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Proportional Growth & Carcass Quality in Swine.

ABSTRACT

Doctor of Philosophy Animal Science (Physiology)

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THE INFLUENCE OF SEX, SLAUGHTER WEIGHT AND CHLORHYDROXYQUINOLINE ON PROPORTIONAL GROWTH AND CARCASS QUALITY OF CROSSBRED BACON-TYPE PIGS.

Chlorhydroxyquinoline supplementation failed to improve productive performance, carcass quality, or organoleptic properties, but did alter the electrophoretic pattern of sarcoplasmic proteins extracted from *M. longissimus dorsi* and *M. semitendinosus*.

Gilts displayed slower growth rates, and superior carcass quality than barrows. Significant sex differences were also observed in the chemical analysis of fat and lean tissue, but organoleptic properties were similar for both sexes.

Successive increments in slaughter weight revealed marked differences for the majority of variables studied. Examples included decreased productive efficiency; increased dressing percentage, fat/lean ratio, backfat thickness, fat trim; and total dissectable muscle, fat, and bone. Widely divergent growth gradients were observed for individual muscles within various regions of the carcass. Noteable differences were also observed between weight groups in the chemical composition of lean and fat, but only minor differences in organoleptic properties were detected.

PROPORTIONAL GROWTH AND CARCASS QUALITY IN SWINE

BY

JOHN HERBERT LINTON

A THESIS

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In Memoriam

This thesis is dedicated to the memory of the late Dr. M. A. Macdonald under whose inspiration and direction the project was initiated.

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In conclusion, the author is indebted to his wife and family for their diligent understanding during the course of these studies.

CLAIMS TO ORIGINAL RESEARCH

1. The first report, as far as the author is aware, of the use of chlorhydroxyquinoline as a feed additive for swine.
2. The first demonstration, as far as the author is aware, of alterations in the electrophoretic pattern of sarcoplasmic proteins in response to chlorhydroxyquinoline supplementation.
3. The first provision of evidence, as far as the author is aware, that loin "eye" area X carcass length is highly correlated with total dissectable muscle content.
4. The first reported study, so far as the author is aware, providing evidence that increases in intermuscular fat content of certain muscles at heavier slaughter weights are partially responsible for the apparent divergent growth gradients between individual muscles.
5. The first reported study, so far as the author is aware, comparing the organoleptic and cooking properties of meat obtained from Lacombe X (Yorkshire X Lacombe) pigs slaughtered at various live weights.
6. The first evidence, as far as the author is aware, of a lower total crude protein and stroma plus myofibrillar nitrogen content of *M. semitendinosus* from Lacombe X (Yorkshire X Lacombe) gilts as compared to barrows.
7. The first report, as far as the author is aware, describing variations in electrophoretic patterns of sarcoplasmic proteins extracted from *M. longissimus dorsi* and *M. semitendinosus* of Lacombe X (Yorkshire X Lacombe) swine as related to sex and slaughter weight.
8. The first provision of evidence, as far as the author is aware, of variations in the fatty acid composition of *M. longissimus dorsi* intramuscular fat and *M. semitendinosus* intermuscular fat of Lacombe X (Yorkshire X Lacombe) swine as related to sex and slaughter weight.

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1. GENERAL INTRODUCTION

Domesticated animals have been selected throughout the world to serve human needs in a multitude of different ways. As a source of food, the pig has evolved as one of our most important meat animals. The improvement in prolificacy, rate of gain, feed efficiency and proportion of edible lean meat in present day stock over their ancestors has been phenomenal. Future improvements will be smaller and more difficult to attain, but are essential if the pig is to survive competition.

The present study was undertaken in an attempt to determine the influence of sex, dietary supplementation of chlorhydroxyquinoline, and slaughter weight on the proportional anatomical composition and carcass qualities of cross-bred bacon-type feeder pigs.

The broad spectrum of activity of chlorhydroxyquinoline, its non-toxic properties and stable composition suggested that it would be ideal for inclusion in feeds for the purpose of stimulating the rate and efficiency of gains.

Canadian hog carcass grading regulations are based on the production of an animal of 200 lbs live weight which was the weight suitable for Wiltshire side production. The cessation of a British market for Wiltshire sides produced in Canada, the reduction in value of animal fats, a consumer demand for smaller cuts of meat containing a greater proportion of lean, necessitated the elucidation of the optimal slaughter weight for current conditions. The variation existing between sexes in rate of gain feed efficiency and proportional composition indicate that the optimal slaughter weight may not be the same for both barrows and gilts.

The main criteria of evaluation was growth rate, feed efficiency and carcass composition as determined by anatomical dissection. Carcass measurements, specific gravity , chemical composition, and organoleptic properties were also determined in an attempt to establish interrelationships which would permit elucidation of the effect of chlorhydroxyquinoline supplementation and optimal slaughter weight.

The work reported herein was conducted between September, 1962 and November, 1965.

2. HISTORICAL INTRODUCTION

The quantity of publications pertaining to the subject presently under investigation serves as a testimonial to the interest in and the importance of body composition studies. Knowledge on body composition is the result of laborious investigations involving numerous methods of evaluation.

2.1 METHODOLOGY IN THE ESTIMATION OF BODY COMPOSITION

2.1.1 TECHNIQUES APPLICABLE TO LIVE ANIMALS

Visual Appraisal And Linear Measurements

Numerous animal production workers have attempted to establish correlations between external body measurements and/or visual appraisal and carcass quality. (Lush and Copeland, 1930; McMeekan, 1941; Willman and Knider, 1943; Hetzler *et al.*, 1950; Bratzler and Margerum, 1953; Henning and Evans, 1953; Harrington, 1958a; Robinson *et al.*, 1960; Harrington *et al.*, 1963; Taylor, 1963; Kirton, 1964a; Lewis *et al.*, 1969). Reported correlations have seldom been large enough to warrant use of the measurements in selection of breeding stock, or in growth studies. Furthermore, a major limiting factor in the use of live animal measurements has been the inaccuracy of the measurements themselves.

Visual appraisal or scoring of live hogs is of limited value in assessment of carcass composition. Experienced livestock men have, however, demonstrated their ability to place groups of hogs on an average value basis. Harrington, *et al.*, 1960; Lewis, *et al.*, 1969). Live hog tape measurements have been shown to be useful guides to shape, size and weight, but not necessarily good guides to lean:fat:bone ratios (Morris, *et al.*, 1950).

Most researchers now agree that differences in conformation of live animals are only of importance in the prediction of carcass value when they reflect differences in content and distribution of the major tissues.

Probe Measurements

The ruler-probe technique has been used to measure subcutaneous fat thickness in the live pig (Hazel and Kline, 1952; Hazel and Kline, 1953; Hetzler *et al.*, 1956). Attempts have been made to establish the accuracy of probe measurements taken at various sites in the prediction of carcass backfat thickness as well as other measures of carcass merit. (Depape *et al.*, 1956; Pearson *et al.*, 1957; Harrington 1958a) In general, the correlation between average measurements taken at various positions on the dorsal surface of the live animal and percentage of carcass primal cuts have been too small to permit an accurate prediction of carcass value.

A refinement of the probe technique was developed by Andrews and Whatley (1954) (as cited by Harrington, (1958a,b). This device made use of the fact that the electrical resistance of muscle tissue is only one-tenth that of fat. A needle carrying the electrodes was pushed through the skin and subcutaneous fat until its tip reached the underlying muscle. The exact depth at which the needle reached the muscle tissue was indicated by a sudden deflection on an ammeter. This device has subsequently been marketed commerically under the name "Lean Meter", and has been tested in several countries (Berg and Bowland, 1956; Dumont, 1957; Harrington, 1958a). Robinson *et al.*, (1960) studied the relationship between nine different live hog measurements taken at various ages and weights in relation to carcass yields. They concluded that backfat thickness at the loin and weight of hogs at 154 days of age explained 42% of the variation in lean cut yield.

Ultrasonic Echo

Dumont (1957) was the first to report the use of the ultrasonic echo-ranging technique in the measurement of backfat thickness of pigs. Ultrasonic waves were propagated at right angles to the skin of the animal and echoes were reflected from the interface between the muscle and the fat. The resulting pulses were amplified and displayed as peaks on a cathode ray tube. The time lapse between the signal and the echo was found to be proportional to the distance between two peaks. Therefore, measurement of the speed at which sound travelled through the skin and fat provided a measure of fat thickness. Good accoustical contact between the transmitting instrument and the skin was ensured by wetting the back of the animal. The method was observed to be rapid, repeatable and harmless to the animal. The agreement between measurements of backfat by this method on the live animal and caliper backfat measurements taken at the same position after slaughter was good.

Subsequently, several research workers have used this technique to study growth and carcass composition (Hazel & Kline, 1959; Stouffer, 1959; Price *et al.*, 1960a,b; Stouffer *et al.*, 1961; Stouffer, 1963; Zobrisky and Hedrick, 1965; Joblin, 1965; Anderson *et al.*, 1969, Gilles *et al.*, 1969; Stouffer *et al.*, 1969; Jones *et al.*, 1970). Although correlations between ultrasonic backfat thickness determinations and carcass caliper measurement was generally high, some important difficulties were encountered. Firstly, even slight movement on the part of the pig caused fluctuations in oscilloscope readings. Secondly, the fascia produced a response on the oscilloscope which could easily be mistaken for a response from the fat-muscle interface. Nevertheless, Joblin (1965) reported a correlation of +0.83 between ultrasonic backfat measurements on live pigs and fat percentage in the carcass. Similarly, Hazel and Kline (1959) found the correlation between average

ultrasonic probe measurements and percent loin cuts to be -0.90. Furthermore, Price et al., (1960a) found that live probe measurements, carcass backfat measurements and measurements made by the ultrasonic method were of equal value for the prediction of weight of lean and primal cuts.

Stouffer (1959) developed a method whereby the cross-sectional area of the loin eye muscle of cattle could be plotted from ultrasonic reflection measurements taken at different angles of incidence. Price et al., (1960b) applied the technique to swine by taking soundings at one inch intervals over the contour of the back at the position of the last rib. Although some subjective judgement was necessary in the completion of the ultrasonic plots, the means of the estimates of muscle area was not significantly different from the area of the loin eye muscle measured from tracings of the rough loin. (r=+0 .74). However, the method was considered too time consuming and tedious for practical use.

More recently, Stouffer et al., (1961) developed an instrument which would record numerous ultrasonic probings in the form of a mechanized scan and which produced the pattern photographically. Subsequent adaptations have resulted in the development of an electronic scanning system. (Stouffer, 1963; Stouffer et al., 1969). Although repeatability on successive ultrasonic measurements was good, it was noted that the relationship between ultrasonic and actual carcass measurements was poor. This was attributed to positional variation of eye muscle area and fat thickness, to changes in shape and size of eye muscle due to slaughtering and hanging, and to variations in pressure of the transducer against the hide.

Recently, Zobrisky and Hedrick (1965) reported the development of a simplified ultrasonic procedure for the measurement of *longissimus dorsi* area in cattle and swine. The procedure was found to be as accurate as the standard

procedure, and required 33% fewer measurements and 75% less time.

Chemical

Chemical methods have also been used in attempts to establish an accurate means of predicting carcass characteristics from live animal measurements. It has been known for some time that the water content of animals decreases as the animal fattens (Murray, 1922; Moulton, 1923). Several workers have shown that the composition of the "fat-free" body (i.e., protein, minerals and water) of many species is relatively constant after maturity is reached. (Harrington, 1958a,b; Morris and Moir, 1963; Ponaretto, 1963a,b,c; Bersadoun et al., 1963; Ponaretto and Till, 1963).

Ponaretto (1963c) reported that the fat-free body mass contains water in a fixed proportion (73-74%), that fat-free dry matter is about 80% protein and that the water and fat contents of the animal body are inversely related. Hence, estimates of total body water could be used to provide an estimate of protein, ash and fat. Once the estimate of the "fat-free" body weight has been obtained, body fat could be predicted by difference from the total body weight.

The validity of the assumption that water, protein and mineral matter in the fat-free body approaches constancy has been questioned. (Clawson et al., 1955; Harrington, 1958a). For example, considerable differences have been observed in the ages at which animals become chemically mature. Furthermore, data obtained for young animals did not fit the straight line relationship which had been shown to occur if there was a constant percentage of water on a fat-free basis. However, in older animals, where the body fat content ranges from 35% to 50%, the relation between body water and body fat percentages approached linearity.

This relationship between body fat and body water has served as the basis for the indirect estimation of body fat by the solute dilution technique. This method involves the intravenous injection of a solute, followed by subsequent sampling and analysis to permit calculation of the degree of dilution. Then, by application of the assumed straight line relationship between body water and body fat, an estimate of body fat can be obtained.

Harrington (1958a), reviewed the requirements that a solute must meet in order to be useful in this technique. He concluded that a solute must, after intravenous injection, spread evenly and rapidly through the body water, must not be soluble in fat or other body solids and must be transformed and excreted slowly and at a precisely measurable rate. Furthermore, the solute must be non-toxic in the required dosage and an accurate, convenient method for its estimation in blood plasma must be available.

The most commonly used chemical for estimation of total body water has been antipyrene. Numerous reports indicate a wide range of correlations between fat content as determined by the antipyrene technique and fat content calculated by direct chemical analysis. (Kraybill et al., 1953; Clawson et al., 1955; Harrington 1958a) In addition, little agreement has been reached on the rate of metabolism of antipyrene. Because of this, Dumont (1957) stated that, "L'emploi de l'antipyrene doit etre abandonné si l'on veut obtenir une mesure précise de l'eau corporelle."

