of the

higher

0.30 pe

percent

on sepa

in this

differe

to anim

differe

Th

- 3.87

to 8.0

Potassium variation on a wet basis. On a wet basis (gm. of potassium per kg. of fresh tissue), the ranking of means in order of descending concentration of potassium was as follows: the *semitendinosus*, *rectus femoris*, *semimembranosus*, and *longissimus dorsi*. The *semitendinosus* was significantly higher in potassium concentration than all other muscles and contained 3.87 gm. of potassium per kg. of tissue. The *rectus femoris* was second highest in potassium content with a mean value of 3.78 gm./kg. and was significantly higher than the *semimembranosus* and *longissimus dorsi* muscles. The *semimembranosus* muscle with a mean potassium content of 3.64 gm./kg. was significantly higher than the *longissimus dorsi*. The *longissimus dorsi* was lowest in potassium with a mean content of 3.56 gm./kg. ($P < .05$).

A range of 0.31 to 0.45 percent was observed in the potassium content of the four lamb muscles in the present study. These values are slightly higher than the following ranges reported in the literature: 0.20 to 0.30 percent for lamb muscle (Toscani and Buniak, 1947), 0.27 to 0.31 percent on sheep muscle (Harris *et al.*, 1952), and 0.27 to 0.34 percent on separable lean from lamb (Kirton and Pearson, 1963). The higher values in this study may have been because different muscles were used or because differences existed in the fat or moisture content of the muscles. Animal to animal variation can not be overlooked as a possible cause of the difference.

The percent decrease between the means of the highest (*semitendinosus* - 3.87 gm./kg.) and the lowest (*longissimus dorsi* - 3.56) muscles amounted to 8.0 percent on a wet basis. The variation in potassium content between mu

ti

pot

aff

and

pota

free

mois

rank

foll

longi

and r

and ha

these

more p

The se

signif

of the

Wh

and lo

a fat-

variati

suggest

muscles indicates that constancy is lacking in the potassium muscle relationship on a wet basis. Unless the muscle to muscle variation in potassium content is due to differences in fat or moisture, it would affect the accuracy of the potassium-composition relationship for sheep.

Potassium variation on a fat-free, moisture-free basis. Since fat and moisture could be responsible for some of the variation in muscle potassium, their effects were removed by converting the values to a fat-free, moisture-free basis, i.e., gm. of potassium per kg. of fat-free, moisture-free tissue. A comparison on this basis did not alter the ranking of means. They ranked from high to low in potassium content as follows: the semitendinosus, rectus femoris, semimembranosus and the longissimus dorsi. The two highest muscles, i.e., the semitendinosus and rectus femoris, did not differ significantly in potassium content and had mean values of 17.86 and 17.61 gm./kg., respectively. Although these latter two muscles were not significantly different, both contained more potassium than the semimembranosus and longissimus dorsi ($P < .05$). The semimembranosus with a mean potassium content of 16.25 gm./kg. had significantly more potassium than the longissimus dorsi, the lowest muscle of the study.

When the means of the highest (the semitendinosus - 17.86 gm./kg.) and lowest (longissimus dorsi - 15.58 gm./kg.) muscles were compared on a fat-free, moisture-free basis a 12.77 percent decrease occurred. This variation in extreme means was higher than it was on a wet basis and would suggest that the variation of potassium in the lamb muscles was not due to f

twee

but

pota

of fa

betwe

able

lack

flecte

ships.

T

indivi

Pearso

separa

over t

conten

higher

a fat-

P

gm. of

signif

fat-fr

contai

ively,

to fat or moisture. However, one can also note that the difference between the semitendinosus and rectus femoris was significant on a wet basis, but not on a fat-free, moisture-free basis. Thus, the variation in potassium was reduced between these two muscles on removing the effects of fat and moisture. Nevertheless, the differences in potassium content between the other muscles are of great enough magnitude to make questionable the constancy of the potassium-lean ratio in lamb muscles. The lack of constancy in the potassium-lean ratio would undoubtedly be reflected in a reduction of accuracy in the potassium composition relationships.

The literature contains no information on the potassium content of individual sheep muscles on a fat-free, moisture-free basis. Kirton and Pearson (1963), however, reported that the potassium content of the separable lean increased by 0.025 to 0.34 percent on a fat-free basis over the wet basis, the amount of increase being dependent upon the fat content of the sample. Since the mean moisture content is about 15-fold higher than the average fat content, if the data had been calculated on a fat-free, moisture-free basis the values would be much higher.

Potassium variation on a protein basis. On a protein basis, i.e., gm. of potassium per kg. of protein, the mean ranking of muscles and the significant differences between muscles were identical to those on a fat-free, moisture-free basis. The semitendinosus and rectus femoris contained 18.97 and 18.90 gm. of potassium per kg. of protein, respectively, and were higher ($P < .05$) than the other muscles of this study, but

con

higl

was

cent

muscl

on a

a lac

of th

for a

total

conte

l

the p

lambs

than

blood

blood

blood

a sta

appro

as th

potas

(Kerr,

but were not significantly different from each other. The semimembranosus contained 17.56 gm. of potassium per kg. of protein and was significantly higher than the longissimus dorsi muscle. The longissimus dorsi muscle was lowest in potassium with a mean content of 16.67 gm./kg. A 12.12 percent decrease existed between the semitendinosus and longissimus dorsi muscles on a protein basis compared to 8.01 and 12.77 percent, respectively, on a wet basis and fat-free, moisture-free basis. These results indicate a lack of constancy in the potassium content of lamb muscles regardless of the basis of comparison. The lack of constancy in potassium accounts for at least part of the error involved in determining composition from total potassium or potassium-40 and limits the usefulness of potassium content for estimating body composition.

Potassium variation in blood as related to muscle variation. When the potassium content of the blood of the 25 lambs was determined, the lambs fell into two groups. Four lambs contained much more blood potassium than the remainder. The blood samples from the lambs, which were high in blood potassium, had a mean content of 1.44 gm. of potassium per kg. of blood with a standard deviation of 0.117. The 21 lambs with low potassium blood had 0.42 gm. of potassium per kg. of blood on the average, with a standard deviation of 0.076. The high blood potassium lambs contained approximately three and one half times as much potassium in the blood as the low potassium group. The difference between the high and low potassium blood group is in close agreement with work reported earlier (Kerr, 1937; Mounib and Evans, 1958; Kidwell et al., 1959).

the

low

two

betw

on ar

ence

potas

(1960

bicep

were

made

Regard

body,

counts

two b

potas

live-

the la

conte

tact

of po

potass

based

Since there may be a carry over of potassium from blood to muscle, the potassium content of the muscles from the two blood types (high and low potassium) was compared. A statistical analysis of the data from the two blood types indicated that a significant difference did not exist between the potassium content of muscles taken from the two blood types on any basis of comparison. The failure to find a significant difference between the potassium content of muscles from low and high blood potassium type sheep was in agreement with the work of Mounib and Evans (1960), who failed to find a difference in the potassium content of the biceps femoris muscle of high and low blood types. Since only four lambs were of the high potassium type blood, definite conclusions cannot be made as to the effect of blood potassium content on the amount in muscles. Regardless of this relationship, since blood composes part of the sheep body, estimates of composition from total potassium or from potassium-40 counts on live sheep would be subject to error with the inclusion of the two blood types (high and low).

In order to determine the influence of different blood types on the potassium content of lamb, the effect was calculated using an average live-weight of 23.2 kg. as obtained in the present study, and assuming the lambs contained 8 percent blood (Dukes, 1955). Using a potassium content of 1.77 gm./kg. on the whole body (Kirton et al., 1961), the intact lamb would contain 41.0 gm. of potassium. If the value of 41.0 gm. of potassium represented the low blood potassium group, the high blood potassium lambs would have a calculated value of 42.9 gm. of potassium, based on values of 0.42 and 1.44 gm. of potassium per kg. of blood (present stu

amo

erro

and

in s

of b

Varia

means

scrip

basis

there

Table

M

Longis

Rectus

Semite

Semime

Overal

$S_{\bar{x}}$[f]

[a]Means

scrip

[f]Square

square

study). The difference between lambs representing the two groups would amount to a 4.4 percent decrease. Although 4.4 percent is not a large error, it would involve a consistent source of variability between high and low blood potassium lambs.

Since high and low potassium blood types have not been found (1966) in swine and cattle, the errors due to the variation in potassium content of blood are apparently negligible in these species.

Variation of Sodium in Sheep Muscles

Table 8 lists the content of sodium in various sheep muscles by means and ranges. The significant differences are indicated by superscripts. Comparisons are shown on a wet basis, fat-free, moisture-free basis and on a protein basis. The animals were not selected by breed and therefore breed differences are not shown.

Table 8. Sodium content of various lamb muscles.

	Wet basis		Fat-free, moisture-free basis		Protein basis	
Muscle	Mean[a]	Range	Mean[a]	Range	Mean[a]	Range
Longissimus dorsi	0.73^{b}	0.59-1.00	3.21^{b}	2.61-4.62	3.44^{b}	2.77-4.82
Rectus femoris	0.65^{c}	0.53-0.78	3.03^{c}	2.42-4.11	3.25^{c}	2.54-4.22
Semitendinosus	0.63^{d}	0.54-0.72	2.89^{d}	2.39-3.36	3.08^{d}	2.52-3.60
Semimembranosus	0.62^{d}	0.53-0.74	2.77^{e}	2.38-3.46	3.00^{d}	2.52-3.67
Overall average	0.66		2.98		3.19	
$S_{\bar{x}}$[f]	0.076		0.039		0.041	

[a]Means within treatment in the same column not bearing the same superscript are significantly ($P < .05$) different.

[f]Square root of variance of the treatment mean where the error mean square is the interaction between muscles and animals.

k

w

a

s

Al

mu

The

wit

fro

stud

of 0

(194

for s

0.069

repor

of 0.0

and 0.

on the

muscle

compar

Evans

hand,

<u>Sodium variation on a wet basis</u>. On a wet basis (gm. sodium per kg. wet tissue), the mean ranking of muscles in descending concentration was as follows: the <u>longissimus dorsi</u>, <u>rectus femoris</u>, <u>semitendinosus</u> and <u>semimembranosus</u>. The longissimus dorsi was significantly higher in sodium than all other muscles with a mean content of 0.73 gm./kg. Although the <u>rectus femoris</u> had less sodium ($P < .05$) than the <u>longissimus dorsi</u> it contained significantly more than the other two muscles. The <u>semitendinosus</u> and <u>semimembranosus</u> were lowest in sodium content with 0.63 and 0.62 gm./kg., respectively, and did not differ significantly from each other.

The overall range in sodium content for the four muscles of this study was 0.053 to 0.100 percent. These values are lower than the range of 0.079-0.140 percent for lamb muscle observed by Toscani and Buniak (1947), but agree closely with the figures of 0.073 and 0.074 percent for sheep muscles reported by Blaxter and Rook (1956) and figures of 0.069-0.081 percent observed on the separable lean from lamb carcasses reported by Kirton and Pearson (1963). The overall mean sodium content of 0.066 percent of this study agrees closely with the figures of 0.062 and 0.064 percent reported by Harris <u>et al</u>. (1952).

Mounib and Evans (1960) reported values of 0.050 to 0.045 percent on the fat-free, blood-free <u>biceps femoris</u> muscle of sheep. Since the muscles in the present study are not on the same basis, they cannot be compared. However, removal of effects of fat in the study of Mounib and Evans (1960) should increase the percentage of potassium. On the other hand, correcting for blood would decrease it, since blood has approximately a

h

co

ex

-m

fo

the

mear

twee

rank

ficar

was h

<u>semit</u>

<u>branos</u>

four r

basis.

C

conter

moistu

conten

four times as much sodium as muscle. Thus, removal of the blood may account for the low values reported by these workers.

In the present study, a 15.1 percent decrease occurred between the highest (longissimus dorsi) and lowest (semimembranosus) muscles in sodium content. This represents a larger variation (15.1 vs 8.0 percent) than existed in the case of potassium on comparing extreme means. The potassium -muscle relationship was more constant than the sodium-muscle relationship for sheep, which indicates that sodium is a poor index of lean content.

Sodium variation on a fat-free, moisture-free basis. By comparing the data on a fat-free, moisture-free basis (gm./kg.), the number of means showing significance was increased while the percent decrease between extreme means for sodium was reduced to 13.7 percent. The mean ranking remained the same as on a wet basis, but all muscles were significantly different from each other. The longissimus dorsi (3.21 gm./kg.) was highest followed by the rectus femoris (3.03 gm./kg.), then the semitendinosus with 2.89 gm. of sodium per kg., and finally the semimembranosus (lowest) with 2.77 gm./kg. The overall mean content of the four muscles was 2.98 gm. of sodium per kg. on a fat-free, moisture-free basis. Comparisons are not available in the literature on this basis.

Constancy is lacking in the sodium-lean ratio, and therefore sodium content provides a poor index of composition. Corrections for fat and moisture content did not alter the variation between sodium and lean content in this study.

(2

te

re

pe

3.

The

ide

twe

pro

prot

good

gene

found

Conte

of th

fat (4

muscl

4.06

conte

longis

Howeve

Sodium variation on a protein basis. The ratio of sodium to protein (gm./kg.) was significantly different for all muscles, except the semitendinosus and semimembranosus, which had 3.08 and 3.00 gm./kg., respectively. The longissimus dorsi was highest with 3.44 gm. of sodium per kg. of protein and was followed by the rectus femoris muscle with 3.25 gm./kg., while the semitendinosus and semimembranosus were lowest. The ranking of means and the means showing significant differences were identical to that for the wet basis. However, the percent decrease between extreme means was decreased slightly (15.1 vs 12.8 percent) on a protein basis.

The lack of constancy in the sodium-muscle, sodium-lean and sodium-protein ratios in lamb muscle indicates that sodium content is not a good indicator of composition on any basis. These conclusions are in general agreement with the work of Kirton and Pearson (1963), who also found that sodium lacks precision as an index of body composition.

Content of Fat, Protein and Moisture in Sheep Muscles

Table 9 summarizes the data on the fat, protein and moisture content of the four lambs muscles studied. The semitendinosus was highest in fat (4.90 percent) and contained significantly more fat than all other muscles. It was followed by the longissimus dorsi muscle, which contained 4.06 percent. The semimembranosus was third from the highest in fat content (3.64 percent), but did not differ significantly from the longissimus dorsi (4.06 percent) nor the rectus femoris (3.56 percent). However, the longissimus dorsi and rectus femoris were significantly d

A

ser

bet

hig

tent

conte

the l

betwe

very

ences

and s

contai

Table 9. Fat, moisture and protein in lamb muscles

Muscle	Mean[a] Fat	Moisture	Protein
Semitendinosus	4.90[b]	73.38[d]	20.42[c]
Longissimus dorsi	4.06[c]	73.09[e]	21.35[b]
Semimembranosus	3.64[cd]	73.96[c]	20.72[c]
Rectus femoris	3.56[d]	74.93[b]	20.00[d]
Overall average	4.04	73.84	20.65
$S_{\bar{x}}$[f]	.159	.092	.111

[a]Means within treatment in the same column not bearing the same superscript are significantly (P < .05) different.
[f]Square root of variance of the treatment mean where the error mean square is the interaction between muscles and animals.

different (P < .05). The *rectus femoris* had the lowest fat content. A 27.3 percent decrease existed between the *rectus femoris* (lowest and *semitendinosus* (highest) muscles, while a 12.3 percent decrease existed between the *rectus femoris* (lowest) and the *longissimus dorsi* (second highest) muscles. These values reflect wide variation in the fat content of the muscles studied.

All of the muscles differed significantly (P < .05) in moisture content. The *rectus femoris* (highest) had 74.93 percent moisture, while the *longissimus dorsi* (lowest) had 73.09 percent. The percent decrease between these two means amounted to only 2.5 percent, which indicates very little variation occurred between muscles, even though the differences were large enough to be significant (P < .05). The *semimembranosus* and *semitendinosus* muscles were intermediate in moisture content and contained 73.96 and 73.38 percent moisture, respectively.

m

w

re

a

th

ce

con

or

Pota

to s

relat

will

tassi

muscle

betwee

and sh

basis

The longissimus dorsi was significantly higher in protein than all other muscles with 21.35 percent protein. It was followed by the semimembranosus (20.72 percent) and the semitendinosus (20.42 percent) muscles, which did not differ significantly, but contained more protein than the rectus femoris ($P < .05$). The rectus femoris was lowest in protein with a mean value of 20.00 percent. Even though the actual differences between the high and low muscles amounted to only 1.25 percent protein, the percent decrease was 6.3 percent.

The effect of variation in fat, moisture and protein on the potassium content is removed by placing the data on a fat-free, moisture-free basis or on a protein basis.

Potassium and Sodium Variation Between Species

Among the various muscles utilized in this study, four were common to swine, cattle and sheep. Since it was of interest to compare the relative amount of potassium and sodium in muscles of these animals, they will be discussed separately under potassium and sodium.

Potassium. Table 10 shows a comparison of the mean content of potassium in four individual muscles and the combined mean of all four muscles. As an indication of the extent of variation, the percent decrease between the highest and lowest means are also included. Swine, cattle and sheep are shown separately on a wet basis, a fat-free, moisture-free basis and on a protein basis.

Av

Pe

Rect
Semi
Semi
Long

Avera

Percen

[a]The p
withi

Table 10. Potassium content of muscles by species.

Muscle	Mean Swine	Mean Cattle	Mean Sheep
	Wet tissue basis, gm./kg.		
Rectus femoris	4.05	3.79	3.78
Semimembranosus	3.88	3.87	3.64
Longissimus dorsi	3.82	3.68	3.56
Semitendinosus	3.65	3.95	3.87
Average of four muscles	3.85	3.80	3.71
Percent decrease[a]	9.9%	6.8%	8.0%
	Fat-free, moisture-free basis, gm./kg.		
Semitendinosus	17.48	17.17	17.86
Rectus femoris	17.30	17.27	17.61
Semimembranosus	16.21	16.37	16.25
Longissimus dorsi	16.11	16.04	15.58
Average of four muscles	16.78	16.71	16.82
Percent decrease[a]	7.8%	7.1%	12.8%
	Protein basis, gm./kg.		
Rectus femoris	19.01	18.47	18.80
Semitendinosus	18.02	18.60	18.97
Semimembranosus	17.70	18.10	17.56
Longissimus dorsi	17.00	17.14	16.67
Average of four muscles	17.93	18.08	18.00
Percent decrease[a]	10.6%	7.8%	12.1%

[a]The percent decrease is calculated from the highest and lowest means within species.

On a wet basis, the difference between the overall averages for the species studied were small. The differences between muscles within a species appear to be larger than the differences between species. On a fat-free, moisture-free basis or on a protein basis, the variation in potassium content between species was reduced. The differences between species based on the overall average of the four muscles from each species were all very small on either a fat-free, moisture-free basis or on a protein basis. Judging from the small differences between species, there appears to be little difference in the potassium content of skeletal muscle if the muscles utilized in this study are representative.

On a wet basis, muscle to muscle variation occurred within all species, and the ranking of muscles by mean content of potassium was extremely variable between all species. Although some muscle to muscle variation was evident on a fat-free, moisture-free basis and on a protein basis, the ranking of means according to their potassium concentration was very similar between species. Only a limited number of muscles varied in the order of ranking from one species to the next, in which case the means involved were generally not significantly different in potassium concentration.

Sodium. Table 11 compares the average sodium content for each of the four muscles, the overall mean sodium content, and percent decrease between extreme muscle means within each species. Sodium values are listed for swine, cattle and sheep on a wet basis and on a fat-free, moisture-free basis. The magnitude of the percent decrease between extreme muscle means indicates large muscle to muscle variations in sodium

content, regardless of the basis of comparison or species examined. Unlike potassium, the ranking of means for sodium concentration was highly variable between species on both a wet basis and a fat-free, moisture-free basis.

Table 11. Sodium content of muscles by species.

Muscle	Mean Swine	Mean Cattle	Mean Sheep
	Wet tissue basis, gm./kg.		
Semitendinosus	0.53	0.50	0.62
Semimembranosus	0.50	0.46	0.63
Rectus femoris	0.49	0.54	0.65
Longissimus dorsi	0.45	0.44	0.73
Average of four muscles	0.49	0.49	0.66
Percent decrease[a]	15.1%	18.5%	15.1%
	Fat-free, moisture-free basis, gm./kg.		
Semitendinosus	2.54	2.17	2.89
Rectus femoris	2.11	2.45	3.03
Semimembranosus	2.08	1.95	2.77
Longissimus dorsi	1.88	1.94	3.21
Average of four muscles	2.15	2.13	2.98
Percent decrease[a]	26.0%	20.8%	13.7%

[a]Percent decrease is calculated from highest and lowest means within species.

Results indicate a general lack of constancy in sodium content among species as well as between individual muscles. The ranking of muscles in order of sodium content was also erratic between species. These factors further verify the low relationship between sodium content and body composition.

Variation of Potassium in Body Compartments of Swine

Table 12 shows the potassium content of the six compartments of the pig in addition to the whole animal and carcass. The data are compared on a wet basis, a fat-free, moisture-free basis and on a protein basis. Superscripts are used to denote significance between means.

Table 12. Potassium content of various compartments of the pig (gm./kg.)

	Mean[a]		
Compartment	Wet basis	Fat-free moisture-free basis	Protein basis
Ham	2.65[b]	13.65[c]	15.33[b]
Shoulder	2.33[c]	12.80[d]	14.66[cd]
Loin	2.18[de]	13.32[c]	15.13[bc]
Side	1.79[h]	14.01[b]	14.06[e]
Blood	2.07[fg]	10.06[e]	14.44[de]
GI and head	1.99[g]	11.37[d]	10.53[f]
Carcass	2.27[cd]	13.35[c]	14.57[de]
Animal - whole	2.16[ef]	12.82[d]	14.87[bcd]
$S_{\bar{x}}$[i]	.02415	0.11814	0.13534

[a]Means within the same column not bearing the same superscript are significantly different ($P < .05$).
[i]Standard error of the mean ($S_{\bar{x}}$).

Potassium variation on a wet basis. On a wet basis, the four compartments comprising the carcass (the ham, shoulder, loin and side) all had significantly different concentrations of potassium. The ham was highest with 2.65 gm./kg. followed by the shoulder with 2.33 gm./kg., then the loin with 2.18 gm./kg. and finally the side with only 1.79 gm. of potassium per kg. of fresh tissue. The potassium content of the blood (2.07 gm./kg.) and the GI tract and head (1.99 gm./kg.) did not differ significantly. When these two compartments were included with the carcass compartments, 2.16 gm. of potassium per kg. of tissue were obtained for the whole animal compared to 2.27 gm. for the carcass compartments alone. Neither the shoulder nor the loin with 2.33 and 2.18 gm./kg., respectively, were significantly different from the carcass (2.27 gm./kg.). Although the loin (2.18 gm./kg.) and blood (2.07 gm./kg.) differed significantly in potassium content, neither compartment showed significance when compared to the value for the whole animal (2.16 gm./kg.).

The ham with 2.65 gm./kg. contained significantly more potassium than all other compartments, including the carcass and whole animal, while the side with only 1.79 gm./kg. contained significantly less potassium than all other compartments. The percent decrease between the potassium content of the highest (ham) and lowest (side) compartments for both the carcass and the whole animal was 32.4 percent.

Although the percent decrease in potassium is quite large between the ham and side, it is not surprising since the ham has a higher concentration of protein than the side. The shoulder, likewise, would be expected to have more potassium than the loin, since the loin compartment included the fatback. In order for potassium differences between individual compartments to be of major importance, the data must be corrected for fat and moisture.

<u>Potassium variation on a fat-free, moisture-free basis</u>. On placing the data on a fat-free, moisture-free basis, the ranking of means in descending order of potassium concentration was as follows: the side, ham, carcass, loin, whole animal, shoulder, GI tract and head and the blood. On this basis of comparison, the various compartments (including the total carcass and animal) fell into four groups. The side was highest in potassium with a mean content of 14.01 gm./kg., which was significantly greater than all other compartments. It was followed by the ham, carcass and loin with 13.65, 13.35 and 13.32 gm./kg., respectively, which did not differ significantly from each other. The content of potassium in the whole animal (12.82 gm./kg.), the shoulder (12.80 gm./kg.) and the GI tract and head (11.37 gm./kg.) were not significantly different from each other, but all were significantly lower than the ham, carcass and loin. The blood was lowest in potassium with a mean content of 10.06 gm./kg. and was significantly lower than all other compartments.

An 8.6 percent decrease in potassium occurred between extreme means of the carcass compartments (side vs shoulder), while a considerably larger percent decrease (28.2 percent) occurred between the extreme means of the total animal compartments (side vs blood). Extremes of this magnitude indicate that constancy does not exist in the potassium-lean ratio of carcasses or whole animals and reflect an important source of error in determining composition from total potassium or potassium-40. However, judging from the differences in the percent decrease of carcass compartments versus animal compartments, one should be able to predict composition of carcasses much more accurately than that of live animals.

<u>Potassium variation on a protein basis</u>. On a protein basis, the ranking of means according to potassium concentration from high to low was as follows: the ham (15.33 gm./kg.), loin (15.13 gm./kg.), whole animal (14.87 gm./kg.), shoulder (14.66 gm./kg.), intact carcass (14.57 gm./kg.), blood (14.44 gm./kg.), side (14.06 gm./kg.) and finally the GI tract and head compartment (10.53 gm./kg.).

The ham was significantly higher in potassium content than the shoulder or side, but did not differ significantly from the loin. The shoulder contained more ($P < .05$) potassium than the side on a protein basis, but the difference between the loin and shoulder was not significant. The concentration of potassium in the whole animal (14.87 gm./kg.) was significantly higher than the concentration of the side and also the GI tract and head, while the difference between the whole animal and all other compartments were not significant ($P < .05$). The carcass contained more potassium ($P < .05$) than the GI tract and head, but significantly less than the ham or loin. Differences between the carcass and the remaining compartments, including the total animal, were not significant ($P < .05$).

The percent decrease between the extreme means for carcass compartments (ham vs side) was 8.3 percent, while it was 31.3 percent for the animal compartments (ham vs GI tract and head). Thus, variation in the potassium-protein ratio of various compartments of the pig suggest that the theoretical basis for using potassium or potassium-40 in determining composition of the intact pig is questionable.

Relationship of Potassium to Composition

Table 13 shows the correlation coefficients between the potassium content of each compartment and the percent fat, protein and moisture of the same compartment, the intact carcass and the whole animal. The relationship between total carcass potassium and composition of the carcass are also indicated by correlation coefficients, while similar relationships are shown for the whole animal. The ham seems to be more closely related to the composition of the carcass and whole animal body than any other compartment. Highly significant correlation coefficients of -.86, 0.83 and 0.87 were obtained when the potassium concentration of the hams was related to carcass fat, protein and moisture, respectively. Slightly higher values of -.87, 0.84 and 0.87, respectively, were obtained on the whole animal when the same comparisons were made.

When the potassium content of each carcass compartment was related to the composition of the carcass or the whole animal, all relationships were highly significant. However, the potassium content of the blood was not related to body composition ($P < .05$). The content of the GI tract and head was related ($P < .05$), but the relationships were too low to be useful. On comparing the potassium content of the carcass with the percent fat, protein and moisture of the carcass, correlation coefficients of -.90, 0.81 and 0.92 were obtained, respectively. When the potassium of the whole animal was related to the fat, protein and moisture content of the whole animal, correlation coefficients of -.93, 0.77 and

Relationship of Potassium to Composition

Table 13 shows the correlation coefficients between the potassium content of each compartment and the percent fat, protein and moisture of the same compartments, the intact carcass and the whole animal. The relationship between total carcass potassium and composition of the carcass are also indicated by correlation coefficients, while similar relationships are shown for the whole animal. The ham seems to be more closely related to the composition of the carcass and whole animal body than any other compartment. Highly significant correlation coefficients of -.86, 0.83 and 0.87 were obtained when the potassium concentration of the hams was related to carcass fat, protein and moisture, respectively. Slightly higher values of -.89, 0.84 and 0.97, respectively, were obtained on the whole animal when the same comparisons were made.

When the potassium content of each carcass compartment was related to the composition of the carcass or the whole animal, all relationships were highly significant. However, the potassium content of the blood was not related to body composition (P < .05). The content of the GI tract and head was related (P < .05), but the relationships were too low to be useful. On comparing the potassium content of the carcass with the percent fat, protein and moisture of the carcass, correlation coefficients of -.90, 0.81 and 0.92 were obtained, respectively. When the potassium of the whole animal was related to the fat, protein and moisture content of the whole animal, correlation coefficients of -.93, 0.77 and

Table 13. Relationship between potassium and the chemical components of body composition of pigs.[a,b]

Independent variables (gm./kg.)	Dependent variables: Compartment[c] % Fat	% Protein	% Moisture	Carcass % Fat	% Protein	% Moisture	Whole animal % Fat	% Protein	% Moisture
K^+ shoulder	-.74	0.63	0.76	-.73	0.59	0.75	-.75	0.53	0.76
K^+ loin	-.84	0.74	0.85	-.81	0.67	0.82	-.85	0.62	0.84
K^+ side	-.91	0.78	0.92	-.80	0.73	0.82	-.82	0.74	0.83
K^+ ham	-.86	0.67	0.86	-.86	0.83	0.87	-.87	0.84	0.87
K^+ GI and head	-.43	0.71	0.53	-.43	0.50	0.46	-.48	0.58	0.53
K^+ blood	--	0.36	-.61	-.03	0.08	0.04	-.04	0.12	-.09
K^+ carcass	-.91	0.80	0.93	-.90	0.81	0.92	-.93	0.80	0.93
K^+ animal	-.93	0.80	0.93	-.91	0.80	0.93	-.93	0.77	0.94

[a]Correlation coefficients > 0.40 are significant at 5% level.
[b]Correlation coefficients > 0.51 are significant at 1% level.
[c]Correlations given under compartment are those for the independent variable opposite the value.

and 0.94, respectively, were obtained. All correlation coefficients for the carcasses and whole animals were highly significant on relating potassium concentration to the chemical components (fat, protein and moisture).

Table 14 contains regression equations for predicting the composition of swine carcasses and of the whole animal from the potassium concentration of the ham, carcass or whole animal. The square root of the error mean square represents the variation from the regression equation which might be expected to occur. The percent moisture of the carcass can be predicted within ± 1.13 percent from the total potassium of the carcass. This gives a total range of 2.26 percent which represents approximately 21.8 percent of the entire range in moisture content between the carcasses used in this study.

Percent fat can be predicted within ± 5.08 percent, which gives a range of 10.16 percent and represents 74.8 percent of the entire range in fat content of the carcasses. The percent protein of a carcass can be predicted within ± 0.56 percent. This gives a range of 1.12 percent and represents 31.1 percent of the entire range in protein content in this study. In view of the magnitude of the standard errors, potassium does not appear to accurately discriminate between individual carcasses.

It should also be pointed out that when total potassium is used to predict the composition of the whole animal, plus or minus one standard error includes 19.4 percent of the total range in percent water, 74.5 percent of the range in fat content and 32.7 percent of the range in protein content. This suggests that potassium does not accurately discriminate between individual animals or carcasses.

Table 14. Regression equations for predicting fat, protein and moisture of swine carcasses and animal bodies from potassium concentration.

Independent variable (X) (gm./kg.)	Dependent variable (Y) (percent)	Regression equation	Square root error mean square
Potassium ham	fat carcass	Y = 14.72 - 15.62X	4.98%
Potassium ham	protein carcass	Y = 3.80X + 5.22	0.53%
Potassium ham	moisture carcass	Y = 12.04X + 16.97	1.42%
Potassium ham	fat animal	Y = 64.34 - 12.77X	4.05%
Potassium ham	protein animal	Y = 3.51X + 5.53	0.47%
Potassium ham	moisture animal	Y = 10X + 23.78	1.18%
Potassium carcass	fat carcass	Y = 14.15X + 16.73	5.08%
Potassium carcass	protein carcass	Y = 4.12X + 5.92	0.56%
Potassium carcass	moisture carcass	Y = 14.15X + 16.73	1.13%
Potassium animal	fat animal	Y = 70.22 - 18.38X	4.17%
Potassium animal	protein animal	Y = 4.33X + 5.47	0.55%
Potassium animal	moisture animal	Y = 14.55X + 18.85	0.82%

Variation of Sodium in Body Compartments of Swine

Table 15 summarizes the sodium content of the compartments of the pig body. The content of sodium is expressed on a wet basis, a fat-free, moisture-free basis and on a protein basis. The total animal includes the four carcass compartments and the remaining two non-carcass compartments, i.e., the blood and GI tract and head.

Table 15. Sodium content of various compartments of the pig (gm./kg.).

	Mean[a]		
Compartment	Wet basis	Fat-free, moisture-free basis	Protein basis
Blood	1.97^{b}	9.50^{b}	9.90^{b}
GI and head	1.37^{c}	7.82^{c}	10.00^{b}
Shoulder	0.85^{de}	4.65^{e}	5.33^{d}
Ham	0.82^{e}	4.21^{fg}	4.73^{e}
Loin	0.65^{g}	3.98^{g}	4.53^{ef}
Side	0.55^{h}	4.30^{f}	4.31^{f}
Carcass	0.73^{f}	4.30^{f}	4.79^{e}
Animal	0.83^{d}	5.19^{d}	5.90^{c}
$S_{\bar{x}}$[i]	0.01185	0.07440	0.08390

[a]Means within a column not bearing the same superscript are significantly different ($P < .05$).
[i]Standard error of the mean ($S_{\bar{x}}$).

Sodium variation on a wet basis. On a wet basis, the ranking of means in descending order of sodium concentration was as follows: the blood, GI tract and head, whole animal, shoulder, ham, carcass, loin and

side. The blood with 1.97 and the GI tract and head with 1.37 gm. of sodium per kg. were significantly different from each other and were significantly higher in sodium content than all four carcass compartments, as well as for the carcass and total animal. Of the carcass compartments, the shoulder and ham were highest in sodium concentration with mean values of 0.85 and 0.82 gm./kg., respectively. They did not differ significantly from each other, but were significantly higher in sodium than the carcass, loin and side. The carcass, loin and side with 0.73, 0.65 and 0.55 gm. of sodium per kg. of tissue, respectively, were relatively low in sodium, and each was significantly different from all other compartments including the total animal. The sodium concentration of the whole animal was 0.87 gm./kg., which was intermediate between the carcass and non-carcass compartments (blood and GI tract and head).

The percent decrease between sodium concentration of the shoulder (highest) and the side (lowest) was 35.4 percent on comparing the carcass compartments. When all compartments were compared, a 72.3 percent decrease occurred between the blood (highest) and the side (lowest). This value indicates that considerable variation exists in the sodium concentration between the body compartments as well as the carcass compartments.