Other solutes employed for the estimation of total body water include deuterium oxide, tritium, urea, and N-acetyl-4-aminoantipyrene (Dumont, 1957; Harrington, 1958a; Kay et al., 1962; Kirton, 1964a; McManus et al., 1969). Methods and equipment necessary for the determination of body water on a routine basis are still being investigated, but as stated by Kirton (1964a),

"It is doubtful whether sufficient accuracy can be achieved to make the methods useful for experimental purposes."

Theoretically, a substance perfectly soluble in fat, but insoluble in other body constituents, could be used for the direct determination of body fat. Unfortunately such a substance has not been found. Therefore, attention has been directed to substances having a higher solubility in fat than in other components of the fat-free body. For example, nitrogen gas has been used since it is five times as soluble in body fat as in body water. According to Harrington (1958a), errors were encountered due to the presence of nitrogen gas in intestinal gases, the absorption of nitrogen through the skin and the requirement for an excessively long "washing-out" period in an atmosphere of pure oxygen. Lesser *et al.*, (1952) investigated the anaesthetic gas cyclopropane and found that the average fat content of ten rats determined by this method was exactly the same as the fat content determined by ether extraction. However, cyclopropane, and similar gases, are not suitable for use with pigs because of the excessive length of time required to reach equilibrium.

Density

Fat has a lower density than other body constituents (Dumont, 1957; Harrington 1958a,b; Behnke, 1961; Panaretto, 1963; Holme *et al.*, 1963a; Kirton, 1964b; Standal, 1965), and therefore, whole body density may be used as an index of gross body composition. The percentage of fat relative to body weight has been shown to be inversely proportional to specific gravity or density of the body.

In order to calculate density, two observations are necessary -- the mass and the volume. The weight of the animal is easily obtained, but a measurement of the volume of an irregularly shaped body, which contains

gas-filled cavities, has proven to be difficult. (Harrington, 1958a,b; Behnke, 1961, Kirton, 1964b). By means of Archemedes principle, underwater weighing permits calculation of density according to the following equations (Holme *et al.*, 1963).

$$\text{density} = \frac{\text{wt. in air} \times \text{density of water at temperature of determination}}{\text{wt. in air} - \text{wt. in water}}$$

If the correction for the density of water is omitted, then the formula gives the specific gravity of the body.

$$\text{Sp. Gravity} = \frac{\text{wt. in air}}{\text{wt. in air} - \text{wt. in water}}$$

The water displacement method has been used successfully with human subjects when an estimate for lung volume can be made. (Behnke, 1961; Kirton, 1964b). In order to circumvent the discomfort of submergence in water and the resulting struggling of farm and laboratory animals, Lynch *et al.*, (1963) described a technique using anesthetised hogs. The method has had limited application to date.

Animal volume, and hence density, has been determined by the method of air displacement (Luizzo *et al.*, 1956, 1958; Harrington, 1958a; Gnaedinger *et al.*, 1963ab; Falkner, 1963; Lim, 1963; Kirton, 1964b) or inert gas dilution (Harrington, 1958a; Behnke, 1961, Siri, 1961; Foman *et al.*, 1963; Gnaedinger *et al.*, 1963a). The air displacement method involved the introduction of a known volume of air into an airtight chamber. Changes in air pressure were calibrated against objects of known volume. On theoretical grounds Harrington (1958a) reported that for the estimate of fat content to be accurate to 1/2%, the density estimate must be accurate to the third decimal place.

The determination of density by gas dilution has been based on the dilution of a known volume of gas when allowed to flow from a small closed chamber into a larger closed chamber containing the subject. Harrington,

(1958a) reported that the standard deviation for a single measurement of volume of a subject by this method was 0.15 liters.

However, Gnaedinger *et al.*, (1963) did not obtain a significant correlation when they related body density of live pigs (as determined by the air displacement method) to a direct determination of body composition. Hix and Pearson (1964), used the same technique but with better control of temperature conditions and claimed high correlations between density of humans as determined by the air displacement method and density as determined by the helium dilution method.

Kay and Jones (1962) determined body density of pigs by a technique which combined the water displacement and helium dilution methods. Subsequently the animals were slaughtered and carcasses were ground to provide samples for chemical analysis. Unfortunately, the relationship between body density and body fat content was poor ($r = -0.57$). A somewhat closer relationship occurred in fatter pigs than in leaner animals.

In addition to the physical difficulty involved in an accurate determination of the volume and density of a live animal, it has been necessary to assume constant values for the density of fat and for the density of the "fat-free" mass in order to make a direct estimate of total body fat from body density. The fallacy of this assumption is that the density of fat may be influenced by the diet fed (Harrington, 1958a) and/or the density of the "fat-free" mass may change due to variations in bone/lean ratio since bone has a higher specific gravity than muscle. (Standal, 1965). This was further substantiated by Barkes *et al.*, (1969) who found that breed differences necessitated the development of separate regression equations for each breed. Within breeds, however, specific gravity was found to be a more accurate method of predicting % lean than linear measurements.

Creatinine Excretion

Increased interest in producing leaner meat, a reflection of current consumer preference, has led to the development of methods for the prediction of lean tissue mass *per se*.

Brody (1945) showed that urinary creatinine excretion was related to the lean tissue mass of the animal. In man it has been generally accepted that there is a relatively constant daily excretion of creatinine which is affected slightly, if at all, by diet, exercise or urinary volume. Also daily creatinine excretion by obese persons has been known to be low in relation to body weight, but normal when related to ideal weight. The creatinine coefficient is defined as the milligrams of creatinine per kilogram of body weight excreted daily. (West and Todd, 1962).

Studies with beef cattle (Dinning *et al.*, 1949; Lofgreen and Garnett, 1954; Wurtheir and Stratton, 1957) indicated that protein intake did not affect creatinine excretion. Nevertheless, rather low correlations were observed between separable lean tissue of the 9-10-11th rib cut and creatinine coefficient ($r = 0.67$) and blood serum creatinine levels ($r = 0.55$).

Saffle *et al.*, (1958), found the creatinine coefficient to be negatively correlated with the amount of body fat in pigs. The highest relationship was found to be between the creatinine coefficient and the lean area of the loin at the last rib ($r = 0.66$). Correlations of similar magnitude were found between the creatinine coefficient and backfat thickness, lean cuts, primal cuts and combined fat, water and protein content of the ham. However, the live probe measure was found to have a higher correlation with other measures of leanness than either urinary or blood serum creatinine. Hence, it was concluded that the live probe method was superior since it was more closely related to other measures of leanness and furthermore measures were quicker and easier to obtain.

Electrolytes

Recently, the body content of electrolytes has been investigated for the purpose of predicting the lean body mass of live animals. The body content of potassium (Remenchik *et al.*, 1968; Kirton, 1964a,b) has received the most attention as it can be estimated by measurement of the naturally occuring radioactive isotope (K^{40}) with gamma radiation detectors which are capable of measuring very low levels of radioactivity (Anderson and Langham, 1961). Anderson (1959) stated that the concentration of potassium in living cells is held constant by hemostatic mechanism and therefore a determination of potassium content would be equivalent to determination of cellulor mass. Because there is no potassium in fat and very little in bone, the higher the proportion of potassium in an animal, or its carcass, the higher the proportion of muscle tissue. The amount of lean in pork hams has been successfully estimated from their K^{40} content (Kulwich *et al.*, 1958; Kulwich *et al.*, 1960a,b). It was found that net counts per minute of K^{40} per ham was highly associated with the weight of separable lean per ham (r = 0.96).

Kirton *et al.*, (1963a), Kirton (1963b) (1964a) and Lohman *et al.*, (1968) reviewed some of the errors and difficulties in the use of potassium relationships for the prediction of leanness in farm animals. In spite of the high cost of monitoring equipment required, inaccuracies can occur in the measurement of the potassium as well as in the determination of gross body composition of the animal. Since the accuracy in the measurement of K^{40} is proportional to the total number of counts (corrected for background), the longer the counting time the greater will be the accuracy of the potassium estimation. Furthermore, as total counts are a function of sample size, the larger the sample (until self-absorption of the radioactivity becomes a problem) the more accurate the potassium estimation.

In addition, biological variability is a limiting factor in relating potassium and sodium content to body composition. Gillet *et al.*, (1965) observed variations as high as 34.7% in the potassium content per kilogram of muscle when they compared individual muscles from the same animal. Muscles from Hampshire pigs contained more potassium and less sodium per unit weight than did muscles from Yorkshire pigs. Variation in the potassium content of different breeds and in different muscles indicated that the potassium to muscle ratio was not constant, and hence was a major source of error in the estimation of body composition. Further confirmation of the inaccuracy of K^{40} measurements in predicting body composition have been reported by Stant *et al.*, (1968) who found that the relative proportions of the various tissues did not remain constant between 23 and 91 kg live weight. In addition, a higher proportion of the total potassium in the carcass was found in the muscle with increasing weight, (Stant *et al.*, 1969).

Doornenbal *et al.*, (1962a) employed chromium -51 with high precision to determine red cell volume as an index of "lean body mass" in pigs. Cuthbertson *et al.*, (1963) were, however, unable to demonstrate a close relationship between red cell mass and dissectable lean tissue in young pigs.

Other

Other techniques which have been employed to estimate composition in live pigs include X-ray; (King and Roberts, 1960; Kraybill *et al.*, 1954; Harrington, 1958a; Stouffer, 1963); Stereo-photogrammetry (Pierson, 1963; Kirton, 1964a); and biopsy core (Everitt and Carter 1961; Everitt, 1963; Bray 1963; Livingstone *et al.*, 1966). The biopsy technique was demonstrated to be of practical value in developmental studies, although only poor correlations with lean content were obtained and there was evidence of adverse effects of the biopsy operation on the older animals. It is apparent that

more fundamental knowledge of muscle structure is required before accurate predictions of body composition from biopsy samples can be obtained.

Experimental results to date suggest that there is no completely satisfactory method of estimating carcass composition from live animal measurements, but several methods appear to have promise. An increase in the accuracy of predictions could come from refinement of current techniques, from new methodology, or by combining results of two or more methods by the use of multiple regression.

2.1.2 METHODS EMPLOYED IN THE ESTIMATION OF CARCASS COMPOSITION

Numerous techniques have been employed as indices of carcass composition since the trend toward consumer demand for leaner cuts of meat began.

Linear Measurements

Values obtained for various linear measurements of carcasses have been shown to be affected by the method of measurement (Zobrisky et al., 1959b; Braude et al., 1957; Harrington et al., 1961; Harrington, 1962). In Danish progeny tests the "length" of a carcass was taken on the chilled side while lying on a cutting table, from the posterior point of the atlas bone to the anterior edge of the [illegible]. In Great Britain, the "length" of a carcass was taken from the junction of the first rib and the sternum to the anterior edge of the [illegible]. The measurement was taken either on hot, cooled or chilled carcasses hanging from the hind legs either before or after the head had been removed. Estimates of the precision of measurement (Braude, et al., 1957) showed that length measurements taken on the hanging carcass from the junction of the first rib and sternum to the [illegible] were less susceptable to errors than the same measurement taken on carcasses lying on a table. Both of these measurements were more accurate than that from the

Atlas bone to the *symphysis pubis*.

Regardless of the accuracy of the measurements themselves, they are only of importance when they enhance the prediction of carcass leanness. In general, linear measurements of length and depth have been shown to be of little value as an index of separable lean. (Harrington, 1961; Harrington, 1962; Bowman, *et al.*, 1962b; Joblin, 1965).

Pomeroy (1965) rationalized that if linear measurements were to be of any value in carcass evaluation they must be related to the proportions of the various tissues obtained by carcass dissection or at least to the proportion of primal cuts. As stated by Pomeroy, (1965), "It is expecting too much of simple linear measurements to ask them to predict either the proportion of swine cuts or the proportion of lean meat in the carcass and little is to be gained by correlating an assortment of measurements without dissection or cutting data. It would be more sensible to combine linear measurements to give measurements of volume since percentages of lean meat and proportion of prime cuts are essentially measures of volume."

Measurements of backfat thickness, whether by caliper, ruler or probe techniques, should also be classified as linear measurements. According to Buck *et al.*, (1962), caliper backfat measurements have been used as indices of carcass composition since the beginning of this century. Correlations obtained between backfat measurements and carcass fatness have been observed to vary with the position of measurement, (Hammond, 1933; McMeekan, 1941; Harrington, 1958a; Buck *et al.*, 1962; Bowman *et al.*, 1962a; Joblin, 1965) and between measurement (Harrington, 1958a; Bowman *et al.*, 1962b; Joblin, 1965). Since the whole carcass is a complex arrangement of bones, muscles and fat depots, Pomeroy (1965) suggested relating a given measurement to a limited region of the carcass in which it occurred rather than to the whole carcass.

Nevertheless, leanmeter measurements have been found to provide a good indication of carcass leanness (Bowman *et al.*, 1962b), in spite of the difficulty in defining the points of insertion accurately. (Harrington, 1958a,b).

According to Pomeroy (1965) most linear carcass measurements that can be taken accurately are mainly measurements of skeleton and should not be considered to be highly related to the composition of the entire carcass in terms of muscle, fat and bone.