Sodium variation on a fat-free, moisture-free basis. On removing the effects of fat and moisture, large variations still occurred between compartments. Among the carcass compartments, the shoulder (4.65 gm./kg.) was significantly higher in sodium content than the side (4.30 gm./kg.), ham (4.21 gm./kg.) and loin (3.98 gm./kg.). The ham did not differ side. The blood with 1.97 and the GI tract and head with 1.77 gm. of sodium per kg. were significantly different from each other and were significantly higher in sodium content than all four carcass compartments, as well as for the carcass and total animal. Of the carcass compartments, the shoulder and ham were highest in sodium concentration with mean values of 0.85 and 0.82 gm./kg., respectively. They did not differ significantly from each other, but were significantly higher in sodium than the carcass, loin and side. The carcass, loin and side with 0.73, 0.65 and 0.55 gm. of sodium per kg., respectively, were relatively low in sodium, and each was significantly different from all other compartments including the total animal. The sodium concentration of the whole animal was 0.87 gm./kg., which was intermediate between the carcass and non-carcass compartments (blood and GI tract and head).

The percent decrease between sodium concentration of the shoulder (highest) and the side (lowest) was 35.4 percent on comparing the carcass compartments. When all compartments were compared, a 72.3 percent decrease occurred between the blood (highest) and the side (lowest). This value indicates that considerable variation exists in the sodium concentration between the body compartments as well as the carcass compartments.

Sodium variation on a fat-free, moisture-free basis. On removing the effects of fat and moisture, large variations still occurred between compartments. Among the carcass compartments, the shoulder (4.65 gm./kg.) was significantly higher in sodium content than the side (4.30 gm./kg.), ham (4.21 gm./kg.) and loin (3.98 gm./kg.). The ham did not differ significantly from the side or loin in sodium concentration, however, the side and loin differed significantly from each other.

The two non-carcass compartments (the blood and the GI tract and head) were significantly higher than all carcass compartments, including the total carcass and whole animal. The blood was significantly higher in sodium content than the GI tract and head. The blood had a mean sodium content of 9.50 gm./kg. compared to 7.82 gm./kg. for the GI tract and head. The whole animal with 5.19 gm. of sodium per kg. of tissue was intermediate in sodium content and was ranked between the carcass and non-carcass compartments. The carcass contained 4.30 gm. of sodium per kg. of tissue and contained significantly more sodium than the loin but less ($P < .05$) than the shoulder. The carcass contained the same concentration of sodium (4.30 gm./kg.) as the side and only slightly more than the ham (4.21 gm./kg.) on a fat-free, moisture-free basis.

A 58.1 percent decrease in sodium occurred between extreme means for the animal compartments (blood vs loin), while a 14.4 percent decrease occurred between extremes in carcass compartments (shoulder vs loin). Variation of this magnitude indicates that constancy is lacking in the sodium-lean ratio, and since the values have been corrected for differences in fat and moisture, the variation may be assumed to be actual. This indicates that sodium content is not a useful index of composition.

<u>Sodium variation on a protein basis</u>. On a protein basis, the content of sodium in the two non-carcass compartments (GI tract and head, and blood) did not differ significantly from each other, but both contained

significantly more sodium than the whole animal, the carcass or any of the individual carcass compartments. The GI tract and head was highest in sodium with 10.00 gm. of sodium per kg. followed by the blood with 9.90 gm./kg. The content of sodium in the animal (5.90 gm./kg.) was next and again was intermediate between carcass and non-carcass compartments. The shoulder with 5.33 gm. of sodium per kg. ranked highest among the carcass compartments and differed significantly from all other compartments as well as the total carcass (4.79 gm./kg.). The loin with 4.53 gm. of sodium per kg. of tissue did not differ significantly from the ham (4.73 gm./kg.), the side (4.31 gm./kg.) or the total carcass (4.79 gm./kg.). The difference between the sodium content of the side and the ham on a protein basis was significant.

A 19.2 percent decrease occurred between the mean sodium content of the shoulder (highest) and side (lowest), when the carcass compartments were compared, while a 56.9 percent decrease occurred between the extremes in the animal compartments (GI tract and head vs side). Regardless of the basis of comparison, variation of considerable magnitude occurred between compartments. Thus, the sodium-muscle, sodium-lean and sodium-protein ratios lack constancy from compartment to compartment.

Relationship of Sodium to Composition

Table 16 shows correlation coefficients between sodium concentration and fat, protein and moisture of the carcass and whole animal. The concentration of sodium in each compartment is related to the chemical components of the same compartment, as well as to the components of the significantly more sodium than the whole animal, the carcass or any of the individual carcass compartments. The GI tract and head was highest in sodium with 10.00 gm. of sodium per kg. followed by the blood with 9.90 gm./kg. The content of sodium in the animal (5.50 gm./kg.) was next and again was intermediate between carcass and non-carcass compartments. The shoulder with 5.35 gm. of sodium per kg. ranked highest among the carcass compartments and differed significantly from all other compartments as well as the total carcass (4.79 gm./kg.). The loin with 4.53 gm. of sodium per kg. of tissue did not differ significantly from the ham (4.73 gm./kg.), the side (4.31 gm./kg.) or the total carcass (4.79 gm./kg.). The difference between the sodium content of the side and the ham on a protein basis was significant.

A 19.2 percent decrease occurred between the mean sodium content of the shoulder (highest) and side (lowest), when the carcass compartments were compared, while a 56.9 percent decrease occurred between the extremes in the animal compartments (GI tract and head vs side). Regardless of the basis of comparison, variation of considerable magnitude occurred between compartments. Thus, the sodium-muscle, sodium-lean and sodium-protein ratios lack constancy from compartment to compartment.

Relationship of Sodium to Composition

Table 16 shows correlation coefficients between sodium concentration and fat, protein and moisture of the carcass and whole animal. The concentration of sodium in each compartment is related to the chemical components of the same compartment, as well as to the components of the

Table 16. Relationship between sodium and the chemical components of body composition of pigs.[a,b]

Independent variables (gm./kg.)	Dependent variables: Compartment[c] % Fat	Compartment[c] % Protein	Compartment[c] % Moisture	Carcass % Fat	Carcass % Protein	Carcass % Moisture	Whole animal % Fat	Whole animal % Protein	Whole animal % Moisture
Na^+ shoulder	-.38	0.16	0.33	-.36	0.25	0.35	-.41	0.17	0.40
Na^+ loin	-.40	0.23	0.33	-.35	0.08	0.29	-.32	0.01	0.24
Na^+ side	-.62	0.47	0.62	-.58	0.54	0.59	-.61	0.51	0.63
Na^+ ham	-.17	0.28	0.13	-.12	0.11	0.10	-.20	-.00	0.22
Na^+ GI and head	-.46	0.13	0.37	-.10	0.01	0.09	-.16	-.04	0.19
Na^+ blood	--	0.14	0.07	-.12	-.01	0.13	-.08	0.05	0.77
Na^+ carcass	-.43	0.28	0.39	-.42	0.28	0.39	-.47	0.18	0.44
Na^+ animal	-.45	0.14	0.48	-.35	0.24	0.34	-.45	0.14	0.48

[a]Correlation coefficients $\gtrsim$ 0.40 are significant at 5% level.
[b]Correlation coefficients $\gtrsim$ 0.51 are significant at 1% level.
[c]Correlations given under compartment are those for the independent variable opposite the values.

carcass and animal. The total sodium of the carcass and animal are also related to the percent fat, protein and moisture of the carcass and animal.

Among the individual compartments of the animal, the sodium content of the side appeared to be most closely related to composition. It was more closely related to the composition of the carcass and whole animal than was the total potassium concentration of the carcass or animal. Although some of the correlation coefficients were significant at $P < .05$ and a few at $P < .01$, the values were all too low to be of practical significance. Therefore, regression equations were not calculated for sodium. In general, the relationships of sodium to composition was much lower than the same relationship for potassium.

Content of Fat, Protein and Moisture in Body Compartments of Swine

Table 17 shows the percent fat, protein and moisture in various compartments of the pig, including the total carcass and whole animal. On considering the four carcass compartments, the percent fat varied inversely with the percent protein and moisture. In every case, the differences between compartments in fat, protein and moisture were significant ($P < .05$). The side was highest in fat content with 48.22 percent followed by the loin (41.02 percent), shoulder (32.07 percent), and ham (26.90 percent). The carcass was intermediate in fat content and contained 36.12 percent, which was significantly lower than the side and loin, but higher ($P < .05$) than the shoulder and ham. The fat content of the blood was so low that it was not determined, while the GI tract and head was next to lowest with only 16.91 percent. The average content of fat in the whole animal amounted to 30.50 percent.

Table 17. Fat, protein and moisture content of various compartments of the pig.

Compartment	Mean[a] % Fat	% Protein	% Moisture
Side	48.22^{b}	12.74^{h}	39.00^{h}
Loin	41.02^{c}	14.43^{f}	42.58^{g}
Shoulder	32.07^{e}	15.90^{d}	49.73^{e}
Ham	26.90^{f}	17.29^{c}	53.68^{d}
Carcass	36.12^{d}	15.28^{e}	46.86^{f}
GI and head	16.91^{g}	13.78^{g}	65.49^{c}
Blood	---^{h}	20.04^{b}	79.20^{b}
Animal	30.50^{e}	14.83^{ef}	50.28^{e}
$S_{\bar{x}}$[i]	0.40476	0.14678	0.27202

[a]Means within a column not bearing the same superscript are significantly different ($P < .05$).
[i]Standard error of the mean ($S_{\bar{x}}$).

The blood was highest in protein with 20.04 percent, while the GI tract and head component was next to lowest (13.78 percent). These two compartments are not considered part of the carcass. Among the carcass compartments, the ham was highest in protein (17.29 percent), followed by the shoulder (15.90 percent), then the loin with 14.43 percent and finally the side with only 12.74 percent. The carcass and animal contained an average of 15.28 and 14.83 percent protein, respectively.

All compartments of the pig body were significantly different in moisture content except the whole animal and the shoulder. The two non-carcass components, i.e., the blood (79.20 percent) and the GI tract and head (65.49 percent) were highest in percent moisture. Among the carcass compartments, the ranking was the same for moisture as for protein. The ham was highest in moisture content with 53.68 percent, the shoulder followed with 49.73, then came the loin with 42.58 and finally the side with only 39.00 percent. The total carcass contained 46.86 percent moisture while the whole animal contained 50.28 percent.

SUMMARY AND CONCLUSIONS

In order to determine the possible sources of error involved in predicting composition from sodium and potassium content, muscle to muscle variation was studied in swine, cattle and sheep. In addition, variation of potassium and sodium in compartments of the pig body and variation in blood and muscles of low and high blood potassium type sheep was examined.

On the basis of the results of these investigations, the following conclusions may be drawn:

1. Potassium concentration was more closely related to composition than sodium in swine, cattle and sheep.

2. The regression equations for predicting composition from potassium have rather large standard errors and suggest that potassium does not accurately distinguish between individuals.

3. Muscle to muscle variation occurs in the potassium and sodium content for swine, cattle and sheep muscles regardless of the basis of comparison.

4. The ranking of muscles by potassium concentration on a fat-free, moisture-free basis or protein basis were generally the same for all species. The values obtained suggest that more variation exists between muscles within a species than between the same muscles from different species.

5. Although the number of lambs with high blood potassium was limited, the data suggest that the blood potassium level was not significantly related to muscle potassium concentration.

SUMMARY AND CONCLUSIONS

In order to determine the possible sources of error involved in predicting composition from sodium and potassium content, muscle to muscle variation was studied in swine, cattle and sheep. In addition, variation of potassium and sodium in compartments of the pig body and variation in blood and muscles of low and high blood potassium type sheep was examined.

On the basis of the results of these investigations, the following conclusions may be drawn:

1. Potassium concentration was more closely related to composition than sodium in swine, cattle and sheep.

2. The regression equations for predicting composition from potassium have rather large standard errors and suggest that potassium does not accurately distinguish between individuals.

3. Muscle to muscle variation occurs in the potassium and sodium content for swine, cattle and sheep muscles regardless of the basis of comparison.

4. The ranking of muscles by potassium concentration on a fat-free, moisture-free basis or protein basis were generally the same for all species. The values obtained suggest that more variation exists between muscles within a species than between the same muscles from different species.

5. Although the number of lambs with high blood potassium was limited, the data suggests that the blood potassium level was not significantly related to muscle potassium concentration.

6. Variation of potassium and sodium between compartments of the pig body occurred regardless of the basis of comparison.

7. Constancy did not exist in the potassium-muscle, potassium-lean, or potassium-protein ratio in muscles or compartments and is responsible for at least part of the error in predicting composition from total potassium or potassium-40.

BIBLIOGRAPHY

Allen, T. H., E. C. Anderson and W. H. Langham. 1960. Total body potassium and gross body composition in relation to age. J. Gerontol. 15:348.

Anderson, E. C. 1957. Scintillation counters. The Los Alamos human counter. British J. Radiol., Suppl. No. 7:27.

Anderson, E. C. 1958. The Los Alamos human counter. p. 211. Liquid Scintillation Counting. Permagon Press, New York - London.

Anderson, E. C. and M. A. Van Dilla. 1958. Low-level gamma ray detection in humans. Ire transactions of the professional group on nuclear science. NS-5:194.

Anderson, E. C. 1959. Application of natural gamma activity measurements to meat. Food Res. 24:605.

Anderson, E. C. and W. H. Langham. 1959. Average potassium concentration of the human body as a function of age. Science 130:713.

Anderson, E. C. 1962. Personal communications to Kirton, A. H., 1962 (see below).

Archdeacon, J. W., W. R. Markesberg and B. R. Binford. 1961. Bone marrow cellularity and Na and K levels in fasting and inanition after bile duct ligation. Am. J. Physiol. 200:1207.

Babineau, L. M. and E. Page. 1955. On body fat and body water in rats. Canad. J. Biochem. Physiol. 33:970.

Benne, E. J., N. H. Van Hall and A. M. Pearson. 1956. Analysis of fresh meat. J. Assn. Official Agr. Chem. 39:937.

Bergstrom, W. H. and W. M. Wallace. 1954. Bone as a sodium and potassium reservoir. J. Clin. Invest. 33:867.

Blaxter, K. L. and J. A. F. Rook. 1956. The indirect determination of energy retention in farm animals. I. The development of method. J. Agr. Sci. 48:194.

Brent, B. E. 1965. Personal communication.

Brozek, J. and A. Henchel (Editors). 1961. Techniques for Measuring Body Composition. Proc. of Conference at Quartermaster Res. and Engin. Center, Natick, Mass., held Jan. 22-23, 1959. National Academy of Sciences - National Research Council, Washington, D. C.

Burch, P. R. J. and F. W. Spiers. 1953. Measurement of the γ - radiation from the human body. Nature 172:519.

Casey, J. H. and B. Zimmermann. 1960. Bone sodium in surgical operations and disease. Annals of Surgery 152:927.

Cheek, D. B. and C. D. West. 1955. An appraisal of methods of tissue chloride analysis : The total carcass chloride, exchangable chloride, potassium and water of the rat. J. Clin. Invest. 34:1744.

Clancy, R. L. and E. B. Brown, Jr. 1963. Changes in bone potassium in response to hypercapnia. J. of Am. Physiol. 204:757.

Conway, E. J. 1957. Nature and significance of concentration relations of potassium and sodium ions in skeletal muscle. Physiol. Rev. 37:84.

Dean, J. A. 1960. Flame Photometry. McGraw-Hill Book Company, Inc., New York.

Drury, A. N. and E. M. Tucker. 1963. Red cell volume, potassium and haemoglobin changes in lamb. Res. in Vet. Med. 4:568.

Dukes, H. H. 1955. The Physiology of Domestic Animals. 7th Edition. Comstock Publishing Associates, Ithaca, New York.

Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics 11:1.

Edelman, I. S., A. H. James, H. Baden and F. D. Moore. 1954a. Electrolyte composition of bone and the penetration of radiosodium and deuterium oxide into dog and human bone. J. Clin. Invest. 33:122.

Edelman, I. S., A. H. James, L. Brooks and F. D. Moore. 1954b. Body sodium and potassium. IV. The normal total exchangable sodium; its measurement and magnitude. Metabolism 3:530.

Edelman, I. S., J. Eeibman, M. P. O'Meara and L. W. Birkenfeld. 1958. Interrelationship between serum sodium concentration, serum osmolarity and total exchangeable sodium, total exchangeable potassium and total body water. J. Clin. Invest. 37:1236.

Edelman, I. S. 1961. Body water and electrolytes. See Brozek and Henschel, 1961. p. 140.

Evans, J. V. 1954. Electrolyte concentrations in red blood cells of British breeds of sheep. Nature 174:931.

Evans, J. V. and J. W. B. King. 1955. Genetic control of sodium and potassium concentrations in the red blood cells of sheep. Nature 175:171.

Evans, J. V., J. W. B. King, B. L. Cohen, H. Harris and F. L. Warren. 1956. Genetics of hemoglobin and blood potassium differences in sheep. Nature 178:849.

Flear, C. T. G., R. G. Carpenter and I. Florence. 1965. Variability in water, sodium,,potassium and chloride content of human skeletal muscle. J. of Clin. Pathol. 18:74.

Forbes, G. B. and A. Perley. 1951. Estimation of total body sodium by isotope dilution. I. Studies on young adults. J. Clin. Invest. 30:558.

Forbes, G. B. and A. M. Lewis. 1956. Total sodium, potassium and chloride in adult man. J. of Clin. Invest. 35:596.

Gillett, T. A., A. M. Pearson and A. H. Kirton. 1965. Variation in potassium and sodium in muscles of the pig. J. of Animal Sci. 24:177.

Guyton, A. C. 1956. Textbook of Medical Physiology. W. B. Saunders Company, Philadelphia and London.

Hall, J. L. 1953. Ether extraction method of estimating degree of fatness in carcasses and cuts. Proc. 6th Ann. Recip. Meats Conf. p. 122.

Harrington, G. 1958. Pig Carcass Evaluation. Commonwealth Agricultural Bureaux, Farnham Royal, Bucks, England.

Harris, H., I. R. McDonald and W. Williams. 1952. The electrolyte pattern in experimental anuria. Australian J. Expt. Biol. Med. Sci. 30:33.

Harrison, H. E. and D. C. Darrow. 1938. The distribution of body water and electrolytes in adrenal insufficiency. J. of Clin. Invest. 17:87.

Hix, V. M., 1966. Determination of specific gravity of live hogs by a modification of the air displacement and helium dilution procedures. Ph.D. Thesis. Michigan State University.

Howes, J. R., G. K. Davis, P. E. Loggins and J. F. Hentges. 1961. Blood potassium and sodium of Hereford and Brahman cattle and some breeds of sheep maintained in Florida. Nature 190:181.

Kerr, S. E. 1937. Studies on the inorganic composition of blood. IV. The relationship of potassium to the acid soluble phosphorus fractions. J. of Biol. Chem. 117:227.

Keys, A. and J. Brozek. 1953. Body fat in adult man. Physiol. Rev. 33:245.

Khattab, G. H., J. H. Watson and R. F. E. Axford. 1964. Inherited physiological differences in red cell characteristics of Welsh mountain sheep. J. of Agric. Sci. 63:173.

Kidwell, J. F., V. R. Bohman, W. A. Wade, L. H. Haverland and J. E. Hunter. 1959. Evidence of genetic control of blood potassium concentration in sheep. J. of Heredity 50:275.

Kirton, A. H., A. M. Pearson, E. C. Anderson and R. L. Schuch. 1960. The use of naturally occurring K^{40} to determinine the carcass composition of live sheep. J. of Animal Sci. 19:1237 (Abstract).

Kirton, A. H., A. M. Pearson, R. W. Porter and R. H. Nelson. 1961. The use of natural gamma activity to measure the composition of pork and lamb samples. J. of Food Sci. 26:475.

Kirton, A. H. 1962. The potassium, sodium and cesium content of animals and the relationship to composition. Ph.D. Thesis. Michigan State University.

Kirton, A. H., R. H. Gnaedinger and A. M. Pearson. 1963. Relationship of potassium and sodium content to the composition of pigs. J. of Animal Sci. 22:904.

Kirton, A. H. and A. M. Pearson. 1963. Comparison of methods of measuring potassium in pork and lamb and prediction of their composition from sodium and potassium. J. of Animal Sci. 22:125.

Kulwich, R., L. Feinstein and E. C. Anderson. 1958. Correlation of potassium-40 concentration and fat-free lean content of hams. Science 127:338.

Kulwich, R., L. Feinstein and C. Golumbic. 1960. Beta radioactivity of the ash in relation to the composition of ham. J. Animal Sci. 19:119.

Kulwich, R., L. Feinstein, C. Golumbic, R. L. Hiner, W. R. Seymour and W. R. Kauffman. 1961a. Relationship of gamma-ray measurements to the lean content of hams. J. Animal Sci. 20:497.

Kulwich, R., L. Feinstein, C. Golumbic, W. R. Seymour, W. R. Kauffman and R. L. Hiner. 1961b. Relation of gamma-ray emission to the lean content of beef rounds. Food Technol. 15:411.

Lade, R. I. and E. B. Brown, Jr. 1963. Movement of potassium between muscle and blood in response to respiratory acidosis. Am. J. of Physiol. 204:761.

Keys, A. and J. Brozek. 1953. Body fat in adult man. Physiol. Rev. 33:245.

Khattab, G. H., J. H. Watson and R. F. E. Axford. 1964. Inherited physiological differences in red cell characteristics of Welsh mountain sheep. J. of Agric. Sci. 63:173.

Kidwell, J. F., V. R. Bohman, M. A. Wade, L. H. Haverland and J. E. Hunter. 1959. Evidence of genetic control of blood potassium concentration in sheep. J. of Heredity 50:275.

Kirton, A. H., A. M. Pearson, E. C. Anderson and R. L. Schuch. 1960. The use of naturally occurring K^{40} to determine the carcass composition of live sheep. J. of Animal Sci. 19:1237 (Abstract).

Kirton, A. H., A. M. Pearson, D. E. Porter and R. H. Nelson. 1961. The use of natural gamma activity to measure the composition of pork and lamb samples. J. of Food Sci. 26:475.

Kirton, A. H. 1962. The potassium, sodium and cesium content of animals and the relationship to composition. Ph.D. Thesis. Michigan State University.

Kirton, A. H., R. H. Gnaedinger and A. M. Pearson. 1963. Relationship of potassium and sodium content to the composition of pigs. J. of Animal Sci. 22:904.

Kirton, A. H. and A. M. Pearson. 1963. Comparison of methods of measuring potassium in pork and lamb and prediction of their composition from sodium and potassium. J. of Animal Sci. 22:125.

Kulwich, R., L. Feinstein and E. C. Anderson. 1958. Correlation of potassium-40 concentration and fat-free lean content of hams. Science 127:338.

Kulwich, R., L. Feinstein and C. Golumbic. 1960. Beta radioactivity of the ash in relation to the composition of ham. J. Animal Sci. 19:119.

Kulwich, R., L. Feinstein, C. Golumbic, R. L. Hiner, W. R. Seymour and W. R. Kauffman. 1961a. Relationship of gamma-ray measurements to the lean content of hams. J. Animal Sci. 20:497.

Kulwich, R., L. Feinstein, C. Golumbic, W. R. Seymour, W. R. Kauffman and R. L. Hiner. 1961b. Relation of gamma-ray emission to the lean content of beef rounds. Food Technol. 15:411.

Lade, R. I. and E. B. Brown, Jr. 1963. Movement of potassium between muscle and blood in response to respiratory acidosis. Am. J. of Physiol. 204:761.

Laug, E. P. and W. C. Wallace. 1959. A survey of radioactive residues in foods before and after 1945 : Evidence of possible fallout contamination. J. Assn. Official Agr. Chem. 42:431.

Lawrie, R. A. and R. W. Pomeroy. 1963. Sodium and potassium in pig muscle. J. Agric. Sci. 61:409.

Manery, J. F. 1954. Water and electrolyte metabolism. Physiol. Rev. 34:334.

McClain, P. E., A. M. Mullins, S. L. Hansard, J. D. Fox and R. F. Boulware. 1965. Relationship of alkali insoluble collagen to tenderness of three bovine muscles. J. of Animal Sci. 24:1107.

Miller, C. E. and A. P. Remenchik. 1963. Problems involved in accurately measuring the K content of the human body. Ann. N.Y., Acad. Sci. 110:175.

Moore, F. D., J. P. McMurry, H. V. Parker and I. C. Magnus. 1956. Total body water and electrolytes : Intravascular and extravascular phase volumes. Metabolism, Clin. and Exptl. 5:447.

Mounib, M. S. and J. V. Evans. 1957. Comparison between three methods used for the preparation of tissues for determination of potassium and sodium. Analyst 82:522.

Mounib, M. S. and J. V. Evans. 1960. The potassium and sodium contents of sheep tissues in relation to the potassium content of the erythrocytes and the age of the animal. Biochem. J. 75:77.

Muldowney, F. P. 1963. The value of muscle biopsy in the diagnosis of clinical alterations in total body water, body potassium, and body sodium. Ann. N.Y. Acad. Sci. 110:654.

Nesterov, V. P. 1964. Issledovanie mikroloaklizatsii Kaliya v miofibrille s pomoshchyu tetrafeniberata natriya i interferentsionnogo mikroskopa. Tsitologiya 6(6):754.

Pfau, A., G. Kallistratos and J. Schroder. 1961. Zur Bestimmung des Fleischgehaltes im Schweineschinken mit Hilfe von ^{40}K-Gammasktivitatsmessungen. Atomprexis 7:279.

Pfau , Von A., G. Kallistratos, B. Ossowski, H. Hoeck and Z. Zivkovic. 1963. Untersuchungen zur Bestimmung von Körperbestandteilen lebender Schweine über ^{40}K-Gamma-Radioaktivitatsmessungen. I. Der Kaliumgehalt des M. longissimus dorsi und des M. semimembranceus bei 110 kg. schweren Schweinen unterschiedlichen Geschlechts und Rasse. Z. Tierz. Züchtungsbiol. 78:179.

Pfau, Von A. and G. Kallistratos. 1963. Untersuchungen zur Bestimmung von Körperbestandteilen lebender Schweine über ^{40}K-Gamma-Radioaktivitatsmessungen. II. Der Kaliumgehalt der Muskulatur eines 110 kg. schweren Schweines. Z. Tierz. Züchtungsbiol. 79:249.

Rasmusen, B. A. and J. G. Hall. 1966. Association between potassium concentration and serological type of sheep red blood cells. Science 151:1551.

Robinson, J. R. 1960. Metabolism of intracellular water. Physiol. Rev. 40:112.

Sievert, R. M. 1951. Measurement of γ-radiation from the human body. Arkiv Fysik 3:337.

Sievert, R. M. 1956. Untersuchungen uber die Gammastrahlung des menschlichen Korpers. Strahlentherapie 99:185.

Smith, J. D. and J. H. Meyer. 1962. Interactions of dietary sodium and potassium and their influence on energy metabolism. Am. J. of Physiol. 203:1081.

Spray, C. M. and E. M. Widdowson. 1950. The effect of growth and development on the composition of mammals. British J. Nutr. 4:332.

Suttle, A. D. Jr. and W. F. Libby. 1955. Absolute assay of beta radioactivity in thick solids. Application to naturally radioactive potassium. Anal. Chem. 27:921.

Toscani, V. and V. Buniak. 1947. Sodium and potassium content of meats. Food Res. 12:328.

Van Dilla, M. A., G. R. Farmer and V. R. Bohman. 1961. Fallout radioactivity in cattle and its effects. Science 133:1075.

Vinogradov, A. P. 1957. The isotope K^{40} and its role in biology. Biokhimiya 22:14. Cited by Kulwich et al., 1960a.

Wolstenholme, G. E. W. and M. O'Connor. 1958. Ciba Foundation Collosuia on Ageing. Vol. 4. Water and electrolyte metabolism in relation to age and sex. pp. 15, 102 and 199. Little, Brown and Company, Boston.

Woodward, K. T., T. T. Trajillo, R. L. Schuch and E. C. Anderson. 1956. On the correlation of total body potassium with body water. Nature 178:97.

Zeidberg, L. D., J. J. Schueneman, P. A. Humphrey and R. A. Prindle. 1961. Air pollution and health : General description of a study in Nashville, Tennessee. J. Air Pollution Control Ass,, 11:289.

Zobrisky, S. E., H. D. Naumann, A. J. Dyer and E. C. Anderson. 1959. The relationship between the potassium isotope, K^{40} and meatiness of live hogs. J. Animal Sci. 18:1480. (Abstract).

APPENDIX

List of Abbreviations Used in Appendix Tables

LD = *Longissimus dorsi*

SM = *Semimembranosus*

ST = *Semitendinosus*

PM = *Psoas major*

BF = *Biceps femoris*

RF = *Rectus femoris*

TB = *Triceps brachii*

SS = *Supraspinatus*

SH = Shoulder compartment

L = Loin compartment

S = Side compartment

H = Ham compartment

GI = GI tract and head compartment

B = Blood compartment

C = Carcass (includes: shoulder, loin, side and ham compartments)

A = Animal (includes carcass compartments plus blood and GI and head compartments)

$S_{\bar{x}}$ = Standard error of the mean

$\bar{x}$ = Mean

d.f. = Degrees of freedom

* = ($P < .05$)

** = ($P < .01$)

N.S. = Not significant at 5% level

List of Abbreviations Used in Appendix Tables

LD = *Longissimus dorsi*

SM = *Semimembranosus*

ST = *Semitendinosus*

PM = *Psoas major*

BF = *Biceps femoris*

RF = *Rectus femoris*

TB = *Triceps brachii*

SS = *Supraspinatus*

SH = Shoulder compartment

L = Loin compartment

S = Side compartment

H = Ham compartment

GI = GI tract and head compartment

B = Blood compartment

C = Carcass (includes: shoulder, loin, side and ham compartments)

A = Animal (includes carcass compartments plus blood and GI and head compartments)

$S_{\bar{x}}$ = Standard error of the mean

$\bar{x}$ = Mean

d.f. = Degrees of freedom

* = ($P < .05$)

** = ($P < .01$)

N.S. = Not significant at 5% level

Table 1. Potassium content of various swine muscles on a wet basis (gm./kg.)

Pig No.	Muscles					
	LD	SM	ST	PM	BF	RF
			Yorkshire			
1	3.960	4.019	3.686	3.581	3.849	4.148
2	3.946	4.019	3.819	3.842	3.919	4.185
3	3.916	3.950	3.724	3.710	3.834	4.047
4	3.855	3.932	3.615	3.933	3.740	4.115
5	3.700	3.766	3.555	3.346	3.603	4.011
6	3.540	3.611	3.488	3.414	3.340	3.779
			Hampshire			
7	3.883	3.988	3.645	3.419	3.841	4.173
8	3.734	3.830	3.734	3.564	3.845	4.198
9	3.963	4.095	3.775	3.701	3.954	4.228
10	3.802	3.890	3.587	3.539	3.720	4.093
11	3.879	4.016	3.742	3.664	3.905	4.315
12	3.936	3.961	3.751	3.723	3.802	4.006
$\bar{x}$ Yorkshire	3.820	3.883	3.648	3.638	3.714	4.048
$\bar{x}$ Hampshire	3.866	3.963	3.706	3.602	3.845	4.169
$\bar{x}$ Total	3.833	3.923	3.677	3.620	3.779	4.108

Table 2. Potassium content of various swine muscles on a fat-free, moisture free basis (gm./kg.).

Pig No.	Muscles					
	LD	SM	ST	PM	BF	RF
			Yorkshire			
1	16.930	17.444	17.807	15.887	17.680	18.129
2	16.713	17.037	18.423	16.866	17.590	18.109
3	16.657	16.169	17.827	15.978	17.636	17.384
4	16.016	16.488	17.447	16.844	16.870	17.638
5	15.605	15.890	17.241	15.018	16.437	16.154
6	14.738	14.335	16.118	15.879	14.871	16.388
			Hampshire			
7	16.927	17.883	17.065	13.887	17.427	18.096
8	16.377	15.972	17.303	16.485	17.884	17.514
9	17.351	16.810	18.193	16.762	18.014	18.968
10	17.400	17.674	17.855	16.249	17.936	18.958
11	16.851	18.033	18.147	16.169	18.551	19.437
12	17.188	17.132	18.496	16.006	16.988	17.749
$\bar{x}$ Yorkshire	16.109	16.218	17.477	16.078	16.847	17.300
$\bar{x}$ Hampshire	17.016	17.251	17.843	15.926	17.800	18.454
$\bar{x}$ Total	16.563	16.735	17.660	16.003	17.324	17.877

Table 3. Potassium content of various swine muscles on a protein basis (gm./kg.).

Pig No.	Muscles LD	SM	ST	PM	BF	RF
			Yorkshire			
1	17.694	18.193	18.430	16.609	18.433	19.071
2	17.663	18.452	19.336	17.869	18.494	19.957
3	17.552	18.432	18.335	16.909	18.423	19.044
4	16.673	17.719	18.720	17.926	17.600	19.364
5	16.263	17.164	16.247	15.933	17.255	18.629
6	16.127	16.229	17.039	16.909	15.762	17.995
			Hampshire			
7	16.000	19.425	18.511	14.648	18.967	20.198
8	17.900	18.574	19.089	18.276	19.282	20.598
9	19.098	19.763	19.579	18.303	19.799	20.972
10	19.095	19.567	18.998	17.642	19.264	20.818
11	19.005	21.070	20.021	18.292	20.650	22.415
12	19.650	20.417	20.452	18.055	19.750	20.512
$\bar{x}$ Yorkshire	16.995	17.698	18.017	17.025	17.661	19.010
$\bar{x}$ Hampshire	18.458	19.803	19.442	17.536	19.618	20.918
$\bar{x}$ Total	17.727	18.750	18.730	17.281	18.640	19.964

Table 4. Sodium content of various swine muscles on a wet basis (gm./kg.)

Pig No.	Muscles					
	LD	SM	ST	PM	BF	RF
			Yorkshire			
1	0.451	0.447	0.495	0.487	0.493	0.442
2	0.430	0.549	0.532	0.539	0.543	0.484
3	0.412	0.484	0.522	0.491	0.481	0.476
4	0.467	0.498	0.544	0.475	0.533	0.524
5	0.405	0.467	0.471	0.453	0.483	0.475
6	0.508	0.544	0.618	0.559	0.560	0.558
			Hampshire			
7	0.419	0.451	0.501	0.460	0.500	0.465
8	0.417	0.484	0.478	0.418	0.516	0.467
9	0.409	0.446	0.415	0.498	0.452	0.418
10	0.441	0.492	0.561	0.551	0.546	0.511
11	0.409	0.437	0.522	0.532	0.502	0.518
12	0.417	0.439	0.470	0.465	0.473	0.432
$\bar{x}$ Yorkshire	0.446	0.498	0.530	0.501	0.516	0.493
$\bar{x}$ Hampshire	0.419	0.458	0.491	0.487	0.498	0.468
$\bar{x}$ Total	0.432	0.478	0.511	0.494	0.507	0.481

Table 5. Sodium content of various swine muscles on a fat-free, moisture-free basis (gm./kg.).