Cross-sectional Measurements

The use of cross-sectional measurements as indices of muscle content of the carcass have been studied extensively by several workers. The most common cross-section cut has been through the loin in the region of the last rib to expose the *M. longissimus dorsi*. Hammond (1933) and McMeekan (1941) found the loin region to be the latest developing region and for this reason it was considered to be the most desirable region for cross-sectional evaluation of muscle and lean content. Cross-sectional areas of *M. longissimus dorsi* have been estimated by tracing on parchment paper (MacKintosh, 1936), by multiplying the maximum width times maximum depth (McMeekan, 1941, Harrington, 1958a; Buck *et al.*, 1962), by photographic techniques (Stull, 1953; Schoonover *et al.*, 1957; Corbin *et al.*, 1959; Deans *et al.*, 1959; Schrewsbury *et al.*, 1961) and by ultrasonic methods (Stouffer *et al.*, 1961; Stouffer, 1963; Gilles *et al.*, 1969; Anderson *et al.*, 1969; Stouffer *et al.*, 1969; Jones *et al.*, 1970).

In spite of the intensive investigations designed to devise a simple and reliable method to estimate *M. longissimus dorsi* area, the relationship between the area of this muscle (loin eye area) and various component parts of the carcass has been relatively poor (Aunan and Winters, 1949; Kline and Hazel, 1955; Cole *et al.*, 1960). According to Bowman (1963), the traditional significance that has been attached to loin eye area has tended to mask an effective appraisal of evaluation techniques. Frequently loin eye area has been almost

regarded as a final criterion of merit, while in reality it is only an estimator of merit. Bowman (1963) ranked loin eye area as to its reliability in predicting percentage lean nearly as low as visual appraisal of live swine.

Conversely, Topel *et al.*, (1965) found that *M. longissimus dorsi* area at the last rib was almost as highly correlated with lean cut weight as was the weight of the muscle itself. The area of the eye muscle accounted for 40% of the variation in lean cut yield, while backfat thickness accounted for only 16%. Joblin (1965) concluded that eye muscle measurements were not satisfactory as indices of percentage lean, but that a combination of eye muscle area and fat thickness appeared promising.

Weight and Analysis of Sample Cuts

The physical and chemical properties of a carcass may be estimated from the weight and composition of one or more cuts. Lush (1926) was the first to examine the relationship between the composition of a single cut of beef and the whole carcass composition. McMeekan (1941) selected the loin and leg as sample joints for the estimation of pig carcass composition. The total weight of skeleton was highly correlated with the bone in the loin ($r = +0.94$) and with the bone in the leg ($r = +0.90$). Total muscle was found to be significantly correlated with muscles of the loin ($r = +0.87$) and with muscles of the leg ($r = +0.97$). It was noteworthy that loin muscles showed a lower correlation with total muscle than did leg muscles. Neither leg nor loin alone showed exceptionally high correlations with the total weight of fat ($r = +0.99$ and $+0.86$ respectively).

Aunan and Winters (1949) reported a correlation of +0.80 between percentage lean in the "loin" cut and percentage of separable lean in the whole carcass. The comparable correlation of percentage fat in the loin with separa-

ble fat in the whole carcass was +0.82.

The ratio of the weight of certain predominantly fat cuts, to the weight of certain predominantly lean cuts has been observed to vary with the fatness of the carcass. (Warner *et al.*, 1934; Harrington, 1958a). Yields of fat cuts have been observed to vary from 14.6 to 37.1% of the entire chilled carcass weight (Warner *et al.*, 1934), while the percentage of fat in the "edible" portion of the carcass as determined by chemical analysis varied from 28 to 68%. The correlation between the two was +0.91 and the standard error of estimate in the prediction of extractable fat in the carcass from the yield of these cuts was about 3%. The ratio of the combined weight of cutting fat and belly to the weight of ham plus loin varied from 1.09 to 0.60 and had a correlation of +0.92 with the percentage of extractable fat in the edible portion of the carcass.

Extensive use has been made in North America of the yield of lean cuts (ham, loin, butt and picnic ham) and prime cuts (lean cuts plus belly). (Jordon, *et al.*, 1956; Zobrisky *et al.*, 1959a,b,c,d). In some instances, lean cut yield has been taken to be nearly synonomous with total lean. For example, Zobrisky *et al.*, (1959a) reported that there was very little difference between the weight of loin, ham or shoulder as an index of leanness, which was actually the yield of the four lean cuts. Correlations observed between loin, ham and shoulder and the four lean cuts were +0.74, +0.73 and +0.70 respectively. However, Zobrisky *et al.*, (1959b) concluded that the yield of fat can be more accurately measured in the live pig or carcass than the yield of the four lean cuts. Zobrisky *et al.*, (1959c) found dressing percentage to be significantly correlated with the yield of carcass trim and leaf fat, and the yield of "miscellaneous" cuts (feet, tail, kidneys, neck loins and jowls).

The danger of placing too much emphasis on lean cut yield was indicated by Self *et al.*, (1957) who cautioned that there was no indication of composition or quality of lean cuts, nor was the effect of sex, weight and carcass grade and quality of cuts known. These shortcomings were substantiated by Barton *et al.*, (1958) who found that there was a differential response evoked in the leg versus the loin of sheep in response to hormone implantation. As stated by Barton *et al.*, (1958) "If either joint had been used individually as a sample of the whole then it is highly probable that a different picture would have been presented for the effects of the treatment on the main tissues of the whole carcass". In addition, Harrington (1958a) reported that cutting errors are also a handicap to this system of carcass evaluation since standardization of cutting methods was difficult to attain. The usefulness of chemical analysis of sample cuts in the prediction of entire carcass composition has been further impaired by the problem of preparing homogeneous samples and moisture losses during processing.

Specific Gravity

The differential density of the various components of a carcass and the fact that fat has a much lower density than the "fat-free" portion of the carcass, has stimulated several investigators to study density and/or specific gravity as a tool in the prediction of carcass composition (Brown *et al.*, 1951; Whiteman *et al.*, 1953; Pearson *et al.*, 1956; Price *et al.*, 1957; Harrington, 1958a; Buck *et al.*, 1962; Holme, 1963a; Adam *et al.*, 1964; Joblin, 1965, Standal, 1965; Pearson *et al.*, 1968; Barkes *et al.*, 1969).

It was found that fat or lean content of a carcass could be as accurately estimated by specific gravity as by the percentage fat or lean cuts (Brown *et al.*, 1951) and was a more reliable indicator of muscle content or actual meatiness than the live probe or backfat thickness (Price *et al.*, 1957).

Highly significant correlations were observed to exist between the specific gravities of hams, loins and shoulders and the specific gravity of the entire carcass. (Whiteman *et al.*, 1953; Pearson *et al.*, 1956; Price *et al.*, 1957). In general, higher correlations were found between specific gravity of hams and entire carcass specific gravity (Pearson *et al.*, 1956; Price *et al.*, 1957) than observed with other cuts. This tends to substantiate the claims of earlier workers (Hankins *et al.*, 1934; McMeekan, 1941; Hetzler *et al.*, 1950) who reported that the proportions of the various tissues of the ham were indicative of the respective tissues in the entire carcass. Contrary to this, Joblin (1965) established higher correlations between the specific gravity of the "rib-end" and percentage fat in the carcass. The inclusion of the weight of "trotters" (feet) with specific gravity of the rib-end provided an accurate estimate of the percentage bone.

Harrington (1958a) proposed that since the relation between specific gravity and body fat percentage was hyperbolic, the reciprocal of specific gravity would yield higher correlations. Recent studies have not confirmed this (Holme, 1963a; Adam *et al.*, 1964; and Standal, 1965), since an increase in the accuracy of prediction of carcass composition was not observed when specific gravity was replaced by it's reciprocal.

According to Standal (1965) the specific gravity of the components of the pig carcass are: fat = 0.952, muscle = 1.064, and bone = 1.199. Since the prediction of carcass composition is dependent on the fact that fat has a much lower density than the fat-free portion of the carcass, any change in the proportion of muscle and bone could interfere with the predictive accuracy of specific gravity. Buck *et al.*, (1962) reported that wide fluctuations in the muscle/bone ratio were observed between pigs at a given level of fatness. In addition, the muscle/bone ratio showed systematic differences between breeds.

Adam *et al.*, (1964) used the muscle/bone ratio in combination with specific gravity in the estimation of percent lean, and found a 12-20% increase in the accuracy of prediction as compared to specific gravity alone. Standal (1965) used the weight of metatarsal bones in combination with specific gravity for the prediction of percent lean and obtained an increase of 15% in the accuracy of prediction. It appears, therefore, that the influence of percent bone, as suggested by Buck *et al.*, (1962) was correctly regarded as a source of error limiting the value of specific gravity as a means of predicting carcass composition. Furthermore, the variation in muscle/bone would likely account for a large part of the observed differences in specific gravity between breeds reported by Barkes *et al.*, (1969).

2.1.3. WHOLE CARCASS ANALYSIS

The analysis of the whole animal body provides the fundamental basis for the evaluation of all techniques used to "estimate" body composition.

Chemical Analysis

Lawes and Gilbert, as cited by Harrington (1958a), first used the method of chemical analysis in 1859. Their technique involved weighing, sampling and analysing each organ separately. The chemical analysis involved the estimation of the amount of water, fat, protein, and ash. The fat was removed from the tissues partly by melting, partly by squeezing out, and partly by ether extraction from the remaining "crude dry substance". Samples were then taken from the crude dry substance for the estimation of nitrogen (by burning with soda-lime) and ash (by incineration).

This clarifies the statement by Morris *et al.*, (1963), "Although a method of body analysis has been available for 100 years, it is not surprising that there has been a lack of interest in its use."

Murray (1922) examined Lawes and Gilbert's data and confirmed their general thesis that the chemical composition of animals was determined when the percentage fat was known. As stated by Murray, "The composition of the non-fatty matter is practically the same in all, it is not affected by the condition (fatness), and it varies only to a slight extent with the age of animals."

Harrington (1958a) reviewed several chemical investigations of growth and development of pigs, but found comparisons between results difficult due to variations in techniques.

The technique described by Morris *et al.*, (1963) in which the animal body is reduced to a single sample was much less labourious than those described by previous workers (Murray, 1922, Callow, 1947; Harrington 1958a). Morris *et al.*, (1963) discarded the contents of the gastro-intestinal tract and dissected the carcass prior to freezing it into blocks, which were subsequently minced, mixed and sampled for chemical analysis.

Sampling may be an important source of error, since homogeneity may be difficult to achieve, (Harrington, 1958a). Furthermore, the estimation of water content is difficult because the tissues constantly lose water by evaporation during processing. The percentage loss has been found to be directly related to the water content, (Harrington, 1958a). However, Morris (1963) reported only 1% loss with the bovine and less than 1.5% with the ovine.

Chemical analysis has also suffered criticism in that changes in composition could not be related to changes in conformation unless analysis was done on small sub-units of the carcass, (Bray, 1963).

In spite of the handicaps, chemical analysis has been used in several recent studies with swine (Hill *et al.*, 1962; Osinka, 1962; Henry *et al.*, 1963 Brooks *et al.*, 1964a,b; Kauffman *et al.*, 1964; Wood *et al.*, 1965) with varying

degrees of success.

Anatomical Dissection

The most direct method of determining the composition of the eviscerated carcass is to dissect it completely into its various anatomical components. As concluded by Callow (1962), "In studies of meat quality, and of the effect of breed and plane of nutrition on meat quality (including carcass conformation) it will be necessary to dissect the whole side or carcass joint by joint, tissue by tissue and muscle by muscle. There are no adequate short-cuts."

Lawes *et al.*, (as cited by Harrington, 1958a) used this method in their investigations reported in 1859. Hammond (1933) considered that their technique was not sufficiently accurate to study the relative rates of development of various parts of the body and introduced the concept of "anatomical joints". According to this system the carcass was divided into well-defined anatomical sections, the position for the subdivision of each joint being fixed by particular skeletal points. The procedure employed for jointing and dissection of the pig carcass has been described in detail by McMeekan (1940a), and was later used by Pomeroy (1941). Similar methods were used with sheep by Wallace (1948) and Palsson *et al.*, (1952). This dissection method provided useful information on the general pattern of growth in the sheep and pig, but it could not yield data concerning the proportions of individual muscles, bones and fat deposits.

Cutbertson *et al.*, (1962a,b) further studied growth and development on the pig utilizing a technique similar to that described for sheep (Bassett, 1960; Fourie, 1962), and for cattle (Walker, 1961). The carcass was dissected on a strictly anatomical basis into its individual bones, muscles and major fat deposits. Muscles and bones were removed, identified and classified according to the nomenclature of Sisson and Grossman (1960). Throughout the dissection

the carcasses were covered with damp towels to minimize any moisture loss.

The use of this method for the study of growth and development provided fundamental knowledge of proportional anatomical composition in terms of individual bones, muscles and fat deposits. Furthermore, it provided a method for the comprehensive study of differences in rate, order and extent of development of particular parts and tissues which are responsible for variation in form, in anatomical and chemical composition, and in conformation of animals of different weights, sex or breed.

2.2 FACTORS AFFECTING PROPORTIONAL COMPOSITION IN THE PIG

Plane of Nutrition

The "level" or "plane" of feeding has been defined (Lucas *et al.*, 1956), as the amount of total digestible nutrients fed to a pig of a given weight. The classical studies by McMeekan (1940b,c) dramatically demonstrated the influence of restricted feeding on the proportional composition of the pig carcass. The experimental procedure produced marked differences in the shape of the growth curve, through quantitative control of the plane of nutrition from birth. Results indicated that in animals which were under-nourished up to 16 weeks, the early developing parts (head, ears, neck and legs) were penalized relatively less by inadequate nutrition than the later developing parts (body depth, loin and hind quarters). In contrast, the high plane of nutrition favoured the later developing parts most. The effect of the plane of nutrition on the proportions of bone, muscle and fat in the carcass is emphasized in the following Table taken from McMeekan (1940c).