Pig No.	Muscles					
	LD	SM	ST	PM	BF	RF
			Yorkshire			
1	1.928	1.940	2.391	2.161	2.264	1.932
2	1.821	2.327	2.566	2.366	2.437	2.094
3	1.752	1.981	2.499	2.114	2.212	2.045
4	1.940	2.082	2.625	2.034	2.404	2.246
5	1.708	1.970	2.284	2.033	2.203	1.913
6	2.115	2.160	2.856	2.600	2.493	2.420
			Hampshire			
7	1.826	2.022	2.346	1.868	2.269	2.016
8	1.829	2.018	2.215	1.933	2.400	1.948
9	1.791	1.831	2.000	2.255	2.059	1.875
10	2.018	2.235	2.792	2.530	2.632	2.367
11	1.777	1.962	2.532	2.348	2.385	2.333
12	1.821	1.899	2.318	1.999	2.113	1.914
$\bar{x}$ Yorkshire	1.877	2.076	2.537	2.218	2.335	2.108
$\bar{x}$ Hampshire	1.843	1.994	2.367	2.155	2.310	2.075
$\bar{x}$ Total	1.861	2.036	2.452	2.187	2.322	2.092

Table 6. Percent fat in various swine muscles.

Pig No.	Muscles					
	LD	SM	ST	PM	BF	RF
			Yorkshire.			
1	4.36	3.74	5.58	2.96	5.55	1.56
2	4.77	3.03	5.76	2.14	4.10	1.26
3	4.42	1.81	6.59	2.88	4.98	1.06
4	4.70	3.28	9.84	2.46	6.08	1.50
5	4.47	3.62	6.30	2.42	5.58	0.31
6	4.50	0.88	3.80	2.54	4.06	0.68
			Hampshire			
7	6.89	4.90	7.94	3.52	6.48	2.37
8	3.86	1.38	3.84	2.68	5.00	0.40
9	4.28	1.01	4.26	2.58	3.80	1.90
10	6.23	3.15	5.23	3.53	5.74	2.06
11	3.94	2.83	6.10	2.66	5.48	1.32
12	4.74	2.82	7.16	2.86	3.72	1.11
$\bar{x}$ Yorkshire	4.54	2.73	6.31	2.57	5.06	1.06
$\bar{x}$ Hampshire	4.99	2.68	5.76	2.97	5.04	1.53
$\bar{x}$ Total	4.76	2.70	6.03	2.77	5.05	1.29

Table 7. Percent protein in various swine muscles.

Pig No.	Muscles					
	LD	SM	ST	PM	BF	RF
			Yorkshire			
1	22.38	22.09	20.00	21.56	20.88	21.75
2	22.34	21.78	19.75	21.50	21.19	20.97
3	22.31	21.43	20.31	21.94	20.81	21.25
4	23.12	22.19	19.31	21.94	21.25	21.25
5	22.75	21.94	21.88	21.00	20.88	21.53
6	21.95	22.25	20.47	20.19	21.19	21.00
			Hampshire			
7	21.44	20.53	19.69	23.34	20.25	20.66
8	20.86	20.62	19.56	19.50	19.94	20.38
9	20.75	20.72	19.28	20.22	19.97	20.16
10	19.91	19.88	18.88	20.06	19.31	19.66
11	20.41	19.06	18.69	20.03	18.91	19.25
12	20.03	19.40	18.34	20.62	19.25	19.53
$\bar{x}$ Yorkshire	22.48	21.95	20.29	21.36	21.05	21.29
$\bar{x}$ Hampshire	20.57	20.04	19.07	20.63	19.61	19.94
$\bar{x}$ Total	21.52	20.99	19.68	20.99	20.32	20.61

Table 8. Percent moisture in various swine muscles.

Pig No.	Muscles LD	SM	ST	PM	BF	RF
			Yorkshire			
1	72.25	73.22	73.72	74.50	72.68	75.56
2	71.62	73.38	73.51	75.08	73.62	75.63
3	72.07	73.76	72.52	73.90	73.28	75.66
4	71.23	72.80	69.44	74.19	71.75	75.17
5	71.82	72.68	73.08	75.30	72.50	74.86
6	71.48	73.93	74.56	75.96	73.48	76.26
			Hampshire			
7	70.17	72.80	70.70	71.86	71.48	74.57
8	73.34	74.64	74.58	75.70	73.50	75.63
9	72.88	74.63	74.99	75.34	74.25	75.81
10	71.92	74.84	74.68	74.69	73.52	76.35
11	73.04	74.90	73.28	74.68	73.47	76.48
12	72.36	74.06	72.56	73.88	73.88	76.32
$\bar{x}$ Yorkshire	71.75	73.30	72.81	74.82	72.89	75.52
$\bar{x}$ Hampshire	72.29	74.31	73.47	74.36	73.35	75.86
$\bar{x}$ Total	72.02	73.80	73.14	74.59	73.12	75.69

Table 9. Analysis of variance of potassium content of swine muscles on a wet basis in ppm (both breeds).

Source of Variance	d.f.	Mean square	F Value
Between muscles	5	269.837	9.4**
Within muscles	66	28.426	
Total	71		
$S_{\bar{x}}$ (Standard error mean)	0.04867		

* (P < .05)
**(P < .01)

Table 10. Analysis of variance of potassium content of swine muscle on a wet basis in ppm by breed.

		Mean square	
Source of variance	d.f.	Yorkshires	Hampshires
Between muscles	5	149.936*	236.247**
Within muscles	30	31.636	8.836
Total	35		
$S_{\bar{x}}$ (Standard error mean)		.07261	.038375

* (P < .05)
**(P < .01)

Table 11. Analysis of variance of potassium content of swine muscles on a fat-free, moisture-free basis in ppm (both breeds).

Source of variance	d.f.	Mean square	F value
Between muscles	5	6,148.681	7.76**
Within muscles	66	791.938	
Total	71		
$S_{\bar{x}}$ (Standard error mean)		.2569	

* (P < .05)
**(P < .01)

Table 12. Analysis of variance of potassium content of swine muscles on a fat-free, moisture-free basis in ppm by breed.

		Mean square	
Source of variance	d.f.	Yorkshires	Hampshires
Between muscles	5	2,336.729 N.S.	4,507.538*
Within muscles	30	811.187	502.371
Total	35		
$S_{\bar{x}}$ (Standard error mean)		.36769	.28936

* (P < .05)
**(P < .01)
N.S. (not significant)

Table 13. Analysis of variance of potassium content of swine muscles on a protein basis in ppm (both breeds).

Source of variance	d.f.	Mean square	F value
Between muscles	5	10,469.718	6.70**
Within muscles	66	1,561.766	
Total	71		
$S_{\bar{x}}$ (Standard error mean)		0.36076	

* (P < .05)
**(P < .01)

Table 14. Analysis of variance of potassium content of swine muscles on a protein basis in ppm by breed.

		Mean square	
Source of variance	d.f.	Yorkshires	Hampshires
Between muscles	5	3,314.941**	8,178.571**
Within muscles	30	793.104	1,009.647
Total	35		
$S_{\bar{x}}$ (Standard error mean)		0.36357	0.41021

* (P < .05)
**(P < .01)

Table 15. Analysis of variance of sodium content of swine muscles on a wet basis in ppm (both breeds).

Source of variance	d.f.	Mean square	F value
Between muscles	5	9.782	6.01**
Within muscles	66	1.627	
Total	71		
$S_{\bar{x}}$ (Standard error mean)		0.01164	

* (P < .05)
**(P < .01)

Table 16. Analysis of variance of sodium content of swine muscles on a wet basis in ppm by breed.

		Mean square	
Source of variance	d.f.	Yorkshires	Hampshires
Between muscles	5	4.962*	5.185**
Within muscles	30	1.698	1.387
Total	35		
$S_{\bar{x}}$ (Standard error mean)		0.01682	0.01520

* (P < .05)
**(P < .01)

Table 17. Analysis of variance of sodium content of swine muscles on a fat-free, moisture-free basis in ppm (both breeds).

Source of variance	d.f.	Mean square	F value
Between muscles	5	533.301	14.87**
Within muscles	66	35.849	
Total	71		
$S_{\bar{x}}$ (Standard error mean)		0.05465	

* (P < .05)
**(P < .01)

Table 18. Analysis of variance of sodium content of swine muscles on a fat-free, moisture-free basis in ppm by breed.

		Mean square	
Source of variance	d.f.	Yorkshire	Hampshire
Between muscles	5	311.394**	230.764**
Within muscles	30	31.125	43.510
Total	35		
$S_{\bar{x}}$ (Standard error mean)		0.07202	0.08516

* (P < .05)
**(P < .01)

Table 19. Analysis of variance of percent fat in various swine muscles (both breeds).

Source of variance	d.f.	Mean square	F value
Between muscles	5	38.4266	33.95**
Within muscles	66	1.132	
Total	71		
$S_{\bar{x}}$ (Standard error mean)		0.30714	

* (P < .05)
**(P < .01)

Table 20. Analysis of variance of percent fat in various swine muscles by breed.

		Mean square	
Source of variance	d.f.	Yorkshires	Hampshires
Between muscles	5	22.2694**	16.6416**
Within muscles	30	1.0139	1.3476
Total	35		
$S_{\bar{x}}$ (Standard error mean)		0.4111	0.4739

* (P < .05)
**(P < .01)

Table 21. Analysis of variance of percent protein in various swine muscles (both breeds).

Source of variance	d.f.	Mean square	F value
Between muscles	5	4.8836	4.935*
Within muscles	66	.98963	
Total	71		
$S_{\bar{x}}$ (Standard error mean)		0.99480	

*(P < .05)
**(P < .01)

Table 22. Analysis of variance of percent protein in various swine muscles by breed.

		Mean square	
Source of variance	d.f.	Yorkshires	Hampshires
Between muscles	5	3.41**	2.1564 N.S.
Within muscles	30	0.26893	.49614
Total	35		
$S_{\bar{x}}$ (standard error mean)		0.21171	none calc.

* (P < .05)
**(P < .01)
N.S. (not significant)

Table 23. Analysis of variance of percent moisture in various swine muscles (both breeds).

Source of variance	d.f.	Mean square	F value
Between muscles	5	19.8322	18.33**
Within muscles	66	1.0822	
Total	71		
$S_{\bar{x}}$ (standard error mean)		0.33031	

* (P < .05)
**(P < .01)

Table 24. Analysis of variance of percent moisture in various swine muscles by breed.

		Mean square	
Source of variance	d.f.	Yorkshires	Hampshires
Between muscles	5	11.7874**	8.7747*
Within muscles	30	0.8160	1.3344
Total	35		
$S_{\bar{x}}$ (standard error mean)		0.11662	0.47157

* ($P < .05$)
**($P < .01$)

Table 25. Potassium content of various steer muscles on a wet basis (gm./kg.).

Animal No.	Muscles							
	LD	SM	ST	PM	BF	RF	TB	SS
				Angus				
1	3.659	3.786	3.956	3.693	3.731	3.603	3.635	3.438
2	3.569	3.796	3.856	3.425	3.577	3.660	3.436	3.341
3	3.871	4.062	4.270	3.977	4.001	4.060	3.783	3.657
4	3.694	3.993	4.117	3.885	4.264	4.040	3.940	3.584
5	3.519	3.888	3.815	3.432	3.533	3.667	3.510	3.350
6	3.786	3.810	3.913	3.608	3.791	3.793	3.613	3.393
7	3.874	4.021	4.088	3.750	3.405	3.867	3.596	3.369
				Hereford.				
8	3.597	3.701	3.850	3.553	3.706	3.794	3.466	3.506
9	3.608	3.756	3.809	3.561	3.558	3.573	3.579	3.421
10	3.545	3.836	4.003	3.696	3.684	3.746	3.657	3.490
11	3.861	3.897	3.954	3.765	3.747	3.848	3.667	3.463
12	3.835	3.945	3.897	3.854	3.805	3.899	3.669	3.455
13	3.512	3.754	3.887	3.689	3.836	3.611	3.633	3.384
14	3.691	3.873	3.978	3.673	3.749	3.839	3.664	3.515
				Shorthorn				
15	3.560	3.923	3.927	3.907	3.792	3.794	3.584	3.428
16	3.700	3.863	3.902	3.564	3.755	3.780	3.547	3.307
$\bar{x}$ Angus	3.710	3.908	4.002	3.681	3.829	3.813	3.645	3.447
$\bar{x}$ Hereford	3.664	3.823	3.911	3.684	3.726	3.759	3.619	3.462
$\bar{x}$ Shorthorn	3.630	3.893	3.915	3.736	3.779	3.787	3.566	3.368
$\bar{x}$ Total	3.680	3.869	3.951	3.690	3.777	3.786	3.624	3.444

Table 26. Potassium content of various steer muscles on a fat-free, moisture-free basis (gm./kg.).

Animal No.	Muscles							
	LD	SM	ST	PM	BF	RF	TB	SS
				Angus				
1	15.978	16.619	17.559	16.673	16.897	16.750	16.419	16.640
2	15.674	16.263	17.260	15.075	16.069	16.952	15.892	15.993
3	16.721	17.038	18.108	17.306	17.105	17.636	16.753	16.759
4	15.998	15.579	17.269	16.965	16.559	17.324	16.540	16.086
5	16.068	16.405	17.000	16.358	16.000	17.503	16.137	16.105
6	17.061	16.464	17.383	17.018	16.649	17.495	16.422	16.543
7	17.310	17.213	17.773	17.273	16.948	17.869	16.858	16.612
				Hereford				
8	15.866	15.980	16.885	16.556	16.434	16.914	15.647	16.413
9	15.652	16.295	17.012	16.609	16.092	18.716	16.607	16.447
10	15.961	16.137	17.374	16.876	15.811	16.988	16.570	16.403
11	16.007	15.906	15.937	16.593	15.567	16.665	15.724	16.017
12	17.143	17.317	17.689	18.119	17.366	18.211	16.745	16.837
13	14.970	16.125	16.966	16.060	16.839	17.081	16.032	16.030
14	15.059	15.629	16.001	15.976	15.732	16.096	15.691	15.289
				Shorthorn				
15	15.478	16.414	16.912	17.418	16.027	16.809	15.985	16.552
16	15.764	16.600	17.640	16.068	16.418	17.363	16.233	15.929
$\bar{x}$ Angus	16.401	16.511	17.478	16.666	16.603	17.361	16.431	16.391
$\bar{x}$ Hereford	15.808	16.198	16.837	16.684	16.263	17.238	16.145	16.218
$\bar{x}$ Shorthorn	15.621	16.507	17.271	16.743	16.223	17.086	16.109	16.241
$\bar{x}$ Total	16.044	16.374	17.173	16.684	16.407	17.273	16.266	16.297

Table 27. Potassium content of various steer muscles on a protein basis (gm./kg.)

	Muscles							
Animal No.	LD	SM	ST	PM	BF	RF	TB	SS
				Angus				
1	16.846	17.658	19.065	17.561	18.424	17.766	17.442	15.901
2	17.845	18.267	18.837	16.989	17.743	18.616	17.231	17.738
3	17.181	18.363	19.303	18.395	18.609	18.640	17.619	18.121
4	16.836	18.249	19.139	18.230	19.138	18.363	18.156	17.884
5	17.403	17.545	17.645	16.948	16.823	18.055	17.147	16.825
6	18.414	17.878	19.535	18.830	17.975	19.361	17.412	18.038
7	18.696	18.869	19.183	18.806	18.675	19.709	18.088	18.151
				Hereford				
8	16.777	17.465	17.725	17.331	17.698	17.646	16.356	17.027
9	16.377	18.101	17.849	17.396	17.280	18.924	17.433	16.868
10	16.808	17.365	18.353	18.135	17.336	18.219	17.735	17.617
11	17.526	17.689	18.801	18.312	17.403	18.517	17.387	17.534
12	18.235	18.590	18.637	19.603	19.226	19.583	18.002	18.184
13	15.985	17.850	18.589	17.995	18.567	18.758	17.508	17.661
14	16.006	17.091	18.057	16.650	16.759	16.850	16.423	16.988
				Shorthorn				
15	16.976	18.409	18.620	19.236	18.108	18.363	17.646	17.606
16	16.285	20.161	18.199	17.284	17.932	18.243	16.668	16.881
$\bar{x}$ Angus	17.603	18.118	18.958	17.965	18.198	18.644	17.585	17.522
$\bar{x}$ Hereford	16.816	17.735	18.287	17.917	17.752	18.353	17.263	17.411
$\bar{x}$ Shorthorn	16.631	19.285	18.410	18.260	18.020	18.303	17.257	17.244
$\bar{x}$ Total	17.137	18.096	18.596	17.981	17.981	18.474	17.391	17.439

Table 28. Sodium content of various steer muscles on a wet basis (gm./kg.).

Animal No.	Muscles							
	LD	SM	ST	PM	BF	RF	TB	SS
				Angus				
1	0.335	0.397	0.443	0.482	0.520	0.476	0.444	0.570
2	0.453	0.442	0.472	0.491	0.493	0.464	0.465	0.495
3	0.422	0.464	0.513	0.474	0.554	0.594	0.605	0.668
4	0.490	0.515	0.560	0.642	0.678	0.667	0.596	0.733
5	0.501	0.516	0.565	0.530	0.598	0.570	0.553	0.644
6	0.442	0.442	0.486	0.496	0.520	0.513	0.512	0.647
7	0.481	0.480	0.522	0.506	0.536	0.563	0.570	0.714
				Hereford				
8	0.394	0.409	0.433	0.439	0.465	0.472	0.484	0.548
9	0.332	0.460	0.475	0.368	0.489	0.420	0.463	0.513
10	0.540	0.547	0.572	0.568	0.630	0.666	0.677	0.807
11	0.483	0.486	0.514	0.500	0.538	0.545	0.533	0.644
12	0.484	0.453	0.487	0.505	0.514	0.526	0.528	0.699
13	0.359	0.375	0.419	0.427	0.494	0.516	0.499	0.598
14	0.473	0.469	0.535	0.565	0.563	0.529	0.554	0.664
				Shorthorn				
15	0.468	0.465	0.518	0.560	0.535	0.542	0.553	0.703
16	0.445	0.460	0.490	0.474	0.537	0.545	0.526	0.612
$\bar{x}$ Angus	0.446	0.465	0.508	0.517	0.557	0.549	0.535	0.638
$\bar{x}$ Hereford	0.437	0.457	0.490	0.481	0.527	0.524	0.534	0.639
$\bar{x}$ Shorthorn	0.457	0.463	0.504	0.517	0.536	0.544	0.540	0.658
$\bar{x}$ Total	0.4439	0.4613	0.5003	0.5017	0.5415	0.5380	0.5351	0.6411

Table 29. Sodium content of various steer muscles on a fat-free, moisture-free basis (gm./kg.).