EFFECT OF PLANE OF NUTRITION ON PROPORTIONS OF BONE, MUSCLE AND FAT IN CARCASS

Ratio	High-High	High-Low	Low-High	Low-Low
Muscle/bone	3.67	3.99	3.76	3.96
Fat/bone	3.48	2.97	4.56	2.22
Fat/muscle	0.95	0.74	1.21	0.51

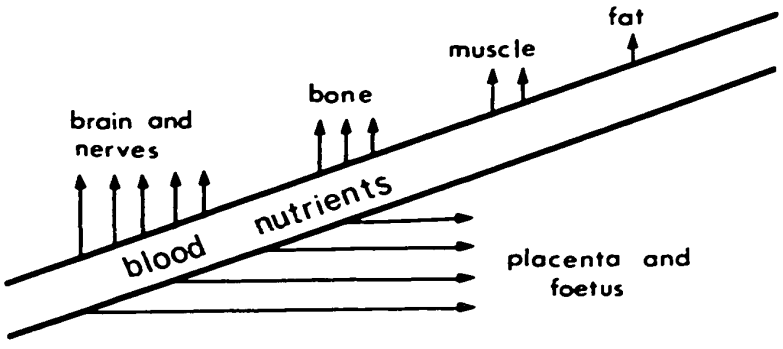
The treatment which yielded the fattest pigs (low-high) showed a 76% greater quantity of subcutaneous fat than the treatment which yielded the leanest pigs (low-low). It was concluded that variations in growth rate significantly affected carcass composition, and that a reduction in growth rate, during the period when pigs were depositing the most body fat, decreased the fat deposition in the carcass. The most desirable treatment was considered to be a high plane of nutrition up to 16 weeks followed by a low plane to 200 lbs.

Several other workers have domonstrated that restricted feeding slowed down the rate of growth and improved grading results (Crampton, *et al.*, 1954; Lucas *et al.*, 1956; Bradley, 1964; Lloyd, 1964), while other experiments have failed to show the same beneficial effect (Geurin, 1963; 1964). In this respect it is noteworthy that in McMeekan's experiments, the pigs were fed to follow extremely different growth curves, and that the pigs which had their feed restricted from 100 to 200 lbs live weight (HL group) took an average of 46 days longer to reach bacon weight than those which were fed to appetite (HH group).

Hammond (1961) stated that the tissue growing most rapidly at the time was the one which suffered the most as a result of lowering the level of nutrition. Any lowering of the level of nutrition at the lower weights would severely restrict muscle growth. The extreme differences in developmental

patterns found to be characteristic of different breeds of pigs led Hammond (1961) to state, "In no breed or type of pig should the nutrition of the pig be lowered before the crossing over point of muscle and fat (i.e. fat deposition exceeds lean growth) for that breed or type. On the other hand after the crossover point for the particular breed or type a lowering of the level of nutrition gives an effective means of checking the deposition of fat without affecting the growth of muscle."

The theory proposed to explain the interplay between nutrition and the development of different organs and tissues of the body has been called, "the partition of nutrients according to metabolic rate." This theory is illustrated schematically in the following figure as presented by Palsson (1955).



The number of arrows denotes the metabolic rate of the particular tissue. When nutritive supply is plentiful all tissues of the growing animal, and/or of a pregnant female, receive sufficient nutrition for maintenance as well as for normal growth. When the supply of nutrients in the blood stream is limited one arrow is deducted from each tissue and growth of fat is halted, whereas growth of other earlier maturing tissues continue but at a slower rate. By further reducing the nutritive supply the direction of the arrow for fat is reversed and another arrow is deducted from each tissue, thus illustrating how tissues such as brain, bone and fetus continue to grow while muscle growth ceases and fat is lost to supply the animal with energy. At still lower levels of nutrition, bone growth ceases and both muscle and fat are broken down for maintenance.

Joubert (1956) cautioned that it is essential not to restrict nutrition below the maintenance level at any time. Pomeroy (1941) found that a submaintenance ration fed to pigs weighing 328 lbs. on average caused a considerable decrease in muscle. However, fat was lost at an even greater rate, which indicated that the tissues were reduced in reverse to their order of development.

Crampton *et al.*, (1954) found that quality of the bacon carcass could be improved by "diluting" relatively highly digestible rations with fibrous feeds during the finishing period. Carcass improvement was accompanied by a decrease in rate of gain and an increase in length of feeding period. Geurin (1963; 1964) after an extensive literature review stated, "There is essentially unanimous agreement of experimental results showing that increased fiber level in the ration improves carcass grade of market hogs." Extra fiber or chemically inert material in the ration reduced the growth rate and carcass fatness, but increased the feed required per pound of gain, since pigs tended to eat on an energy basis rather than on pounds of feed. Dressing percentage was also lowered on high

fiber rations and it was found that the increase in value due to the higher grade was not enough to overcome the lowered sale value due to the lowered dressing percentage. In summary, Geurin (1963) stated, "Adding large amounts of fiber to the finishing ration creates a cruel mirage so fascinating that one walks unaware into the pit of poverty."

It is also apparent that physical restriction of the ration (limit feeding) is not the answer. As stated by Lloyd (1964), "Invariably rate of gain is decreased and time to market is increased, improvement in feed efficiency may or may not be found, and carcass characteristics in terms of fat reduction are usually improved, although soft carcasses have been noted. Obviously, limited feeding is not the final answer for the most efficient production of hogs of high market quality."

It appears that, although limit feeding and/or diluents improve carcass composition, (Bowland *et al.*, 1959; Geurin, 1963; 1964; Lloyd, 1964; Bowland 1970) hope for future improvement in carcass quality is in breeding animals that will yield carcasses with a higher percentage of muscle and a minimum of fat when fed to gain at their maximum.

Nutrient Interrelationships

The research reviewed by Geurin (1963; 1964) showed that a lack of protein quantity or quality resulted not only in slow inefficient growth but also poor carcasses. Furthermore, rations moderately low in protein quantity or quality, or the addition of fat which reduced the protein-energy ratio, caused significant differences to show up in the carcass of the hog. (Ashton *et al.*, 1955; Bowland *et al.*, 1959; Clark *et al.*, 1961; Clawson *et al.*, 1961; Geurin, 1963; Bowland, 1970). Increasing the productive energy level brought about changes in the carcass which included higher dressing percentage, more backfat production, less lean cuts, lower lean/fat ratios and increased intra-

muscular fat in the *longissimus dorsi* muscle. Increasing the quantity of protein from 13-25% resulted in a significant decrease in backfat, increased lean cuts, and decreased intermuscular fat (Clark *et al.*, 1961). Gillet *et al.*, (1962) reported that dietary protein levels of 18-25% in starter and grower periods (low-low) as compared to 29-25% (high-high) had no bearing upon carcass composition. However, the pigs maintained on low protein level (12%) during the finishing phase had significantly fatter carcasses. Conversely, high protein (21%) fed during the finishing phase produced 0.89 and 1.28% more trimmed and skinned ham and 0.98% more trimmed loin than the low protein ration. The high protein ration fed during the finishing period resulted in significantly heavier *biceps femorus, semitendinosus* ($P<.01$) and *semimembranosus* plus *adductor* muscles ($P<.05$). Nevertheless, several workers have shown that higher than normal protein levels did not result in any further improvement of carcass composition or grade (Beacom, 1959; Clawson *et al.*, 1961; Geurin, 1963), which indicated that a complete well-balanced ration was important and that extra dietary protein did not make a better ration.

Protein quality (amino acid make-up) is also important. According to Clausen (1965), "The protein requirements of growing meat-type pigs must be defined as the quantities of the essential amino acids, and the quantitative ratio of these amino acids to one another, which ensure maximum lean meat formation in pigs."

If full lean meat formation is to be achieved it was claimed that the total ration must not only contain the necessary quantities of amino acids in the correct proportion to one another, but must contain vitamins of the B-complex in sufficient quantities to enable the pig to transform the amino acids into lean meat. Lysine or lysine plus methionine, given alone or in combination with vitamins of the B-complex, to rations deficient in these amino acids have been

shown to result in the same lean meat content in the cross section at the last rib as obtained by feeding skim milk as a protein supplement (Clausen, 1965). Methionine and lysine supplementation has also been shown to improve gains, feed conversion, nitrogen balance, loin eye muscle area and total yield of lean muscle (Ostrovski, 1969). Such supplementation has not, however, been able to reduce the total area of fat in the cross section of the last rib, (Clausen, 1965). It was reasoned that the supplements improved the utilization of the total ration. The following three basic laws governing lean and fat formation in the pig were presented by Clausen (1965):

"1. No pig can form lean meat up to the limit determined by its heredity unless its diet contains sufficient quantities of protein of high biological value.

2. No pig can be forced, by means of extraordinary high levels of protein in its diet, to produce more lean meat than permitted by its heredity.

3. When the pig's daily requirements for maintenance and lean meat production have been covered, the rest of the ration must inevitably be used for the formation of fat, or, in other words, the more food the pig gets per day (i.e., the more calories the daily ration contains), the fatter it becomes."

Antibiotics

The beneficial effects of antibiotics on growth rate and feed efficiency in swine have been widely demonstrated (Catron, 1949; Bowland *et al.*, 1951; Harrington *et al.*, 1955; Ashton *et al.*, 1955; Clausen, 1956; Braude, 1958; Beacom, 1959; Barber *et al.*, 1960; Gorrill *et al.*, 1960; Lloyd *et al.*, 1961; Squibb, 1961, Braude *et al.*, 1962; Beames, 1965; Welch, 1965). However, some experiments have indicated that the feeding of antibiotics to swine resulted in

fatter, less desirable carcasses, (Bowland *et al.*, 1951; Clausen, 1956; Beacom, 1959; Braude *et al.*, 1962), while other workers found no deleterious effects (Harrington *et al.*, 1955; Clausen, 1956; Barber *et al.*, 1960).

Hanson *et al.*, (1955) and Clausen (1956) explained that antibiotics tended to increase the appetite, and that the response to antibiotics was less in terms of feed efficiency than in terms of growth. This they explained was because the increased appetite, under *ad libitum* feeding conditions resulted in higher feed consumption and greater deposition of fat. Clausen (1956) found that the feeding of antibiotics to pigs fed a restricted diet had no effect on thickness of backfat, thickness of streak, weight of leaf fat, number of scores for amount of lean meat in the carcass, and on the grading of pigs according to thickness of backfat.

Hormones

The oral administration of diethylstilbestrol and related hormone materials to feeder cattle and lambs has generally resulted in faster and more economical gains and in leaner carcasses. Similar studies with pigs indicate few, if any, beneficial effects. (Beeson *et al.*, 1955; Taylor *et al.*, 1955; Sewell *et al.*, 1957; Tribble *et al.*, 1958; Thrasher *et al.*, 1959; Hale *et al.*, 1960). Likewise, the subcutaneous implantation of stilbestrol either as a single dose (Dennison *et al.*, 1951; Heitman *et al.*, 1957; Gorrill *et al.*, 1964) or as more than one dose (Woehling *et al.*, 1951; Pearson *et al.*, 1952) showed no significant effects on rate or economy of gains, or carcass quality of either barrows or gilts. Detrimental side effects such as mammary gland and reproductive organ development and increased sexual behavior were frequently encountered. In contrast, Cahill *et al.*, (1959) found that a positive relationship existed between the amount of stilbestrol implanted and both size of eye muscle and percent primal cuts. Beacom (1963) reported that the implantation of stilbestrol in barrows

had a marked beneficial effect on feed efficiency, on area of loin and on R.O.P. score when they were fed an undiluted ration with added protein. On the diluted ration with no added protein, implantation of barrows doubled the percentage of A grade carcasses. Implantation of barrows fed a diluted ration with added protein improved rate of gain, feed efficiency and carcass quality. Hormone implantation of gilts was not found to be beneficial.

Beeson *et al.*, (1955) found that carcasses from testosterone fed pigs contained heavier lean cuts (hams, loins, picnics and Boston butts) and lighter fat cuts (backfat, bellies and jowls). Chemical analysis showed that the pigs which had received testosterone were 5% leaner and had about 5% less fat than the controls. Carcasses from stilbestrol fed pigs were about intermediate in fat content between control animals and testosterone fed animals. Perry *et al.*, (1955) found that carcasses from hogs fed 27 mg or more of methyltestosterone per day contained significantly less fat than carcasses from hogs fed no hormone (from 4% to 14% lighter bellies; from 11% to 15% lighter fat backs; 11% to 15% lighter jowls; and from 11% to 14% less backfat). A daily intake of methyltestosterone higher than 27 mg resulted in some additional carcass alterations toward a leaner carcass, but this change was far greater between intakes of 0 and 27 mg per day than between 27 and 62 mg per day.

Sex

Although Fitzherbert in 1534, (cited by Blair *et al.*, 1965) advocated the superiority of entire males (boars) for pork production, the use of castrates has continued to the present day. Within the past 30 years several experiments have been carried out to test the effect of castration on meat production of pigs (Hammond *et al.*, 1937; Winters *et al.*, 1942; Cahill *et al.*, 1959; Cahill *et al.*, 1960; Cahill *et al.*, 1961; Charette, 1961;

Zobrisky *et al.*, 1961; Prescott *et al.*, 1964; Blair, 1965; Prescott *et al.*, 1967). Results have indicated that uncastrated males grow faster, utilize feed more efficiently and are leaner than castrated males. For example, Blair *et al.*, (1965) observed that daily gains were 8.3% higher ($P<.001$), daily feed intake 3.7% lower ($P<.05$) and feed-conversion efficiency 11.3% higher ($P<.001$) in entire males than in castrated males. The faster growth of the entire males was reflected in a significant reduction ($P<.05$) in days-to-slaughter of 7.2. Furthermore, maximum backfat thicknesses were 11% less, minimum backfat thickness 15.5% less, loin backfat thickness 23.3% less, and the cross sectional area of *M. longissimus dorsi* 14.3% larger in the entire males, than in castrates. Density of sides was also greater in the entire males (indicating less fat), while no significant differences were noted in the proportional weight of the fore-cuts (anterior to last rib), length or dressing percentage.

In contrast, Prescott *et al.*, (1964) reported that boars were found to have a greater development of fore-end (head and shoulder) and less middle (including loin) than castrated counterparts. In addition, other workers, have presented data, based on carcass measurements and dissection, which indicated boar carcasses tended to contain a higher percentage of bone. (Hammond *et al.*, 1937; Zobrisky *et al.*, 1961; Cahill *et al.*, 1961; Charette, 1961).

In comparing entire males with females, Blair *et al.*, (1965) found dressing percentages 1.2% less, maximum backfats 2.8% less, loin backfat 13.7% less, and weight of fore-cuts 1.6% less in the entire males. Density of sides was also greater in the entire males. There were no differences in lengths, minimum backfat, areas of *M. longissimus dorsi* or in backfat thickness over the eye muscle. Similar results have been reported by other workers, (Charette, 1961; Zobrisky *et al.*, 1961).

The comparison of castrated males with females by Blair *et al.*, (1965) showed that loin backfats were 8.5% less, fat thickness over the *m. longissimus dorsi* 17.3% less, the proportionate weight of fore-cuts 1.5% less and area of *m. longissimus dorsi* 15.2% larger in females. Density of sides was also greater in the females. No significant differences were noted for dressing percentage, length or maximum or minimum backfat. These results are similar to those of other workers (Lucas *et al.*, 1956; Bowland *et al.*, 1959; Charette, 1961; Buck *et al.*, 1962).

Blair *et al.*, (1965) suggest that delayed castration (castration delayed until near slaughter weight) or castration by the Russian method outlined by Baiburtcjan in 1960 should be considered as ways of preventing over-fatness in castrated males.

Prescott *et al.*, (1964) concluded that the use of boars was likely to pose few problems for the light pork trade and would have advantages in the more efficient production of lean meat. However, it was further stated, "The heavier the boar, the greater the advantage over the hog with respect to economy of production and leanness but the greater the development of the fore-end and the risk of taint."

Breed

During the progress of evolution under domestication, Palsson (1955) related that the different species have undergone vast changes in body proportions and conformation. The "improved breeds" have reached proportionally a much more advanced stage of development of the late maturing parts and tissues of the body than the wild ancestral species. McMeekan (1959) pointed out that proportional changes in growth of the pig were responsible for the differences between "pork" and "bacon" type. In the "pork" type, breeds such as Berkshire and Middle White go through growth changes rapidly and at 100 lbs live-weight

have the same conformation and body structure (bone, muscle and fat proportions) which the bacon types such as Tamworth and Large White (Yorkshire) only reach at 200 lbs. live-weight. As stated by McMeekan, "If pork-type pigs are carried to bacon weight, the extra growth is mainly of late-developing fat-tissue and the carcass is too short, too deep, and too fat for the consumer. Similarily, if the bacon type is killed at pork weight, it is unfinished with too much wasteful leg, under-developed loin and hams, and insufficient fat."

Minor differences also exist between breeds of the same type as indicated by Roache (1964) who found the purebred Landrace had a slightly higher percentage ham and a lower percentage shoulder as compared to purebred Yorkshire. Buck *et al.*, (1962) found that shoulder backfat thickness was significantly thicker in Large Whites than Landrace (the differences being about 6% of the mean), while maximum loin fat thickness was greater in the Landrace than the Large White (5% of the mean). Carcass grading based on shoulder and minimum loin backfat and sex tended to upgrade too many Landrace pigs and downgrade too many Large Whites, for at constant shoulder and minimum loin fat, the Large White pigs had some 1.73% more of its side weight as lean meat.

Noffsinger *et al.*, (1959) studied the Yorkshire, two lines of Chester White and the cross between lines of Chester White and found there were highly significant differences in average backfat between lines ($P<.01$). The Yorkshire at all weights had significantly less backfat than any of the other lines. At 100 lbs, backfat measurements of the pigs from the Chester White cross were intermediate between the two parent lines while at 200 lbs. the backfat of the crosses were no greater than that of the thinnest line.

Age and Weight

Growth and development, with age and weight increases involve marked proportional composition changes. According to McMeekan (1940a, 1959) and Palsson (1955), at birth the head is relatively large, legs long and body small, while in the mature animal the head is small, legs relatively short and body large. Thus the conformation of the animal completely changes from what it was at birth. Such changes are the result of various tissues and parts of the body growing at different rates. Growth of the main body tissues (bone, muscle and fat) is relatively greater than growth of organs so that the dressing percentage (the proportion of carcass to total live weight) increases with age.

Of greatest importance to the meat producer is the differential rate of growth of the three major tissues, (bone, muscle and fat), and the consequent changes in proportional composition of the carcass. It has been shown that bone completes the greatest proportion of its growth earlier in life than either muscle or fat while fat makes the greatest proportion of its growth later in life. (McMeekan, 1940a). This has been substantiated in sheep by Wallace (1948), Palsson and Verges (1952) and Bassett (1960); in pigs by Pomeroy *et al.*, (1961), Cuthbertson *et al.*, (1962a,b); Cuthbertson *et al.*, (1963); and Pomeroy (1965).

The fact that different intensities of growth exist between different parts of the skeleton was first demonstrated in the pig by McMeekan (1940a). By plotting increases over birth weight of individual bones their relative intensities of growth could be clearly seen. In respect to the bones of the head and vertebral column, it was found that the skull and lower jaw both made a relatively smaller amount of growth after birth than did the vertebrae. The lower jaw increased its birth weight slightly more than the skull. As regards the vertebral column, a growth gradient was noted with the lumbar and sacral

groups showing relatively greater growth than the cervical and thoracic. Conversely, Pomeroy *et al.*, (1961) found the thoracic vertebrae were considerably later developing than the lumbar vertebrae both at 176.1 and 212.5 days of age. McMeekan (1940a) noted that the ribs and sternum followed the growth pattern of the thoracic vertebrae fairly closely. The limb bones were found to be relatively early developing with their rate of increase falling between the skull, and neck and thorax. The pelvis showed the greatest proportional increase.

Pomeroy *et al.*, (1961) and McMeekan (1940a) observed a well-defined centripetal gradient in rate and order of development of the bones of the limbs. Proceeding up the limb, the rate of increase of the individual bones over their birth weight increases.

The Cannon bones made a relatively smaller amount of growth after birth than did the radius-ulna, and the latter a proportionally smaller amount than the scapula. Similar observations were made with the cannons, tibia-fibula, and femur of the hindlimb. Cuthbertson *et al.*, (1962b) found that in both the thoracic and pelvic limb the more proximal bones grew faster than the distal bones from 50-60 Kg carcass weight but from 68-92 Kg carcass weight this was reversed. Furthermore, it was observed that from 50-68 Kg carcass weight there was a fairly rapid growth of length in the bones of the limbs, a rather less rapid growth in circumference and considerably slower growth in density. This was taken as an indication that growth of the organic matrix proceeded more rapidly than ossification. Conversely, between 68 and 92 Kg carcass weight, there was a tendency for the length growth to slow down while there was an increase in circumference growth and considerable increases in density. This phase was characterized by a thickening and ossification of the bones.

McMeekan (1940a), Pomeroy *et al.*, (1961) and Cuthbertson *et al.*, (1962b) found that as with bone, muscles of one area of the body grow at a dif-

ferent rate from those in another area. In fact, growth of musculature followed the same general trend as noted in respect to adjacent bone groups. That is, there was a greater rate and amount of growth with age proceeding from fore to hind end of the body. Likewise, the muscles surrounding the scapula and humerus (shoulder muscles), showed a greater relative increase than those surrounding the radius-ulna (arm muscles). The latter grew more rapidly than those around the metacarpal bones (cannon). A similar centipetal growth gradient was observed in the pelvic limb with the wave of growth moving anteriorally and converging in the lumbar region (McMeekan, 1940a) and thorax region (Pomeroy *et al.*, 1961).

Cuthbertson *et al.*, (1963) found that at birth the proportion of muscular tissue in the carcass was about five times that of fatty tissue. Between birth and 5 Kg live-weight the proportion of fat trebled and thereafter remained fairly constant while the proportions of bone and remainder fell markedly. Muscle increased by only about 3% of carcass weight from birth to 40 Kg live-weight. Cuthbertson *et al.*, (1962b) found that at 50 and 68 Kg carcass weight, the weight of muscle considerably exceeded that of other tissues, while at 92 Kg the weight of muscle exceeded that of fat by only a small amount. Although each pig was killed at a fixed weight, rather than a fixed age, the weight of muscle in pigs at each stage did not appear to be affected by age. When the data were plotted against the average carcass weight between 1 Kg (birth) and 50 Kg, 50 and 68 Kg, and 68 and 92 Kg, the cross-over of rate of growth for muscle and fat was found to occur at about 48 Kg carcass weight.

McMeekan (1940a) found that perinephric fat (around the kidney) and retroperitoneal fat (behind the peritonenium) were the latest developing depots while intermuscular fat (between the muscles) was earlier developing, but not as early as subcutaneous fat. Conversely, Pomeroy *et al.*, (1961) found the

order of development of the main fat depots was intermuscular fat, followed by subcutaneous fat with perinephric and retroperitoneal last. The divergence between these results with regard to the order of development of subcutaneous and intermuscular fat was considered by Pomeroy *et al.*, (1961) to be due to intensive selection since McMeekan's experiments against subcutaneous fat, which has resulted in a redistribution of fat between the two depots.

Pomeroy *et al.*, (1961) found the subcutaneous fat in the middle region of the carcass latest developing followed by the ham and then the shoulder. Similar findings were reported by McMeekan (1940a). As regards intermuscular fat, regions, Pomeroy *et al.*, (1961) observed the thorax, abdomen, back and loin were the latest developing, followed by the tail, pelvic limb, thoracic limb and neck in that order.

Buck (1963a) compared the carcass quality and performance of littermate pigs slaughtered at 150, 200 and 260 lbs live weight. Comparison of dissection results indicated that there was 4% more fat and skin in sides from 200 lb as compared to 150 lb Large Whites. The same difference was observed between 260 and 200 lb with the change being similar for both sexes although heavier hogs experienced a greater increase than the heavy gilts. These fat increases were accompanied by decreases of 3% in lean and 1% in bone. The weights of the different cuts as a percentage of side weight did not appear to change much between slaughter weights. For all cuts and for both sexes, the percentage of lean meat added in the range of 200-260 lbs live weight was less than that for the range 150-200 lbs live weight. This difference was more severe for hogs than for gilts especially in the back cut. Buck (1963b) observed that increased lean was associated with increased bone, a larger eye muscle area and less backfat. Carcass conformation score for 260 lb pigs had a high negative association with average backfat and was considered to be indicative that the

extreme amounts of fat on some hogs at this weight adversely affected the balance of the carcass.

Hill (1962) studied the chemical composition of pigs slaughtered at 124, 206 and 256 lbs live weight. It was found that 53.7% of the carcass weight gain between 124 and 206 lbs live weight was chemical fat, while 60% of the carcass weight gain between 206 and 265 lbs. live weight was chemical fat.

Varney *et al.*, (1962) found that in percent of total weight of individual cuts, the heavy (215 lb live weight) Berkshire were higher in boneless ham and ham fat and skin while the light (159 lb live weight) hogs were higher in boneless defatted ham, boneless defatted ham cushion and ham bone. The light group was higher in sirloin and section of loin, while the heavier hogs yielded a higher percent of skinless smoked bacon and were superior in yields of sliced, first grade bacon. The light hogs were higher in percent lean and primal cuts on live weight and carcass weight basis. This has recently been confirmed by Bradley (1964) who slaughtered gilts at 150, 175, 200 and 225 lbs live weight and found that separable lean production significantly favoured the light weight carcasses. Likewise, Brooks *et al.*, (1964b) in studies of body composition and feed efficiency changes in swine of 50, 100, 150 and 200 lbs live weight found that the net result of developmental patterns was a continuous decline in carcass yield of lean and primal cuts as slaughter weight increased. The greatest change in development was the increased rate of fat deposition, which accounted for the entire change in carcass yield as the hogs grew larger.

Exercise

The effect of exercise on proportional composition has been studied in rats, (Kimeldorf *et al.*, 1954) guinea pigs, (Helander, 1961; Brozek, 1961), rabbits (Helander, 1961; Brozek, 1961) and swine (Skjervold *et al.*, 1963).