	Muscles							
Animal No.	LD	SM	ST	PM	BF	RF	TB	SS
				Angus				
1	1.463	1.743	1.966	2.176	2.355	2.213	2.006	2.759
2	1.989	1.894	2.113	2.161	2.215	2.149	2.151	2.370
3	1.823	1.946	2.176	2.063	2.369	2.580	2.679	3.061
4	2.122	2.009	2.349	2.803	2.633	2.860	2.502	3.290
5	2.288	2.177	2.518	2.526	2.708	2.721	2.543	3.096
6	1.992	1.910	2.159	2.340	2.284	2.366	2.327	3.155
7	2.149	2.055	2.270	2.331	2.326	2.602	2.672	3.521
				Hereford				
8	1.738	1.766	1.899	2.046	2.062	2.104	2.185	2.566
9	1.440	1.996	2.121	1.716	2.212	2.200	2.148	2.466
10	2.431	2.301	2.483	2.594	2.704	3.020	3.068	3.814
11	2.002	1.984	2.072	2.204	2.235	2.360	2.286	2.979
12	2.164	1.989	2.211	2.374	2.346	2.457	2.410	3.406
13	1.530	1.611	1.829	1.859	2.169	2.441	2.202	2.833
14	1.930	1.893	2.152	2.458	2.363	2.218	2.373	2.888
				Shorthorn				
15	2.035	1.946	2.231	2.497	2.261	2.401	2.467	3.394
16	1.896	1.977	2.215	2.137	2.348	2.503	2.407	2.948
$\bar{x}$ Angus	1.975	1.962	2.221	2.342	2.412	2.498	2.411	3.036
$\bar{x}$ Hereford	1.890	1.934	2.109	2.178	2.298	2.400	2.381	2.999
$\bar{x}$ Shorthorn	1.966	1.962	2.223	2.317	2.305	2.452	2.437	3.171
$\bar{x}$ Total	1.937	1.950	2.173	2.267	2.349	2.449	2.402	3.034

Table 30. Sodium content of various steer muscles on a protein basis (gm./kg.).

	Muscles							
Animal No.	LD	SM	ST	PM	BF	RF	TB	SS
				Angus				
1	1.542	1.852	2.135	2.292	2.568	2.347	2.131	2.636
2	2.265	2.127	2.306	2.436	2.445	2.360	2.332	2.627
3	1.873	2.098	2.319	2.192	2.577	2.727	2.818	3.310
4	2.233	2.354	2.603	3.013	3.043	3.032	2.747	3.658
5	2.478	2.329	2.613	2.617	2.848	2.806	2.702	3.235
6	2.150	2.074	2.426	2.589	2.406	2.619	2.467	3.440
7	2.321	2.252	2.450	2.538	2.563	2.870	2.867	3.847
				Hereford				
8	1.838	1.930	1.994	2.141	2.221	2.195	2.284	2.661
9	1.507	2.217	2.226	1.798	2.375	2.225	2.255	2.530
10	2.560	2.476	2.623	2.787	2.965	3.239	3.283	4.074
11	2.192	2.206	2.260	2.432	2.499	2.623	2.527	3.261
12	2.301	2.135	2.329	2.569	2.531	2.642	2.591	3.679
13	1.634	1.783	2.004	2.083	2.391	2.681	2.405	3.121
14	2.051	2.070	2.429	2.561	2.517	2.319	2.483	3.209
				Shorthorn				
15	2.232	2.182	2.456	2.757	2.555	2.623	2.723	3.611
16	1.959	2.401	2.285	2.299	2.564	2.630	2.472	3.124
$\bar{x}$ Angus	2.123	2.155	2.407	2.525	2.644	2.680	2.580	3.250
$\bar{x}$ Hereford	2.011	2.116	2.266	2.338	2.499	2.560	2.546	3.219
$\bar{x}$ Shorthorn	2.096	2.292	2.571	2.528	2.560	2.627	2.598	3.368
$\bar{x}$ Total	2.070	2.155	2.341	2.444	2.570	2.621	2.568	3.251

Table 31. Percent fat in various steer muscles.

Animal No.	Muscles							
	LD	SM	ST	PM	BF	RF	TB	SS
				Angus				
1	4.58	3.28	3.32	6.68	5.26	6.86	5.51	6.80
2	8.11	3.90	3.68	8.04	5.70	7.08	5.66	5.81
3	5.08	2.68	2.25	4.26	2.85	3.16	3.88	3.71
4	5.70	1.63	2.86	7.61	1.73	4.07	3.49	3.73
5	8.66	2.93	4.00	10.44	5.84	7.64	5.73	6.63
6	4.97	2.62	2.90	6.81	2.72	4.33	4.30	4.17
7	6.82	3.30	3.30	7.88	3.64	6.02	8.11	6.58
				Hereford				
8	7.86	4.10	4.37	9.59	4.71	4.80	7.00	5.48
9	6.10	4.97	5.29	9.25	7.25	10.67	7.36	6.51
10	9.57	4.23	4.12	9.08	6.05	7.12	7.50	7.73
11	4.58	2.44	2.54	4.95	3.61	4.21	4.08	4.38
12	3.72	2.64	4.23	5.09	4.73	4.31	4.01	3.98
13	7.50	4.50	5.11	7.59	6.02	7.78	7.83	7.94
14	5.76	3.04	3.48	7.11	4.72	6.34	4.80	5.36
				Shorthorn				
15	6.08	2.42	2.74	7.29	3.82	4.00	4.68	4.19
16	4.33	2.16	2.89	6.70	2.63	4.38	2.81	4.14
$\bar{x}$ Angus	6.27	2.91	3.19	7.39	3.96	5.59	5.24	5.35
$\bar{x}$ Hereford	6.44	3.70	4.16	7.52	5.30	6.46	6.08	5.91
$\bar{x}$ Shorthorn	5.21	2.29	2.82	7.0	3.23	4.19	3.75	4.17
$\bar{x}$ Total	6.21	3.18	3.57	7.40	4.46	5.80	5.42	5.42

Table 32. Percent moisture in various steer muscles.

Animal No.	Muscles							
	LD	SM	ST	PM	BF	RF	TB	SS
				Angus				
1	72.52	73.94	74.15	71.17	72.66	71.63	72.35	72.54
2	69.12	72.76	73.98	69.24	72.04	71.33	72.72	73.30
3	71.77	73.48	74.17	72.76	73.76	73.82	73.54	74.47
4	71.21	72.74	73.30	69.49	72.52	72.61	72.69	73.99
5	69.44	73.37	73.56	68.58	72.08	71.41	72.52	72.57
6	72.84	74.24	74.59	71.99	74.51	73.99	73.90	75.32
7	70.80	73.34	73.70	70.41	73.32	72.34	70.56	73.14
				Hereford				
8	69.47	72.74	72.83	68.95	72.74	72.77	70.85	73.16
9	70.85	72.00	72.32	69.31	70.62	70.24	71.09	72.69
10	68.22	72.00	72.84	69.02	70.65	70.83	70.43	71.11
11	71.30	73.06	72.65	72.36	72.32	72.70	72.60	74.00
12	73.91	74.58	73.74	73.64	73.36	74.28	74.08	75.50
13	69.04	72.22	71.98	69.44	71.20	71.08	69.51	70.95
14	69.73	72.18	71.66	69.90	71.45	69.81	71.85	71.65
				Shorthorn				
15	70.92	73.68	74.04	70.28	72.52	73.43	72.90	75.10
16	72.20	74.57	74.99	71.12	74.50	73.85	75.34	75.10
$\bar{x}$ Angus	71.10	73.41	73.92	70.52	72.98	72.45	72.61	73.62
$\bar{x}$ Hereford	70.36	72.68	72.57	70.37	71.76	71.67	71.49	72.72
$\bar{x}$ Shorthorn	71.56	74.13	74.57	70.70	73.51	73.64	74.12	75.10
$\bar{x}$ Total	70.83	73.18	73.41	70.48	72.52	72.26	72.31	73.41

Table 33. Percent protein in various steer muscles.

Animal No.	LD	SM	ST	PM	BF	RF	TB	SS
	Muscles							
				Angus				
1	21.72	21.44	20.75	21.03	20.25	20.28	20.84	21.62
2	20.00	20.78	20.47	20.16	20.16	19.66	19.94	18.84
3	22.53	22.12	22.12	21.62	21.50	21.78	21.47	20.18
4	21.94	21.88	21.51	21.31	22.28	22.00	21.70	20.04
5	20.22	22.16	21.62	20.25	21.00	20.31	20.47	19.91
6	20.56	21.31	20.03	19.16	21.09	19.59	20.75	18.81
7	20.72	21.31	21.31	19.94	20.91	19.62	19.88	18.56
				Hereford				
8	21.44	21.19	21.72	20.50	20.94	21.50	21.19	20.59
9	22.03	20.75	21.34	20.47	20.59	18.88	20.53	20.28
10	21.09	22.09	21.81	20.38	21.25	20.56	20.62	19.81
11	22.03	22.03	21.03	20.56	21.53	20.78	21.09	19.75
12	21.03	21.22	20.91	19.66	21.31	19.91	20.38	19.00
13	21.97	21.03	20.91	20.50	20.66	19.25	20.75	18.16
14	23.06	22.66	22.03	22.06	22.37	22.81	22.31	20.69
				Shorthorn				
15	20.97	21.31	21.09	20.31	20.94	20.66	20.31	19.47
16	22.72	19.16	21.44	20.62	20.94	20.72	21.28	19.59
$\bar{x}$ Angus	21.09	21.57	21.12	20.50	21.03	20.46	20.72	19.71
$\bar{x}$ Hereford	21.80	21.56	21.39	20.59	21.09	20.52	20.98	19.89
$\bar{x}$ Shorthorn	21.85	20.24	21.27	20.47	20.94	20.69	20.80	19.53
$\bar{x}$ Total	21.50	21.40	21.26	20.53	21.05	20.52	20.84	19.77

Table 34. Analysis of variance of potassium content of steer muscles on a wet basis, fat-free, moisture-free basis, and on a protein basis (gm./kg.).

Source of variance	d.f.	Mean squares		
		Wet basis	Fat-free, moisture-free basis	Protein basis
Between muscles	7	0.390771**	3.152915**	4.386063**
Between steers	15	0.097531**	1.645118**	2.287500**
Error	105	0.006586	0.135846	0.260386
Total	127			
$S_{\bar{x}}$ (standard error mean)		0.020288	0.092143	0.127570

* (P < .05).
**(P < .01).

Table 35. Analysis of variance of sodium content of steer muscles on a wet basis, fat-free, moisture-free basis and on a protein basis (gm./kg.).

Source of variance	d.f.	Mean squares		
		Wet basis	Fat-free, moisture-free basis	Protein basis
Between muscles	7	0.058680**	1.925604**	2.102941**
Between steers	15	0.023214**	0.386128**	0.481118**
Error	105	0.000950	0.022570	0.030063
Total	127			
$S_{\bar{x}}$ (standard error mean)		0.007763	0.037558	0.043347

* (P < .05).
**(P < .01).

Table 36. Analysis of variance of the percent fat, protein and moisture in steer muscles.

Source of variance	d.f.	Mean squares		
		% Fat	% Protein	% Moisture
Between muscles	7	31.16753**	5.282254**	20.004246**
Between steers	15	12.96883**	2.862659**	10.665746**
Error	105	0.82233	0.294079	0.531949
Total	127			
$S_{\bar{x}}$ (standard error mean)		0.226706	0.13506	0.18234

* (P < .05).
**(P < .01).

Table 37. Potassium content of lamb muscles and blood on a wet basis (gm./kg.).

	Muscles				
Animal No.	LD	SM	ST	RF	Blood
1	3.512	3.488	3.782	3.546	0.351
2	3.252	3.372	3.545	3.495	0.357
3	3.567	3.636	3.959	3.809	0.371
4	3.198	3.284	3.278	3.330	0.349
5	3.370	3.532	3.599	3.314	0.343
6	3.160	3.111	3.412	3.245	1.329
7	3.600	3.631	3.923	3.916	0.470
8	3.718	3.497	3.905	3.781	1.434
9	3.431	3.579	3.781	3.757	0.396
10	3.592	3.651	3.848	3.861	0.596
11	3.449	3.505	3.892	3.888	0.467
12	3.534	3.558	3.908	3.799	0.456
13	3.659	3.692	3.729	3.758	0.493
14	3.746	3.792	4.127	3.964	0.426
15	3.339	3.669	3.868	3.762	0.436
16	3.668	3.748	3.980	3.773	0.448
17	3.482	3.585	3.792	3.694	1.632
18	4.288	4.060	4.482	4.315	0.543
19	3.792	3.835	3.839	3.853	0.350
20	3.606	3.879	3.993	4.008	0.494
21	3.565	3.615	3.960	3.762	1.368
22	3.559	3.633	3.777	3.769	0.337
23	3.489	3.681	4.075	3.936	0.279
24	3.713	3.916	4.216	4.123	0.393
25	3.669	3,947	4.113	3.984	0.358
$\bar{x}$	3.558	3.636	3.871	3.778	0.579

Table 38. Potassium content of lamb muscles on a fat-free, moisture-free basis (gm./kg.).

	Muscles			
Animal No.	LD	SM	ST	RF
1	14.743	14.836	15.998	16.999
2	14.102	15.141	16.128	16.010
3	15.981	16.655	18.456	17.992
4	13.631	14.866	14.839	15.677
5	14.153	15.230	17.178	16.087
6	14.183	14.160	15.004	14.756
7	15.597	15.974	17.896	18.393
8	16.755	16.033	18.298	17.709
9	15.323	16.209	18.013	17.015
10	16.100	16.633	18.159	17.260
11	15.784	15.924	18.682	18.764
12	15.706	16.063	18.338	17.793
13	16.916	17.333	18.216	18.403
14	16.343	16.551	18.556	17.287
15	15.877	16.761	18.384	18.069
16	16.073	16.532	18.366	17.923
17	14.995	15.772	17.346	16.836
18	16.372	18.936	21.342	20.596
19	16.515	16.739	17.914	17.537
20	15.404	17.426	16.507	18.226
21	15.100	16.081	18.115	17.123
22	15.049	15.271	16.847	16.744
23	15.759	17.265	19.405	19.135
24	17.150	16.256	19.260	19.168
25	16.000	17.542	19.139	18.643
$\bar{x}$	15.584	16.248	17.855	17.606

Table 39. Potassium content of lamb muscles on a protein basis (gm./kg.).

Animal No.	Muscles LD	SM	ST	RF
1	16.350	16.421	17.214	18.287
2	15.434	15.625	16.666	17.904
3	16.392	17.565	19.425	19.035
4	14.464	15.446	16.292	16.387
5	15.374	17.137	17.816	16.847
6	15.287	15.370	16.766	16.225
7	16.378	16.671	18.539	19.130
8	17.181	16.636	19.613	19.154
9	16.252	17.190	18.914	19.246
10	17.755	18.227	19.493	19.237
11	17.082	17.782	18.929	19.626
12	16.725	16.999	19.279	18.732
13	17.625	18.562	19.261	19.431
14	17.669	18.301	19.765	20.142
15	16.570	18.100	19.846	19.164
16	17.053	18.177	19.433	18.883
17	16.150	17.310	18.497	18.451
18	18.643	20.099	21.884	21.141
19	17.244	18.115	18.699	18.905
20	16.112	18.453	18.897	19.031
21	16.451	17.222	19.084	17.922
22	16.104	17.144	17.883	18.640
23	16.575	17.929	20.395	19.949
24	18.192	18.927	20.505	20.340
25	17.698	19.539	21.211	20.578
$\bar{x}$	16.670	17.558	18.972	18.895

Table 40. Sodium content of lamb muscles on a wet basis (gm./kg.).

Animal No.	Muscles			
	LD	SM	ST	RF
1	0.755	0.588	0.566	0.629
2	0.734	0.596	0.622	0.634
3	0.715	0.601	0.578	0.653
4	0.735	0.616	0.586	0.598
5	0.718	0.636	0.676	0.709
6	0.790	0.675	0.692	0.679
7	0.645	0.574	0.535	0.569
8	0.599	0.552	0.567	0.601
9	0.740	0.623	0.680	0.667
10	0.688	0.617	0.603	0.646
11	0.647	0.672	0.596	0.586
12	0.588	0.527	0.561	0.577
13	0.613	0.565	0.576	0.573
14	0.773	0.605	0.618	0.636
15	0.972	0.681	0.702	0.781
16	0.726	0.635	0.618	0.651
17	0.643	0.596	0.595	0.648
18	0.999	0.742	0.706	0.861
19	0.729	0.614	0.613	0.605
20	0.700	0.588	0.640	0.624
21	0.674	0.556	0.572	0.532
22	0.777	0.662	0.717	0.694
23	0.737	0.653	0.697	0.715
24	0.867	0.665	0.659	0.688
25	0.741	0.665	0.709	0.687
$\bar{x}$	0.732	0.620	0.627	0.650

Table 41. Sodium content of lamb muscles on a fat-free, moisture-free basis.