Kimeldorf (1954), exercised rats by exhaustive swimming. Body weight loss was extensive in that animals exercised 30 days weighed only 61% of controls. The *gluteus medeus* muscle was significantly smaller in exercised animals on the 30th day of the experiment, but constituted a proportionately larger part of body weight as compared to controls. In the trained state, cardiac hypertrophy and a relative increase in the size of muscles participating in the exercise, were observed.

Guinea pigs maintained on a severe exercise regime for 8 months were found to be slightly lighter in weight than the unexercised controls (Brozek, 1961). The specific gravity of the eviscerated carcass was substantially higher and total extractable fat was lower. Likewise, soldiers that participated in 3 weeks of strenuous exercise underwent a small decrement in weight, an increase in total body water, and a small increase in body density and basal oxygen consumption. (Brozek, 1961).

Helander (1961) observed that in guinea pigs there was a slight tendency for muscle weight to increase with rising functional activity. Water content was significantly lower in the exercised group, whereas total N of wet muscle was higher in exercised animals. No differences between groups were observed in sarcoplasmic portein, stroma protein and non-protein-nitrogen. However, a higher content of myofilamental protein nitrogen was observed in the exercised group.

Skjervold *et al.*, (1963) studied the effect of long term exercise on the quantity of muscle in pigs. The method of exercising was to place feed in

a trough which was moved upwards as the animals grew. The height was adjusted so that the animals had to stand on their hind legs to reach their feed. By this method the weight resting on the hind legs was increased by about 50%. Although no significant difference in muscle development was noted, there was a slight trend in favour of the exercised group for some characters associated with muscle development. It was suggested that possibly a more intensive exercise treatment, for instance feeding many times a day, may have resulted in larger differences. Nevertheless, the exercise treatment did result in a significant decrease in the length of some metatarsal and phalanx bones.

2.3. CHARACTERISTICS INFLUENCING EATING QUALITIES OF THE CARCASS

Proportional Composition

According to Palsson (1955), the concept of "meat quality" varies to some extent between countries as well as between markets within a country. Among the numerous factors contributing to meat quality, the one of universal importance is proportional composition in terms of bone, muscle and fat. As stated by Palsson, "The percentage of muscle should be high and that of bone low, and just sufficient fat to prevent the meat from undue drying in storage, transit and cooking."

A high proportion of subcutaneous to intermuscular fat has also been considered desirable (Palsson, 1955). Cuts having a high percentage of intermuscular fat are in less demand and consequently are lower priced than those with a lower percentage of intermuscular fat (for example, loin, ham). Pomeroy (1958) related that consumer preference studies showed that the housewife mainly wanted joints for grilling and roasting. Such cuts are located in the hind leg and along the back where the muscles are aggregated into thick blocky masses with a minimum of interspersed fat.

Quality of Lean

In addition to the quantity of lean relative to fat and bone, quality of lean is equally important. Pearson, as quoted by Cook (1963), defines quality as "that combination of physical, structural and chemical characteristics of meat which results in maximum desirability from the standpoint of appearance and eatability."

Colour of lean and fat are important in relation to the appearance of meat. Cook (1963) pointed out that it is generally accepted that the consumer has definite preconceived ideas as to the optimum colour of meat for each species of animal. Beef should be a bright cherry red, lamb a purplish red, and pork a greyish pink. Any deviation from these colours is considered by the consumer to be an indication of inferior quality.

Most problems with meat colour stems from handling just prior to slaughter rather than with animal management (Cook, 1963; Briskey et al., 1960a). Recent research has elucidated a close relationship between colour, pH and quality. Howard (1963) explained that differences in quality of bacon from farm and factory slaughtered pigs were associated with differences in the ultimate pH of the muscle. Both the pH differences and corresponding quality differences (uptake of salt, ease of growth of spoilage organisms) could be experimentally brought about by subjecting the pigs to relatively mild transport stress corresponding to that between farm and factory. In the aerobic situation in the live animal, glycogen is converted to lactic acid which is then removed as CO_2 while glycogen is regenerated from glucose (Bate-Smith, 1948, as cited by Hammond, 1961). However, when the system becomes anaerobic after slaughter, the lactic acid remains within the system, regeneration of glycogen ceases, and pH falls to an extent dependent upon buffering capacity and on lactic acid produced. The struggling which sometimes occurs during slaughter was shown to be responsible for raised

ultimate pH, some glycogen being lost as CO_2 before the system becomes anaerobic. Severe exercise before slaughter reduces glycogen and also results in high ultimate pH (Briskey *et al.*, 1960a). High ultimate pH of muscle has been associated with shady, dark colour. In beef at pH of 5.6 or below, the colour is normally bright. At pH of 5.7 the muscle became shady and dull while above pH of 6.5 the muscle became dark coloured. Wismer-Pederson and Briskey (1961) observed a similar colour pH relationship in pork muscle. They also showed that pork muscle colour was associated with the rate of post-mortem glycolysis, antemortem environmental temperature, and antemortem feeding practices. Briskey *et al.*, (1960a) found that high sucrose rations produced hams which were lighter in colour and softer in structure than controls, while exercise decreased glycogen, increased pH, resulted in darker colour and decreased "expressible" water.

Briskey *et al.*, (1960b) reported that wide ranges existed between pork muscles in ultimate pH values, expressible water percentages and myoglobin concentration. Muscles with the highest pH values showed the greatest myoglobin concentration and were darkest in colour. Myoglobin is reported to function in the maintenance of high oxygen tension between contractions when blood flow is inadequate to sustain the high rate of oxygen utilization by the tissue. Muscles with larger myoglobin concentrations are those which exhibit slow movements over a period of time. With regard to expressible water, Briskey *et al.*, (1960a) stated "It is understood that the exact amount of free and bound water cannot be determined in muscle. This is an accepted fact since there is no specific dividing line between the two types of water. In addition, the lack of knowledge of meat protein components and the water of hydration of these components under different circumstances, limits available measures to a relative status." For these reasons the relative free water was referred to as "expressible water". The isoelectric point of meat was reported to be about pH 5.0, and it has been

shown that as the pH approaches the isoelectric point there is an increase in the amount of expressible water. The reverse was observed for muscles with a high ultimate pH.

In an attempt to establish correlations between expressible water and meat quality, pressure techniques have been developed. Urbin *et al.*, (1962) used a modification of the filter paper press techniques of Wierbichi and Deatherage (1958) and Briskey *et al.*, (1960a,b), in which a pressure of 500 lbs per square inch was applied for one minute with a motor driven lab press.

Consumers, in general, tend to discriminate against soft, watery meat (Cook, 1963). The cause of this soft, watery condition in pork muscle has been extensively investigated by Briskey *et al.*, (1961). It was found to be associated with factors affecting ultimate pH, rate of glycolysis and post-mortem rate of carcass cooling. Furthermore, texture has been implicated in the quality, colour, pH relationship, since Wismer-Pederson *et al.*, (1961) observed that pork muscle showing an open structure was usually dark in colour, had a high pH and was firm and dry. Conversely, muscle with a closed structure was light in colour, had a lower pH and tended to show soft watery characteristics.

According to McLaughlin (1968) when rigor mortis developes in muscle soon after death, and pH values at or below 6.0 are reached before temperature of the muscle has fallen below 35°C, a marked reduction occurs in the solubility of sarcoplasmic and myofibrillar proteins. Such changes in the solubility of the proteins have been associated with pale, soft, exudative post-rigor muscle (Sayre *et al.*, 1963; Sayre *et al.*, 1964; Borchert *et al.*, 1964 and 1965; Sayre *et al.*, 1966). Although breed differences have been noted in the rate of post-mortem glycolysis, genetic background apparently does not influence the extractability of muscle proteins before differences in the rate of post-mortem glycolysis induce changes in protein solubility (McLaughlin 1968).

Tenderness of cooked meat is a further quality trait important in assuring consumer satisfaction. Hill (1961) reported that tenderness, texture, drip on freezing and thawing, and shrinkage on cooking were all related to the degree of hydration of muscle proteins. Water is reported to be attached to the protein in muscle by ionizable basic and acidic groups such as occur in arginine and methionine or by non-ionic groups such as occur in cystine, cysteine, or serine. In addition to this electrostatically bound water, muscles contain physically absorbed water (free) held on the proteins by secondary forces such as water dipole-dipole induction, hydrogen bonds and capillary and surface attractions. The post-mortem decrease in pH was found to be associated with an increase in the juice expressed on cooking. pH affected the water holding capacity by altering the charges on the proteins. Increases in pH resulted in increases in the charge on the protein and hence a better water holding capacity. By increasing the water holding capacity, Hill (1961) claims the density of the fibers will be reduced and the meat will be more tender. Other factors which have been linked with meat tenderness include; breed, age, sex, muscle fiber diameter, size of muscle bundles, amount and kind of connective tissue, intramuscular fat and muscular activity.

In general, the smaller the muscle fiber, and the more muscle fibers per bundle, the finer the texture and the more tender the meat (Harrison et al., 1959; Carpenter et al., 1963). Increases in the size of muscle bundles with age was reported to be brought about by increases in muscle fiber size (Joubert, 1956; Hill, 1961), and thickness of connective tissue (Carpenter et al., 1963). Young animals as compared to old, have smaller muscle bundles and more tender meat. The size of fibers and relation to toughness appear to hold for individual muscles within the same animal since Ramsbottom et al., (1945) found muscle fiber size was much greater in the superficial pectoral, a tough muscle, than

in psoas major, a tender muscle. Furthermore, exercise enhances myofilamental density in the muscle cell, whereas restricted activity reduced myofilamental density and increased the sarcoplasmic content. (Hill, 1961).

Intramuscular fat (marbling) has been implicated in tenderness by several workers (Harrison *et al.*, 1959; Harrington *et al.*, 1960; Hill, 1961 Henry *et al.*, 1963). Harrington *et al.*, (1960), using both a "chew count" technique and the Warner-Bratzler shear device, determined that marbling significantly improved the tenderness of pork loin chops. A significant difference of 1.3 lbs in shear value existed between the two types of loin. About 38% of the variation in shear value was explained by the amount of intramuscular fat ($r = -0.62$). Wang *et al.*, (1954) stated that it was not the total amount of intramuscular fat, but rather the way it was distributed that affected tenderness of broiled steaks. They observed a consistent positive correlation between the amount of "linear" fat of raw meat and tenderness of cooked samples.

Flavour, because of its effect on consumer satisfaction, has stimulated considerable research into the elucidation of various factors of importance. Much attention has been given to fat-soluble constituents, with only limited success. Hornstein *et al.*, (1960), and Macy *et al.*, (1964) have studied water-extractable components of cooked meat. Randall (1965) studied the sarcoplasmic proteins (water-soluble) of bovine skeletal muscle and found that there was a marked change in starch gel electrophoresis pattern between muscles as well as between aging periods. *Obliquus abdominus externus* (tough flank muscle) and *psoas major* (tender loin muscle) exhibited vivid differences in densometric plots of certain protein bands. Pattern changes were also observed as post-mortem aging time increased, although nearly no change was noted from 24 hours up to 8 days. The sarcoplasmic fraction is believed to contain practically all the enzymes of the muscle cell, including those involved in the anaerobic glycolytic

the amount and type of unsaturated fatty acids present. (Amer *et al.*, 1970). Thus it is apparent that excessive dietary intakes of unsaturated fatty acids have an adverse effect on fat quality. Amer *et al.*, (1970) have recently shown a high correlation between oxygen uptake and melting point in pork fat.

Pork fat, in general, is characterized by three principle saturated fatty acids (myristic (C_{14}); palmitic (C_{16}); and stearic (C_{18}) and three major unsaturated fatty acids (palmitoleic (C_{16}); oleic ($C=_{18}$) and linoleic ($C^{2}=_{18}$)). Jurgens (1970) noted palmitic acid to be the most prevalent saturated fatty acid in pork muscle and backfat, while stearic was most abundant in liver. Oleic acid was the primary unsaturate in all tissues studied. Considerable variation in fatty acid make-up of adipose tissues has been observed between depot sites. For example, Sink *et al.*, (1964) found the consistency of depot fat softened gradually from internal to external parts of the body. Saturated fatty acids were preferentially deposited in perirenal rather than subcutaneous and inside subcutaneous rather than outside subcutaneous sites. The preferential deposition pattern of unsaturated fatty acids was in the reverse. This selective deposition of saturated fatty acids increased with slaughter weight. McMeekan (1940) observed a decrease in iodine number of backfat after 8 weeks of age and attributed the increase in degree of saturation to the increased rate of fat deposition resulting in a larger proportion being synthesized from dietary carbohydrates. This tendency toward an increased degree of saturation during growth has also been confirmed by other workers. (Elson *et al.*, 1963; Allen *et al.*, 1967; Elliot *et al.*, 1970).

Sex differences have also been noted in that backfat of barrows have been reported to contain more total saturated fatty acids than that of gilts (Jurgens *et al.*, 1970; Elliot *et al.*, 1970). The levels of palmitic and stearic acids were observed to be greater in barrows, while linolenic acid was greater

cycle. In addition, the proteolytic enzymes, the cathepsins, are present in the water soluble (sarcoplasmic) protein fraction. These cathepsins have long been implicated in the tenderization of meat which occurs during aging (Randall, 1965). It seems plausible that flavour may also be affected since Macy *et al.*, (1964a) reported that the amino acid and carbohydrate content of meat are extremely important as potential flavour and odor precursors. The products formed by the interaction of these materials during heating are considered to contribute to flavour and/or odor of cooked meat (Macy *et al.*, 1964b).

Recently, Randall and Bratzler (1970a,b) have reported changes in the solubility and electrophoretic pattern of pork muscle protein in response to heating and smoking process. The cationic proteins were found to be more heat stable than the anionic components, while the smoking process further reduced stainability of the sarcoplasmic proteins. (Randall *et al.*, 1970a). Conversely the myofibrillar protein nitrogen fraction, pH and free sulfhydryl groups were increased as a result of heating, but declined in response to the smoking process. (Randall *et al.*, 1970b).

Quality of Fat

The chemical nature of fat in relation to quality as indicated by appearance, flavour, odor, nutritive value and keeping quality has been the subject of intensive investigation for some time.

The pig, typical of non-ruminants, is subject to dietary manipulation of the fatty acid composition of adipose tissue. McMeekan, 1940; Dahl, 1958a,b; Jurgens *et al.*, 1970; Elliot *et al.*, 1970). Excessive intakes of unsaturated fatty acids has led to the development of "soft fat" or "oily" carcasses. (Dahl, 1958 a,b; 1960).

Keeping quality and hence consumer acceptability as related to the development of oxidized flavour or rancidity has been found to be a function of

in the backfat of gilts. However, *longissimus dorsi* intramuscular fat of gilts was more highly saturated than that of barrows. (Jurgens *et al.*, 1970).

Recently, dietary components other than fatty acids themselves have been reported to influence the proportional relationships between fatty acid in various depot fats of swine. For example, Elliot *et al.*, (1970) and Amer *et al.*, (1970) have reported that the effect of supplemental copper when administered at a level of 250 ppm was to stimulate the production of softer backfat as indicated by a decreased melting point. Elliot *et al.*, (1970) reported an increase in levels of total unsaturated fatty acids and a concomitant decrease in levels of saturated fatty acids of backfat at various live weights in response to copper supplementation. The response varied with source of protein and was postulated as being due to variations in copper complexing properties between the protein sources. Increased proportions of total unsaturated fatty acids were attributed to increases in the weight % of monounsaturated (16:1 and 18:1) and diunsaturated (18:2) fatty acids (Elliot *et al.*, 1970; Amer *et al.*, 1970). Similarily, Jurgens *et al.*, (1970) reported that the total weight % of unsaturated fatty acids (primarily linoleic) was increased with the addition of vitamin D_3 to the diets of growing - finishing swine. A trend toward a concomitant reduction in concentration of all the saturated fatty acids was also observed. Interestingly, stearic acid was reduced in *longissimus dorsi* intramuscular fat of barrows, but increased in gilts due to vitamin D_3 supplementation. Furthermore, vitamin D_3 addition to the diet was found to result in a reduction of the myristic acid and an increase in oleic acid content of the outer backfat layer.

The foregoing, when considered in relation to the very low level of natural tocopherols in pork fat (Amer *et al.*, 1970) indicates the importance of factors affecting the chemical nature of fat on the various qualitative

factors associated with storage, rancidity and organoleptic characteristics.

3. EXPERIMENTAL

3.1. GENERAL

The presence of sub-clinical infections, located chiefly in the gastrointestinal tract, often prevent maximum weight gains and cause reduced feed efficiency. Chlorhydroxyquinoline (CHQ), a development of the Squibb Research Laboratories (Squibb, 1961) has a broad spectrum of antibacterial activity and is non-absorbable and non-toxic when given orally (Heseltine *et al.*, 1959; Heseltine *et al.*, 1960). These properties together with its stable composition made CHQ seem ideal for inclusion in pig rations for the purpose of promoting growth and increasing feed efficiency.

The possibility of different responses occurring between sexes and ages of pigs (Bowland *et al.*, 1951; Lloyd *et al.*, 1961) together with the need for reassessment of the optimal slaughter weight (MacDonald, 1960) led to the outline of a 4 X 3 X 2 X 2 X 2 factorial design. The studies were conducted at Macdonald College (McGill) between 1962 and 1965.

3.2. ANIMALS

Ninety-six crossbred feeder type pigs (Lacombe sires) X (Lacombe X Yorkshire sows) comprising 48 barrows and 48 gilts born during the fall of 1962 (Rep. 1) and the fall of 1963 (Rep. 2) were selected for the study. Three barrows and three gilts of uniform weight were selected from each litter and assigned to treatments at 22.7 kg liveweight.

3.3. RATIONS

The diets were standard commercial grower and finisher meal formulations manufactured by E. W. Caron and Sons Co., Ltd., Montreal, Quebec. The composition of the grower and finisher rations are outlined in Table I.

Table I Basal Feed Composition (%)

Ingredient	Grower	Finisher
screenings (wheat) #1	25.00	17.50
barley	45.00	25.00
corn	10.00	25.00
soybean meal	9.375	2.50
meat meal	2.50	2.50
rice meal[1]	3.125	22.50
molasses	2.50	2.50
vitamin mixture[2]	0.25	0.25
trace mineral mixture[2]	0.125	0.125
limestone	0.625	0.625
iodized salt	0.50	0.50
calcium phosphate	1.00	1.00
	100.00	100.00

[1] Product of Mount Royal Rice Mills Ltd., Montreal, P.Q.

[2] Commercial, Premixes provided by Delmar Chemicals Co. Ltd. Montreal, Que.

The CHQ was premixed with Cr_2O_3 colour marker, then blended with the mineral and vitamin components to provide levels of 0, 62.5 and 125 gm of CHQ/ton of complete feed. The mixing operation was supervised to ensure the homogeneous distribution of the 0.25% Cr_2O_3 colour marker throughout the complete feed.

The grower formulation (16% crude protein) was fed until the animals reached 56.7 kg liveweight, while the finisher (14% crude protein) was fed from 56.7 to 90.7 kg liveweight.

3.4 MANAGEMENT

Housing: - All animals were housed in the Swine Research Building Macdonald College, in pens designed to confine individual animals during feeding, but to allow exercise in groups of three between feeding periods. Therefore, three barrows from the same litter were confined in one pen, while litter-mate gilts were placed in the adjacent pen.

Feeding: - All animals were individually fed on a time restricted *ad libitum* program consisting of three 30-minute feeding periods per day. The confinement gates were closed and latched after each feeding period to prevent access to the self feeders prior to the next feeding period. Each pig was numbered with colour marking crayon to correspond to its appropriate confinement pen, to ensure that the proper treatment was provided.

Weighing: - All animals and feed residues were weighed and recorded at weekly intervals, just prior to the noon feeding period. Any animal that was up to or exceeded its predetermined slaughter weight, was taken off feed and slaughtered 24 hours later.

Slaughter: - Each animal was stunned by a mallet blow to the skull, bled by sticking, scalded to facilitate removal of bristles, and dressed as described by Ziegler, (1963). Kidney fat, liver and heart were removed and weighed. The carcass was then weighed with head on and placed in a chilling room for about 24 hours prior to cutting.

3.5 CARCASS EVALUATION

Each carcass was removed from the chiller about 24 hours after slaughter, and reweighed to permit determination of chiller shrinkage. The head was then removed at the atlas bone, weighed, examined for signs of rhinitis and discarded. The carcass was split by carefully sawing down the centre of the vertebral column while the carcass was hanging on the rail. Each side was

then weighed separately and caliper backfat measurements were taken along the cut surface of the mid-line at the shoulder, mid-back and loin.

The left side of the carcass was cut according to the Montreal commercial cutting methods described by Roache (1964). Each cut was weighed, trimmed of excess subcutaneous fat and reweighed both in air and water in order to determine specific gravity. A small loin roast was removed from the centre of the loin, packaged in a plastic bag, labelled and frozen for subsequent taste panel evaluation.

The right hand side of the carcass was cut by the Canadian R.O.P. cutting method as outlined by the production and marketing branch of the Canadian Department of Agriculture. The length was measured using the R.O.P. ruler-square from the anterior tip of the *symphisis pubis* to the anterior edge of the first rib. The ham was removed by cutting 1½ in anterior to the tip of the *symphisis pubis*, using the anterior edge of the R.O.P. square as the straight edge. Likewise, the centre cut was made by sliding the square anterior and cutting along the straight-edge so as to leave seven lumbar vertebrae in the posterior cut. Front and back legs were removed by separation at the knee and hock joints respectively.

Tracings of the cut surface of the "eye muscle" at the position of the center cut described above were made using polyfilm with one rough side which permitted mapping of lean and fat with a lead pencil. Tracings were subsequently measured with a Planimeter to determine the loin "eye" area and the relative area of fat and lean. The method applied to determine fat to lean ratios is outlined diagrammatically in Fig. (1). A triangle was placed over the tracing so that the right angle touched the edge of the tracing 10.2 cm from the mid-line cut. The line passed through the intersect point between the *M. multifidus dorsi* and *M. longissimus dorsi*. Loin eye area and area of fat bounded by

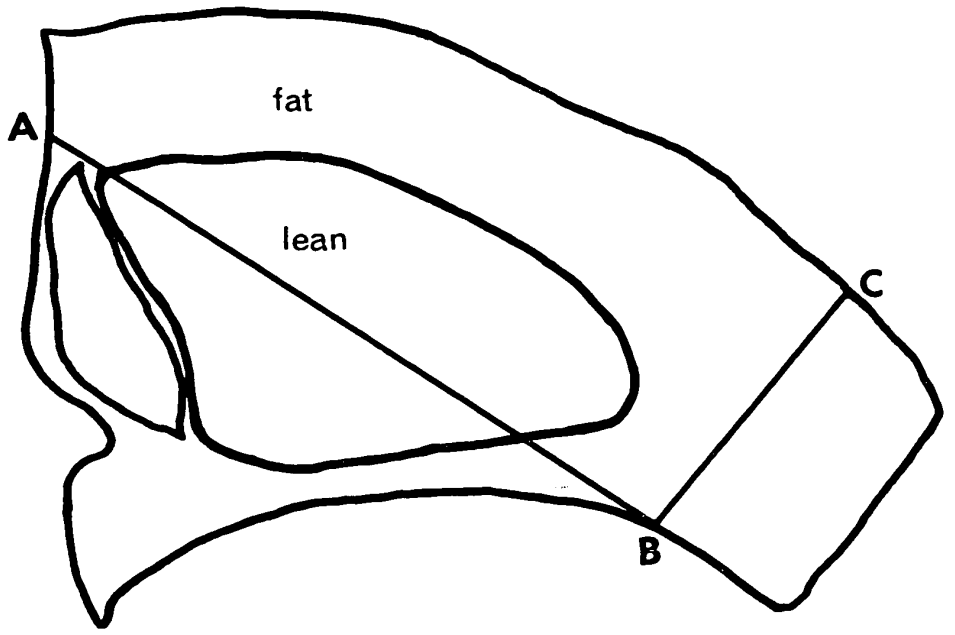


Figure I Loin tracing taken at the position of the centre cut

ABC and the exterior surface of subcutaneous fat was determined with the aid of a planimeter.

Grid photographs were taken of the ham cut surface prior to dissection. Relative areas of fat and lean tissue were determined by projecting the transparencies onto a standard viewing screen and counting squares of fat and lean tissue.

Core samples of *m. longissimus dorsi* were taken from the centre of the muscle at the position of the centre cut and placed in 10% formalin for subsequent muscle fiber diameter measurements by the method of Joubert (1956).

Each cut was then weighed in air and again in water in order to determine specific gravity.

The four R.O.P. cuts from the right hand side were placed in heavy plastic bags, sealed and frozen for subsequent anatomical dissection.

3.6 ANATOMICAL DISSECTION

The right hand side of one animal from each treatment group (24 animals) was subjected to complete anatomical dissection. The day before dissection cuts were removed from the freezer but left in polyethylene bags to thaw overnight at room temperature. Each cut was weighed and photographed in cross section behind a grid just prior to commencing dissection so as to permit determination of freezer shrinkage and relative area of lean to fat. Complete anatomical dissection was accomplished using surgical instruments and following a modification of the procedure of Cuthbertson and Pomeroy (1962). Cold, damp towelling was used to wrap the cut being dissected and thus minimize moisture loss. The skin and subcutaneous fat were removed together. Where distinction between subcutaneous and intramuscular fat was not obvious, the fat was classified as subcutaneous until it reached the same horizontal level as the two adjacent peripheral muscles. Upon removal of the muscle and adhering intramuscular fat, a

number tag was attached corresponding to the muscle nomenclature of Sisson and Grossman (1960). Numbered muscles and adhering fat were then placed in a large polyethylene bag which was closed tightly immediately after each muscle was added. Meanwhile a technician withdrew muscles from the same bag and weighed them before and after removing all adhering intramuscular fat, tendons and blood vessels. Weights were recorded to the nearest 0.1 gr. The entire *M. semitendinosis* and the lumbar region of *M. longdissimus dorsi* were saved and re-frozen to -30°F for subsequent chemical and electrophoretic study.

When all the muscles were removed from the bones of each cut, they were cleaned of all adhering tissue and weighed together for that cut. That is, no attempt was made to separate and identify each bone individually as described by Cuthbertson and Pomeroy (1962a).

The intramuscular fat surrounding the *M. semitendinosis* was placed in a tightly sealed plastic bag and frozen at 0°F for subsequent gas chromatographic analysis.

3.7 ORGANOLEPTIC EVALUATION

The loin roasts taken from the left hand side of each animal (96) were subjected to organoleptic evaluation in the Home Economics Department of Macdonald College.