Animal No.	Muscles LD	SM	ST	RF
1	3.169	2.501	2.394	3.015
2	3.183	2.676	2.830	2.904
3	3.203	2.753	2.695	3.085
4	3.133	2.789	2.653	2.815
5	3.016	2.743	3.227	3.442
6	3.546	3.072	3.043	3.088
7	2.795	2.525	2.441	2.673
8	2.699	2.531	2.627	2.815
9	3.305	2.815	3.239	3.021
10	3.084	2.811	2.846	2.878
11	2.961	3.053	2.861	2.828
12	2.613	2.379	2.633	2.703
13	2.834	2.653	2.814	2.806
14	3.373	2.641	2.695	2.774
15	4.622	3.111	3.337	3.751
16	3.181	2.801	2.852	3.093
17	2.769	2.622	2.722	2.954
18	3.970	3.461	3.362	4.110
19	3.175	2.680	2.860	2.754
20	2.990	2.642	2.646	2.838
21	2.855	2.473	2.617	2.421
22	3.285	2.783	3.198	3.083
23	3.329	3.063	3.319	3.476
24	4.005	2.760	3.011	3.199
25	3.232	2.956	3.299	3.215
$\bar{x}$	3.213	2.772	2.889	3.030

Table 42. Sodium content of lamb muscle on a protein basis (gm./kg.).

	Muscles			
Animal No.	LD	SM	ST	RF
1	3.515	2.768	2.576	3.243
2	3.483	2.761	2.932	3.247
3	3.285	2.903	2.836	3.283
4	3.324	2.897	2.912	2.942
5	3.275	3.085	3.347	3.604
6	3.821	3.334	3.400	3.395
7	2.934	2.635	2.528	2.780
8	2.768	2.626	2.847	3.044
9	3.505	2.992	3.401	3.417
10	3.400	3.080	3.054	3.219
11	3.240	3.409	2.899	2.955
12	2.782	2.518	2.767	2.845
13	2.952	2.840	2.975	2.962
14	3.646	2.919	2.960	3.231
15	4.824	3.360	3.602	3.979
16	3.375	3.080	3.018	3.258
17	2.982	2.877	2.902	3.236
18	4.521	3.673	3.447	4.218
19	3.315	2.900	2.985	2.968
20	3.127	2.797	3.028	2.962
21	3.110	2.648	2.756	2.534
22	3.516	3.124	3.394	3.432
23	3.501	3.180	3.488	3.623
24	4.248	3.214	3.205	3.394
25	3.575	3.292	3.657	3.549
$\bar{x}$	3.440	2.996	3.077	3.253

Table 43. Percent fat in various lamb muscles.

	Muscles			
Animal No.	LD	SM	ST	RF
1	4.03	3.15	3.81	4.59
2	3.60	3.42	4.56	2.64
3	6.57	4.43	5.67	4.78
4	5.81	6.07	7.04	5.43
5	1.72	1.80	3.56	2.99
6	4.61	3.87	4.14	2.75
7	3.18	3.06	4.23	4.09
8	5.21	4.59	5.27	4.07
9	3.52	3.25	4.59	2.52
10	4.45	4.02	6.85	2.49
11	5.23	3.55	5.09	4.01
12	4.92	5.29	5.62	4.54
13	7.19	7.88	9.12	6.48
14	3.62	2.96	3.50	1.17
15	4.31	3.05	4.20	3.49
16	4.29	4.72	5.29	4.15
17	4.44	3.76	5.09	3.50
18	0.59	2.76	5.34	3.34
19	3.34	2.91	5.06	3.15
20	3.65	2.84	1.58	2.85
21	3.85	4.31	6.05	3.89
22	2.03	1.46	3.34	1.86
23	4.50	5.50	5.56	4.70
24	4.20	0.40	4.07	3.37
25	2.57	1.96	3.94	2.07
$\bar{x}$	4.06	3.64	4.90	3.56

Table 44. Percent protein in various lamb muscles.

	Muscles			
Animal No.	LD	SM	ST	RF
1	21.48	21.24	21.97	19.39
2	21.07	21.58	21.21	19.52
3	21.76	20.70	20.38	20.01
4	22.11	21.26	20.12	20.32
5	21.92	20.61	20.20	19.67
6	20.67	20.24	20.35	20.00
7	21.98	21.78	21.16	20.47
8	21.64	21.02	19.91	19.74
9	21.11	20.82	19.99	19.52
10	20.23	20.03	19.74	20.07
11	20.19	19.71	20.56	19.83
12	21.13	20.93	20.27	20.28
13	20.76	19.89	19.36	19.34
14	21.20	20.72	20.88	19.68
15	20.15	20.27	19.49	19.63
16	21.51	20.62	20.48	19.98
17	21.56	20.71	20.50	20.02
18	23.00	20.20	20.48	20.41
19	21.99	21.17	20.53	20.38
20	22.38	21.02	21.13	21.06
21	21.67	20.99	20.75	20.99
22	22.10	21.19	21.12	20.22
23	21.05	20.53	19.98	19.73
24	20.41	20.69	20.56	20.27
25	20.73	20.20	19.39	19.36
$\bar{x}$	21.35	20.72	20.42	20.00

Table 45. Percent moisture in various lamb muscles.

	Muscles			
Animal No.	LD	SM	ST	RF
1	72.15	73.34	72.55	74.55
2	73.34	74.31	73.46	75.53
3	71.11	73.73	72.88	74.05
4	70.73	71.84	70.87	72.33
5	74.47	75.01	75.49	76.41
6	73.11	74.16	73.12	75.26
7	73.74	74.21	73.85	74.62
8	72.60	73.60	73.39	74.58
9	74.09	74.67	74.42	75.40
10	73.24	74.03	71.96	75.14
11	72.92	74.44	74.08	75.27
12	72.58	72.56	73.07	74.11
13	71.18	70.82	70.41	73.10
14	73.46	74.13	74.26	75.90
15	74.66	75.06	74.76	75.69
16	72.89	72.61	73.04	78.80
17	72.34	73.51	73.05	74.56
18	73.22	75.80	73.66	75.71
19	73.70	74.18	73.51	74.88
20	72.94	74.90	74.23	75.16
21	72.54	73.21	72.09	74.14
22	74.32	74.75	74.24	75.63
23	73.36	73.18	73.44	74.73
24	74.15	75.51	74.04	75.12
25	74.50	75.54	74.57	76.56
$\bar{x}$	73.09	73.96	73.38	74.93

Table 46. Analysis of variance of potassium content of various lamb muscles (gm./kg.).

Source of variance	d.f.	Mean squares		
		Wet basis	Fat-free, moisture-free basis	Protein basis
Between lambs	24	0.1935105**	4.555024**	4.948083**
Between muscles	3	0.4925730**	29. 29.532249**	30.901144**
Error	72	0.0079683	0.308923	0.210880
Total	99			
$S_{\bar{x}}$ (standard error mean)		0.017853	0.111162	0.091843

* (P < .05). **(P < .01).

Table 47. Analysis of variance of sodium content of various lamb muscles (gm./kg.).

Source of variance	d.f.	Mean squares		
		Wet basis	Fat-free, moisture-free basis	Protein basis
Between lambs	24	0.0160417**	0.3582195**	0.4346587**
Between muscles	3	0.0661936**	0.9032909**	0.9708096**
Error	72	0.0014580	0.0386903	0.0418330
Total	99			
$S_{\bar{x}}$(Standard error mean)		0.0763662	0.0393397	0.0409062

* (P < .05). **(P < .01).

Table 48. Analysis of variance of the percent fat, protein and moisture in lamb muscles.

Source of variance	d.f.	Mean squares		
		% fat	% protein	% moisture
Between lambs	24	6.1539073**	0.8143198**	4.0919794**
Between muscles	3	9.4823343**	8.1373467**	16.4396080**
Error	72	0.6299454	0.1965675	0.2111408
Total	99			
$S_{\bar{x}}$ (Standard error mean)		0.1587382	0.1108398	0.0918999

* (P < .05). **(P < .01).

Table 49. Potassium content of various compartments of the pig body on a wet basis (gm./kg.).

	Pig compartments						Total	
Animal No.	SH	L	S	H	GI	B	C	A
1	2.384	2.153	2.077	2.704	2.162	2.021	2.353	2.241
2	2.215	2.300	1.597	2.610	1.889	1.977	2.209	2.099
3	2.583	2.457	1.918	2.854	1.875	2.033	2.505	2.328
4	2.261	2.108	1.606	2.365	1.886	2.082	2.119	2.035
5	2.238	2.084	1.625	2.419	1.755	2.160	2.131	2.020
6	2.292	2.151	1.539	2.491	1.789	1.965	2.166	2.040
7	2.484	2.049	1.723	2.624	1.796	2.018	2.263	2.118
8	2.296	2.064	1.517	2.447	1.778	2.129	2.125	2.011
9	2.276	2.092	1.721	2.507	2.037	2.050	2.181	2.104
10	2.110	2.069	1.480	2.311	2.028	2.174	2.034	1.992
11	2.085	2.475	1.997	2.744	2.054	1.984	2.349	2.219
12	2.412	2.150	1.903	2.668	2.011	1.971	2.308	2.180
13	2.383	1.934	1.694	2.609	2.060	2.030	2.185	2.103
14	2.466	2.335	1.841	2.628	2.044	1.850	2.363	2.236
15	2.223	2.086	1.566	2.522	2.001	1.679	2.141	2.060
16	2.426	2.388	1.872	2.875	2.028	1.865	2.431	2.280
17	2.554	2.502	2.161	2.997	2.144	2.335	2.583	2.441
18	2.233	1.882	1.644	2.591	1.953	2.216	2.120	2.049
19	2.514	2.558	1.933	2.994	2.250	2.000	2.543	2.410
20	2.035	1.730	1.545	2.366	1.889	2.126	1.948	1.893
21	2.273	1.827	1.758	2.608	1.882	2.239	2.137	2.049
22	2.341	1.980	1.820	2.774	2.108	2.151	2.266	2.177
23	2.608	2.673	2.469	3.056	2.063	2.173	2.713	2.502
24	2.166	2.179	1.837	2.655	2.099	2.256	2.218	2.144
25	2.344	2.378	1.935	2.117	2.084	2.192	2.410	2.272
$\bar{x}$	2.328	2.184	1.791	2.649	1.987	2.067	2.272	2.160

Table 50. Potassium content of various compartments of the pig body on a fat-free, moisture-free basis (gm./kg.).

	Pig compartments						Total	
Animal No.	SH	L	S	H	GI	B	C	A
1	12.695	11.827	15.157	14.547	11.461	10.407	13.346	12.876
2	12.214	12.456	13.778	13.503	9.806	10.040	12.832	12.131
3	12.954	12.720	12.746	13.124	9.800	9.839	12.920	12.299
4	11.760	13.002	12.813	11.989	10.300	10.158	12.287	11.857
5	12.112	11.731	12.875	12.400	8.446	10.104	12.198	11.395
6	13.422	15.253	13.274	13.505	11.216	9.750	13.838	13.073
7	13.775	13.566	14.143	13.249	10.274	9.888	13.616	12.825
8	12.834	13.385	13.019	12.693	10.027	10.552	12.951	12.240
9	12.258	13.453	13.756	12.930	11.015	10.288	12.961	12.435
10	12.760	14.526	14.256	13.011	11.669	10.716	13.473	12.955
11	11.449	14.560	14.244	13.603	12.258	9.809	13.295	12.921
12	14.318	14.559	15.526	14.316	12.409	9.491	14.559	13.871
13	13.563	12.828	14.113	13.689	12.730	10.127	13.488	13.171
14	13.546	13.724	13.747	13.681	11.202	10.055	13.661	12.982
15	12.174	13.034	13.304	13.264	11.991	10.055	12.874	12.538
16	12.334	13.236	13.946	14.307	11.472	8.881	13.373	12.848
17	13.074	13.901	14.816	14.371	12.708	10.174	13.925	13.538
18	12.734	12.995	14.211	13.734	11.282	9.778	13.299	12.782
19	13.377	14.357	14.026	15.262	12.998	9.902	14.264	13.868
20	12.166	11.872	13.107	12.984	10.865	9.569	12.479	12.035
21	12.489	11.759	13.645	13.729	11.405	10.213	12.826	12.481
22	12.601	11.950	13.466	13.510	12.960	10.465	12.834	12.732
23	14.139	15.237	16.848	15.326	12.855	10.372	15.145	14.500
24	11.856	12.681	14.089	13.667	10.678	10.293	12.907	12.364
25	13.314	14.269	15.220	14.833	12.398	10.462	14.266	13.732
$\bar{x}$	12.797	13.315	14.005	13.649	11.369	10.055	13.345	12.818

Table 51. Potassium content of various compartments of the pig body on a protein basis (gm./kg.).

	Pig compartments						Total	
Animal No.	SH	L	S	H	GI	B	C	A
1	15.813	14.631	16.051	16.385	14.703	11.563	15.715	15.369
2	15.550	15.945	14.986	16.479	14.812	10.906	15.833	15.433
3	15.637	15.614	14.619	15.515	14.022	10.893	15.445	15.080
4	15.238	15.499	11.683	14.771	14.110	11.146	14.482	14.282
5	15.152	15.129	13.166	14.850	13.503	11.121	14.742	14.384
6	14.545	16.391	13.314	14.933	15.082	11.351	14.891	14.749
7	15.558	17.668	15.937	14.798	14.042	10.013	15.830	15.231
8	14.074	14.428	12.500	13.385	14.194	11.622	13.711	13.692
9	14.575	15.161	13.832	14.032	16.145	11.660	14.437	14.584
10	14.764	15.669	13.553	14.960	16.521	10.871	14.870	14.946
11	13.134	15.766	15.248	15.101	14.046	10.178	14.728	14.353
12	15.524	15.665	14.656	15.510	15.206	9.150	15.410	15.033
13	15.137	14.642	13.531	15.765	15.042	10.186	14.935	14.694
14	15.267	15.347	13.887	15.418	14.722	10.531	15.120	14.730
15	14.100	14.720	13.460	14.727	14.525	10.531	14.350	14.109
16	13.765	14.750	13.202	15.372	13.476	9.248	14.397	14.025
17	14.106	15.512	14.321	15.692	14.447	10.487	14.945	14.623
18	14.505	14.512	13.865	15.480	13.706	9.944	14.696	14.270
19	14.530	15.888	13.702	16.543	14.652	10.261	15.317	14.987
20	13.211	12.732	12.818	14.160	12.975	9.752	13.316	13.064
21	13.775	13.190	13.963	14.820	13.806	10.461	13.959	13.767
22	14.740	12.641	13.945	15.496	14.246	10.636	14.288	14.074
23	15.691	16.307	16.622	17.085	14.455	10.372	16.375	15.713
24	13.759	13.982	14.274	15.209	14.481	10.070	14.323	14.106
25	14.277	16.377	14.299	16.699	14.044	10.320	15.513	14.971
$\bar{x}$	14.657	15.127	14.057	15.327	14.439	10.531	14.865	14.571

Table 52. Total potassium content of various compartments of the pig body (gm.).

	Pig compartments						Total	
Animal No.	SH	L	S	H	GI	B	C	A
1	106.9	93.2	62.6	120.6	81.6	14.6	383.3	479.5
2	105.9	92.8	54.7	111.4	70.8	15.2	364.8	450.8
3	127.6	95.4	55.7	123.5	63.8	12.2	402.2	478.2
4	114.9	100.9	58.3	113.3	72.1	16.1	387.4	475.6
5	114.1	93.5	52.4	109.0	63.6	16.6	369.0	449.2
6	100.8	81.3	45.0	101.7	64.4	15.2	328.8	408.4
7	114.2	89.4	55.3	110.1	67.4	15.8	369.0	452.2
8	106.4	87.0	47.0	103.2	72.1	17.2	343.6	433.9
9	106.9	89.6	52.7	103.7	82.5	17.5	352.4	452.4
10	84.6	79.6	41.2	92.9	75.6	15.1	298.3	388.9
11	96.4	102.8	58.4	119.3	84.7	18.8	376.9	480.4
12	105.1	90.7	57.6	107.8	85.0	15.3	361.2	461.5
13	104.3	88.0	52.5	110.2	88.6	17.5	355.0	461.1
14	114.2	97.3	54.3	117.8	84.8	18.1	383.6	486.5
15	96.3	84.2	45.9	102.8	82.5	16.1	329.2	427.8
16	111.5	100.6	56.9	123.9	78.7	13.4	392.9	485.0
17	116.1	104.4	64.3	124.6	71.8	20.5	409.4	501.7
18	108.5	83.3	51.3	109.6	62.5	17.6	352.7	432.8
19	111.3	102.8	53.3	116.3	73.7	14.1	383.7	471.5
20	93.8	68.5	46.4	95.3	62.8	15.3	304.0	382.0
21	116.4	88.9	59.9	115.6	68.2	17.3	380.8	466.3
22	105.1	85.2	50.9	117.0	77.5	19.6	358.2	455.3
23	115.8	109.1	62.0	110.2	74.3	18.7	397.1	490.1
24	105.4	92.7	54.1	115.9	74.0	18.6	368.1	460.7
25	92.8	86.8	44.9	102.2	69.8	15.2	326.7	411.7
$\bar{x}$	107.0	91.5	53.5	111.2	74.1	16.5	363.1	453.7

Table 53. Sodium content of various compartments of the pig body on a wet basis (gm./kg.).

Animal No.	Pig compartments						Total	
	SH	L	S	H	GI	B	C	A
1	0.884	0.700	0.631	0.804	1.409	2.028	0.766	0.900
2	0.898	0.716	0.498	0.807	1.407	1.961	0.747	0.890
3	0.848	0.723	0.553	0.857	1.382	1.996	0.767	0.887
4	0.841	0.683	0.506	0.854	1.330	1.883	0.737	0.856
5	0.797	0.716	0.521	0.801	1.378	1.921	0.726	0.856
6	0.860	0.643	0.497	0.866	1.379	1.976	0.738	0.883
7	0.853	0.637	0.529	0.836	1.396	1.962	0.728	0.874
8	0.860	0.660	0.556	0.927	1.406	1.662	0.767	0.905
9	0.930	0.681	0.584	0.935	1.363	2.027	0.800	0.939
10	0.856	0.644	0.536	0.711	1.327	1.856	0.700	0.845
11	0.900	0.684	0.597	0.933	1.371	1.924	0.798	0.937
12	0.775	0.577	0.539	0.817	1.367	1.983	0.686	0.851
13	0.819	0.598	0.522	0.827	1.457	2.014	0.702	0.886
14	0.840	0.628	0.545	0.828	1.395	1.972	0.729	0.890
15	0.832	0.638	0.546	0.856	1.370	1.972	0.734	0.895
16	0.919	0.734	0.571	0.822	1.423	1.848	0.779	0.914
17	0.876	0.666	0.538	0.792	1.354	1.689	0.735	0.860
18	0.750	0.585	0.494	0.735	1.377	1.832	0.654	0.793
19	0.846	0.512	0.577	0.737	1.401	2.026	0.685	0.836
20	0.790	0.580	0.513	0.742	1.321	2.100	0.671	0.811
21	0.796	0.619	0.532	0.727	1.350	2.077	0.679	0.817
22	0.840	0.694	0.571	0.740	1.320	2.147	0.726	0.874
23	0.809	0.645	0.587	0.806	1.355	2.168	0.724	0.885
24	0.858	0.640	0.552	0.782	1.309	2.227	0.726	0.861
25	0.859	0.643	0.559	0.829	1.307	2.104	0.742	0.877
$\bar{x}$	0.845	0.650	0.546	0.815	1.370	1.972	0.730	0.873

Table 54. Sodium content of various compartments of the pig body on a moisture-free basis (gm./kg.).

	Pig compartments						Total	
Animal No.	SH	L	S	H	GI	B	C	A
1	4.703	3.845	4.600	4.331	7.472	10.429	4.345	5.172
2	4.948	3.879	4.307	4.182	7.313	9.934	4.340	5.145
3	4.254	3.747	3.684	3.943	7.220	9.677	3.958	4.686
4	4.371	4.214	4.044	4.328	7.271	9.177	4.272	4.989
5	4.310	4.028	4.128	4.107	6.640	8.963	4.152	4.827
6	5.033	4.559	4.277	4.701	8.378	9.807	4.714	5.663
7	4.729	4.219	4.271	4.224	7.988	9.625	4.384	5.292
8	4.813	4.277	4.765	4.809	7.929	8.221	4.674	5.506
9	5.012	4.384	4.674	4.825	7.370	10.235	4.755	5.550
10	5.173	4.526	5.156	4.006	7.635	9.149	4.634	8.493
11	4.906	4.023	4.244	4.629	8.191	9.531	4.515	5.457
12	4.605	3.900	4.394	4.382	8.438	9.255	4.239	5.413
13	4.655	3.965	4.355	4.335	9.009	10.058	4.335	5.547
14	4.614	3.695	4.076	4.309	7.649	9.457	4.213	5.164
15	4.564	3.994	4.638	4.503	8.212	8.880	4.411	5.545
16	4.668	4.066	4.265	4.088	8.047	8.808	4.285	5.150
17	4.482	3.702	3.687	3.795	8.035	7.363	3.963	4.768
18	4.272	4.041	4.266	3.897	7.960	8.055	4.103	4.944
19	4.507	2.877	4.184	3.858	8.095	10.000	3.844	4.812
20	4.721	3.986	4.350	4.074	7.595	9.438	4.298	5.158
21	4.367	3.981	4.123	3.824	8.177	9.467	4.079	4.979
22	4.520	4.194	4.233	3.603	8.110	10.428	4.113	5.112
23	4.383	3.673	3.995	4.047	8.443	10.333	4.043	5.130
24	4.702	3.871	4.245	4.021	6.652	10.166	4.225	4.965
25	4.878	3.859	4.407	4.369	7.780	10.069	4.393	5.304
$\bar{x}$	4.648	3.980	4.295	4.208	7.824	9.501	4.295	5.191

Table 55. Sodium content of various compartments of the pig body on a protein basis (gm./kg.).

	Pig compartments						Total	
Animal No.	SH	L	S	H	GI	B	C	A
1	5.858	4.757	4.872	4.878	9.586	11.587	5.117	6.173
2	6.300	4.966	4.685	5.104	11.046	10.791	5.356	6.546
3	5.135	4.599	4.226	4.661	10.380	10.714	4.731	5.746
4	5.663	4.992	3.687	5.332	9.961	10.069	5.036	6.009
5	5.392	5.194	4.221	4.918	10.616	9.866	5.018	6.093
6	5.455	4.899	4.290	5.198	11.616	11.418	5.072	6.389
7	5.341	5.494	4.813	4.718	10.917	9.747	5.097	6.285
8	5.278	4.610	4.574	5.071	11.223	9.054	4.948	6.160
9	5.959	4.941	4.698	5.237	10.802	11.600	5.297	6.509
10	5.986	4.882	4.901	4.605	10.810	9.281	5.115	6.337
11	5.668	4.356	4.543	5.139	9.386	9.892	5.002	6.062
12	4.993	4.197	4.148	4.748	10.340	8.922	4.582	5.866
13	5.196	4.536	4.175	4.993	10.645	10.116	4.800	6.189
14	5.201	4.132	4.118	4.856	10.052	9.206	4.663	5.863
15	5.286	4.510	4.692	5.000	9.947	9.706	4.917	6.128
16	5.210	4.531	4.037	4.392	9.452	9.172	4.613	5.622
17	4.836	4.131	3.563	4.144	9.135	7.590	4.253	5.150
18	4.866	4.512	4.162	4.393	9.671	8.192	4.533	5.519
19	4.896	3.184	4.087	4.182	9.125	10.362	4.128	5.200
20	5.127	4.275	4.254	4.443	9.070	9.618	4.586	5.598
21	4.817	4.466	4.219	4.128	9.899	9.697	4.439	5.492
22	5.288	4.362	4.384	4.132	8.915	10.598	4.579	5.651
23	4.864	3.931	3.941	4.513	9.494	10.333	4.371	5.559
24	5.457	4.268	4.301	4.475	9.022	9.946	4.689	5.664
25	5.231	4.434	4.140	4.918	8.813	9.932	4.777	5.782
$\bar{x}$	5.332	4.526	4.309	4.727	9.995	9.896	4.789	5.904

Table 56. Total sodium content of various compartments of the pig body (gm.).

	Pig compartments						Total	
Animal No.	SH	L	S	H	GI	B	C	A
1	39.6	30.3	19.0	35.9	53.2	14.6	124.8	192.6
2	42.9	28.9	17.1	34.5	52.8	15.0	123.4	191.2
3	41.9	28.1	16.1	37.1	47.0	12.0	123.2	182.2
4	42.7	32.7	18.4	40.9	50.9	14.5	134.7	201.5
5	40.6	32.1	16.8	36.1	50.0	14.7	125.6	190.3
6	37.8	24.3	14.5	35.4	49.6	15.3	112.0	176.9
7	38.2	27.8	16.7	35.1	52.4	15.4	118.8	186.6
8	39.9	27.8	17.2	39.1	57.8	13.4	124.0	195.2
9	43.5	29.2	17.9	38.7	55.2	17.4	129.3	201.9
10	34.3	24.8	14.9	28.6	49.4	12.9	102.6	164.9
11	41.6	28.4	17.4	40.6	56.6	18.3	128.0	202.9
12	33.8	24.3	16.3	33.0	57.8	14.9	107.4	180.1
13	35.8	27.2	16.2	34.9	62.7	17.4	114.1	194.2
14	38.9	26.2	16.1	37.1	57.9	17.4	118.3	193.6
15	36.1	25.8	16.0	34.9	56.5	16.5	112.8	185.8
16	42.2	30.9	17.4	35.4	55.2	13.3	125.9	194.4
17	39.8	27.8	16.0	32.9	45.4	14.8	116.5	176.7
18	36.4	25.9	15.4	31.1	41.1	14.5	108.8	167.4
19	37.5	20.6	15.9	29.4	45.9	14.3	103.4	163.6
20	36.4	23.0	15.4	29.9	43.9	15.1	104.7	183.7
21	40.7	30.1	18.1	32.2	48.9	16.0	121.1	186.0
22	37.7	29.9	16.0	31.2	48.5	19.5	114.8	182.8
23	35.9	26.3	14.7	29.1	48.8	18.6	106.0	173.4
24	41.8	28.3	16.3	34.1	46.1	18.4	120.5	185.0
25	34.0	23.5	13.0	30.1	43.8	14.6	100.6	159.0
$\bar{x}$	38.8	27.4	16.4	34.3	51.2	15.6	116.9	184.5

Table 57. Percent fat in various compartments of the pig body.

	Pig compartments						Total	
Animal No.	SH	L	S	H	GI	B	C	A
1	29.88	38.29	43.96	26.23	15.36	---	33.72	28.97
2	33.62	33.37	52.93	29.99	17.48	---	36.63	31.22
3	25.27	33.12	40.11	21.79	18.14	---	28.91	25.60
4	30.66	42.02	50.95	28.48	17.69	---	37.09	31.90
5	31.72	40.27	48.20	27.69	18.01	---	36.07	31.02
6	34.36	45.07	52.45	29.47	18.45	---	39.19	33.03
7	31.69	45.43	49.45	26.06	15.25	---	37.35	31.20
8	35.19	44.80	54.08	28.63	16.42	---	39.60	32.82
9	31.56	42.62	48.91	24.78	16.19	---	36.04	30.13
10	36.70	45.19	54.67	32.73	18.46	---	41.25	34.51
11	31.28	38.82	45.00	26.67	15.36	---	34.48	28.49
12	33.89	44.07	47.49	27.25	15.61	---	37.55	30.87
13	33.71	46.63	50.45	28.03	15.39	---	39.04	31.96
14	33.14	40.00	47.17	28.73	14.93	---	36.23	29.89
15	34.61	44.52	52.73	30.06	17.94	---	39.46	32.77
16	28.08	36.00	44.46	22.53	14.36	---	31.75	26.73
17	26.51	36.12	41.27	22.02	14.68	---	30.63	26.02
18	36.99	47.85	53.30	30.58	17.04	---	41.31	35.12
19	28.61	33.35	44.51	22.20	15.84	---	31.13	26.66
20	38.38	48.50	53.47	33.07	21.79	---	42.49	36.45
21	32.74	43.24	49.25	28.21	20.92	---	37.64	32.81
22	29.10	39.59	46.09	23.65	17.98	---	33.51	28.50
23	28.07	33.93	38.96	21.00	16.19	---	29.82	25.26
24	34.66	42.93	48.41	28.15	14.34	---	37.59	31.39
25	31.27	39.65	47.34	24.41	19.04	---	34.45	29.29
$\bar{x}$	32.07	41.02	48.22	26.90	16.91	---	36.12	30.50

Table 58. Percent protein in various compartments of the pig body.

	Pig compartments						Total	
Animal No.	SH	L	S	H	GI	B	C	A
1	15.08	14.71	12.92	16.51	14.69	17.53	14.97	14.58
2	14.24	14.43	10.65	15.82	12.74	18.08	13.95	13.60
3	16.52	15.74	13.13	18.39	13.38	18.68	16.22	15.44
4	14.84	13.61	13.75	16.01	13.36	18.62	14.63	14.25
5	14.77	13.78	12.36	16.30	13.00	19.39	14.46	14.05
6	15.76	13.12	11.56	16.68	11.87	17.29	14.54	13.83
7	15.97	11.60	10.99	17.74	12.81	20.21	14.29	13.90
8	16.30	14.30	12.12	18.29	12.54	18.30	15.50	14.69
9	15.63	13.80	12.44	17.85	12.62	17.60	15.11	14.43
10	14.30	13.21	10.92	15.45	12.28	19.98	13.68	13.33
11	15.89	15.69	13.11	18.17	14.63	19.49	15.95	15.46
12	15.53	13.72	12.98	17.21	13.22	21.59	14.98	14.50
13	15.74	13.22	12.53	16.56	13.69	19.98	14.63	14.32
14	16.16	15.22	13.23	17.06	13.88	21.42	15.63	15.18
15	15.77	14.18	11.63	17.12	13.77	20.29	14.92	14.60
16	17.63	16.19	14.19	18.70	15.06	20.21	16.89	16.25
17	18.10	16.14	15.08	19.11	14.84	22.26	17.28	16.69
18	15.39	12.96	11.85	16.75	14.25	22.32	14.43	14.36
19	17.30	16.09	14.12	18.09	15.35	19.53	16.60	16.08
20	15.39	13.57	12.06	16.72	14.57	21.80	14.63	14.49
21	16.50	13.85	12.61	17.59	13.64	21.45	15.31	14.89
22	15.88	15.66	13.05	17.90	14.81	20.24	15.86	15.47
23	16.62	16.39	14.85	17.90	14.28	21.01	16.57	15.92
24	15.73	15.00	12.87	17.46	14.50	22.44	15.49	15.20
25	16.39	14.53	13.54	16.88	14.83	21.30	15.53	15.18
$\bar{x}$	15.90	14.43	12.74	17.29	13.78	20.04	15.28	14.83

Table 59. Percent moisture in various compartments of the pig body.

	Pig compartments						Total	
Animal No.	SH	L	S	H	GI	B	C	A
1	51.34	43.50	42.36	55.17	65.78	80.60	48.65	51.35
2	48.20	48.18	35.51	50.67	63.24	80.30	46.21	49.45
3	54.80	47.55	44.84	56.46	62.70	79.29	51.70	53.10
4	50.12	41.76	36.53	51.78	64.00	79.53	45.67	48.82
5	49.81	41.96	39.19	52.35	61.20	78.56	46.46	48.87
6	48.57	40.81	35.96	52.08	65.10	79.82	45.16	49.03
7	50.29	39.47	38.14	54.14	67.25	79.62	46.04	49.89
8	46.93	39.78	34.27	52.09	65.85	79.80	43.99	48.51
9	49.86	41.83	38.59	55.86	65.30	80.03	47.13	50.90
10	46.77	40.59	34.94	49.53	64.17	79.65	43.65	47.87
11	50.49	44.80	40.95	53.14	67.88	79.76	47.85	51.90
12	49.27	41.16	40.27	54.11	68.17	79.20	46.60	50.94
13	48.72	38.28	37.57	52.89	68.43	79.93	47.76	49.74
14	48.65	42.99	39.48	52.06	66.82	79.15	46.47	50.63
15	47.13	39.48	35.49	50.91	65.37	80.08	43.92	48.72
16	52.25	45.94	42.09	57.38	67.96	78.96	50.07	53.10
17	53.97	45.87	44.14	57.13	68.46	77.11	50.81	53.62
18	45.49	37.66	35.14	50.56	65.67	77.66	42.75	46.53
19	52.61	48.82	41.73	58.18	66.84	79.86	51.05	53.44
20	44.90	36.92	34.73	48.70	60.81	77.84	41.90	45.19
21	49.06	41.22	37.85	52.79	62.60	78.06	45.70	48.41
22	52.31	43.85	40.38	55.82	65.75	79.49	48.83	51.92
23	53.48	48.52	46.38	59.06	67.76	79.03	52.26	54.97
24	47.08	40.51	38.57	52.41	66.00	78.06	45.22	48.77
25	51.12	43.66	39.93	56.61	64.15	79.04	48.66	51.28
$\bar{x}$	49.73	42.58	39.00	53.68	65.49	79.20	46.86	50.28

Table 60. Analysis of variance of potassium content of various compartments of the pig body (gm./kg.).

Source of variance	d.f.	Mean squares: Wet basis	Mean squares: Fat-free, moisture-free basis	Mean squares: Protein basis
Between pigs	24	0.168357**	3.3761992**	2.713408**
Between compartments	7	1.616344**	43.4957843**	58.777723**
Error	168	0.014586	0.3489043	0.457889
Total	199			
$S_{\bar{x}}$ (standard error mean)		0.024154	0.118136	0.135335

*(P < .05) **(P < .01)

Table 61. Analysis of variance of sodium content of various compartments of the pig body (gm./kg.).

Source of variance	d.f.	Mean squares: Wet basis	Mean squares: Fat-free, moisture-free basis	Mean squares: Protein basis
Between pigs	24	0.0072992**	0.4358854**	1.2005977**
Between compartments	7	5.5471252**	103.9893168**	140.8647658**
Error	168	0.0035083	0.1383771	0.1759954
Total	199			
$S_{\bar{x}}$ (standard error mean)		0.011846	0.074398	0.083904

*(P < .05) **(P < .01)

Table 62. Analysis of variance of percent fat, protein and moisture of various compartments of the pig body.

Source of variance	d.f.	Mean squares: % fat	Mean squares: % protein	Mean squares: % moisture
Between pigs	24	61.769790**	5.813932**	37.775576**
Between compartments	7	5,599.103198**	129.171073**	4,294.590340**
Error	168	4.095694	0.538624	2.663815
Total	199			
$S_{\bar{x}}$ (standard error mean)		0.40476	0.14678	0.27202

*(P < .05) **(P < .01)

MICHIGAN STATE UNIVERSITY LIBRARIES
3 1293 03061 4303