Cooking Procedures

Each roast was placed in a numbered aluminum pan and weighed to the nearest 0.1 gm. A meat thermometer was inserted into the centre of the *M. longissimus dorsi*, and 16 roasts were cooked together in a large commercial hot-air oven to an internal temperature of 180°F. The 16 roasts selected represented one from each sex and slaughter weight in the same replicate.

When each roast reached an internal temperature of 180°F, it was removed from the oven and reweighed to determine the evaporation loss during

cooking. Juices were then poured off and, by reweighing, the amount of drip loss during cooking was determined by difference. Roasts were tightly wrapped in aluminum foil and placed in a house-hold refrigerator overnight.

Taste Panel

The 16 roasts were removed from the refrigerator at about 9:00 a.m. and rectangular pieces (3/4" X 1/2" X 1/2") were cut from the *m. longissimus dorsi* so that muscle fibers were parallel to the long axis of the cut. Samples from eight different roasts were placed in coded positions around the perimeter of plasticized paper plates, for panel assessment at 11:00 a.m.

Twelve tasters were employed and were presented with two plates of eight samples representing animals from each sex and slaughter weight classification. Tasters were requested to use one plate of samples for the assessment of flavour and juiciness, while the other plate was to be used only in tenderness evaluation. Samples were rerandomized to different plate positions for subsequent panels to avoid having samples from animals of one weight or sex classification always appearing in the same plate position. By this method, every roast was evaluated for tenderness, juiciness and flavour by six different individuals.

Tenderness was estimated by a modification of the chew-count method described by Harrington *et al.*, (1960). The tasters were requested to note the number of chews to masticate the sample to the point at which they would normally swallow, and also to the point where an insoluble residue or no residue remained.

Flavour and juiciness were estimated by scoring from 1 to 10 where 1 = very poor, 5 = average, and 10 = perfect. Salt shakers, and a glass of water were provided for each member of the panel. Instructions were given to record their assessment of juiciness after the first two chews, to assess juiciness and flavour first, and to avoid swallowing samples prior to tenderness evalu-

ation. A typical taste panel form is displayed in Appendix Table 19.

The average ratings of the six individuals who evaluated each roast were subjected to statistical analysis.

Press Fluid

Samples of all roasts presented to the taste panel were subjected to press fluid determination on the same day the taste panel was conducted. Rectangular samples (3/4" X 1/2" X 1/2") from the roasted loin cuts were sandwiched between two layers of Whatman #2 filter paper and subjected to 2500 p.s.i. in a hydraulic press for five minutes. Areas of juice penetration in the paper and flattened meat residue were measured by means of a planimeter. The meat/juice ratio was then calculated as follows:

$$\text{meat/juice ratio} = \frac{(\text{Area of flattened meat residue})}{(\text{Area of juice penetration})} \times 100$$

3.8 CHEMICAL ANALYSIS

3.8.1. MUSCLES

The *m. semitendinosus* and *m. longissimus dorsi* muscles selected from one animal of each treatment subgroup in replicate I, were frozen immediately after dissection and subjected to subsequent chemical analysis.

pH Determination

A cross-section sample of frozen *m. longissimus dorsi* weighing 50 gm was removed from the mid-loin region with the aid of a fine-toothed saw. The entire 50 gm sample was then homogenized with 50 ml of distilled water in a Waring Blendor for 1 min. The slurry was then transferred to a ground glass tissue homogenizer for 1 min additional maceration. the pH was then determined on the resultant homogenate with the aid of a Beckman Zeromatic pH meter.

Protein Separation

The sarcoplasmic (water-soluble) protein fraction was separated from the stroma plus myofibrillar fractions by a slight modification of the technique described by Randall (1965) for bovine skeletal muscle.

Ten gm samples were taken from frozen *m. longissimus dorsi* and *m. semitendinosus* by sawing thin cross sections from the center portion of each muscle. The samples were then homogenized in 40 ml of glass distilled water in a Waring Blendor for 1 min. The slurry was then quantitatively transferred to an all-glass homogenizer for an additional 1 min. The entire homogenate was then transferred to 50 ml centrifuge tubes and centrifuged at 2600 rpm for 20 min. The supernatant (sarcoplasmic fraction) was decanted, lyophilized, weighed and stored in a desiccator at about -20°C. The remaining insoluble fraction (stroma plus myofibrillar protein) was also lyophilized, weighed and stored at about -20°C. Dried samples of both fractions of *m. longissimus dorsi* and *semitendinosus* were subsequently assayed for nitrogen content by the A.O.A.C. (1960) micro-Kjeldahl method. Moisture content was determined by difference from the total dry matter remaining after lyophilization. Total lipid content was determined by the method of Chen *et al.*, (1965).

Horizontal Starch-gel Electrophoresis

Sarcoplasmic protein (water-soluble) fractions of *m. longissimus dorsi* and *m. semitendinosus* were subjected to electrophoretic separation in a discontinuous buffer system.

The apparatus employed and methods used were similar to those described by Randall (1965), except for the following modifications:

1. The pH of the gel buffer was adjusted to 8.6 since preliminary runs indicated this to be the optimal pH for distinct separation of bands.

2. Starch gels were poured using 50 ml of a stock solution of Tris (0.017M)- HCl (0.2M) buffer per 450 ml of glass distilled water.
3. The content of starch (Connaught Medical Laboratories, Toronto) in the gel preparation was maintained at 12% since small variations were found to alter patterns obtained. The same lot of starch was used throughout all electrophoretic runs.
4. A 60 mg sample of sarcoplasmic proteins was dissolved in 0.25 ml of glass distilled water.

Small filter paper inserts were soaked in the sample solution, blotted free of excess sample, and applied to the insert line. Inserts were left in place for 15 min at 165 volts. After removal of inserts, 300 volts were maintained until the forward boundry had travelled 8 cm. Six samples were run simultaneously on each gel. Three gels were run for each sample.

Each gel was sliced on a horizontal plane and stained with Amido Black 10B dye. Unbound dye was removed by washing in 4 changes of 10% acetic acid over a 48 hr period. Gels were then sliced into individual sample strips and densitometric plots were obtained using a Photovolt Densicord Model 542 at a response setting of 8. The relative density of each protein band was determined directly from the photovolt electronic integrator.

3.8.2. FAT

Samples were taken from the *m. longissimus lomb.* intramuscular fat, and from the intermuscular fat of the ham adjacent to the *m. semitendinosus* of all carcasses dissected. The samples were then prepared for Gas-Chromatographic Analysis in an attempt to ellucidate any differences that may exist between treatments.

The total lipids were extracted using the following modification of the methods of Bligh and Dyer (1959) and Chen *et al.*, (1965).

Ten gm of ham intramuscular fat and 78.5 ml of distilled water were placed in a Waring Blendor and homogenized for 30 seconds. Chloroform (100 ml) and methanol (200 ml) were then added and the mixture was homogenized for another 30 seconds.

The mixture was then filtered, under suction, through Whatman No. 1 filter paper. The Waring Blendor and filter were washed with 40 ml chloroform, which was added to the original filtrate. The filtrate was transferred to a 500 ml separatory funnel and the suction flask was rinsed with 10 ml of chloroform which was then added to the filtrate. The filtrate was then left standing for 2 hr to permit complete separation of the two phases. The lower chloroform layer was then run off into a tared round bottom flask and the solvent was evaporated on a rotary flask evaporator in a water bath held at 60°C.

The flask and contents were weighed after solvent evaporation to permit calculation of the weight of total lipids. The lipid was then dissolved in ethyl ether and transferred to a sample vial with the aid of a pasteur pipette. The ether was then evaporated under a stream of nitrogen and the lipid was then stored under nitrogen in a disiccator at -20°C.

Samples of *M. longissimus dorsi* (50 gm) were extracted by the same technique described above, except that 50 ml of distilled water was added to the Waring Blendor in the first homogenization step.

Methylesters were prepared following the procedure of Hyan *et al.*, (1965). Ten mg of lipid material was dissolved in 4 ml of boron trifluoride-methanol reagent (BF_3-methanol) and 1 ml benzene in a screw cap test tube. The air in the tube was replaced by nitrogen gas and the cap replaced securely. The reaction mixture was then heated to 70° and shaken periodically for a period of

24 hours.

After cooling 10 ml of distilled water was added and the fatty acid methylesters were extracted with 4 ml petroleum ether. The petroleum ether layer was separated and the aqueous layer re-extracted twice with 3 ml portions of petroleum ether. The petroleum extracts were pooled and dried over Na_2SO_4 - $NaHCo_3$ mixture (1 - 2 gm, 4:1 mixture) for about 1 hour. The dried extract was quantitatively transferred to a sublimation tube of the microinteresterification assembly with 12 portions of petroleum ether. The solvent was evaporated under a stream of nitrogen gas while maintained at a temperature of 0°C.

The sublimation tube was connected to the microsublimation system and immersed in the sand-bath heater maintained at 125°C. The entire system was then gassed with nitrogen on a continuous basis to ensure the complete absence of air during the sublimation procedure. Cold water prepared by looping flexible plastic tubing through a salt-ice-water bath was passed throught the cold finger during the entire 45 min procedure. After cooling, the assembly was disconnected and the methylesters of the short chain fatty acids were washed off the cold finger with 2 ml of petroleum ether.

The cold finger was then re-inserted in the sublimation tube which was then heated to 60°C and maintained under vacuum of about 0.2 mmHg for 1 hr. The system was then cooled and disconnected to permit washing the cold finger with petroleum ether to remove the predominantly long chain fatty acid methylesters. The petroleum ether was washings were collected in the same tube containing the washings from the first sublimation. The combined petroleum ether washings were evaporated to dryness under a stream of nitrogen while held at 0°C. The vials were then tightly capped and stored in a desiccator. Each sample was re-dissolved in 0.1 ml of chloroform (redistilled) immediately before

gas chromatographic analysis.

The methylesters of the fatty acids were assayed in an F & M Model 700* Laboratory Chromatograph employing a 6 ft copper column packed with diethylene-glycol-succinate and Chromasorb W (12:100). The mobile phase used was helium gas at a flow rate of 200 ml per minute. The inport, column, and detector temperatures were maintained at 280, 170, and 270°F respectively. Samples of methylesters were redissolved in 0.1 ml of redistilled chloroform and 2.0 ml were injected into the column with the aid of a Hamilton syringe.

The component fatty acids were identified by comparison with chromatograms of standard mixtures of known fatty acid composition (Hormell Institute, University of Minnesota, U.S.A.) and by homologus series plots. Relative percentages of the fatty acids were determined using the ratio of peak areas which were determined by triangulation.

3.9 STATISTICAL MANIPULATION

The raw experimental data was transcribed to punch cards and compiled with the aid of an IBM 1620 computer. The initial programs computed the analysis of variance for all variables. The differences between means of variables displaying significant "f" values were subjected to Duncan's New Multiple Range Test as described by Steele and Torey (1960). In addition, the association of selected variables was examined by multiple correlation and regression analysis.

*F & M Scientific Corporation,
Avondale, Pennsylvania, U.S.A.

4. RESULTS AND DISCUSSION

4.1 GROWTH PERFORMANCE

The variation between sexes in swine growth performance have been documented by several workers (Lucas *et al.*, 1956; Harrington, 1958; Bowland *et al.*, 1959; Buck *et al.*, 1962; Blair *et al.*, 1965; Rahnefeld, 1965; Friend *et al.*, 1970). Further confirmatory data is contained in Table 2. As anticipated, barrows displayed higher average daily gain ($P<.01$) and required fewer days to reach slaughter weight ($P<.05$). Similarly, feed and efficiency data, although not statistically significant, indicated that barrows tended to consume more feed and utilize it somewhat more efficiently. A graphical comparison of the average rate of gain between sexes up to the various slaughter weights (Fig. 2) revealed that barrows tended to gain more rapidly overall but reached a plateau at about 79 kg while gilts reached their maximum rate of gain at about 68 kg.

The amount of feed required per unit gain (feed efficiency) increased in relation to slaughter weight for both sexes as shown in Fig. 3. Barrows, however, were somewhat more efficient up to 68 kg live weight whereas gilts demonstrated superior feed efficiency up to heavier weights. This "switch-over" in efficiency is probably related to sex differences in the shift in physiological growth gradient between fat and lean tissues. That is, in barrows more feed would be required per unit of gain because of the difference in energy requirement of higher fat to lean live weight gain. This presupposes the higher fat content of barrow versus gilt carcasses of comparable weight. It is therefore likely that the optimal slaughter weight for maximum efficiency and for production may vary with sex as suggested by MacDonald (1960).

Analysis of variance of growth and performance data revealed that CHQ had no effect on average daily gain, feed intake, feed efficiency or days

Table 2 Mean growth performance of barrows and gilts

Item	Sex			
	barrows	gilts	S.E.[2]	Significance of F[3]
No. of animals	48	48		
Cummulative gain (kg)	50.9	50.7	0.24	N.S.
Ave. daily gain (kg)	0.58	0.54	0.01	**
Cummulative Feed intake (kg)	176.8	176.9	3.61	N.S.
Ave. daily Feed intake (kg)	1.94	1.86		N.S.
Feed effictency[1]	3.42	3.48	0.07	N.S.
Ave. slaughter wt. (kg)	74.5	74.5	0.34	N.S.
Ave. days from 22.7 kg to slaughter	88	93		*

Note 1 Kg feed/kg gain 2 Standard error of means 3 N.S. = non significant * = (P<.05) ** = (P<.01)

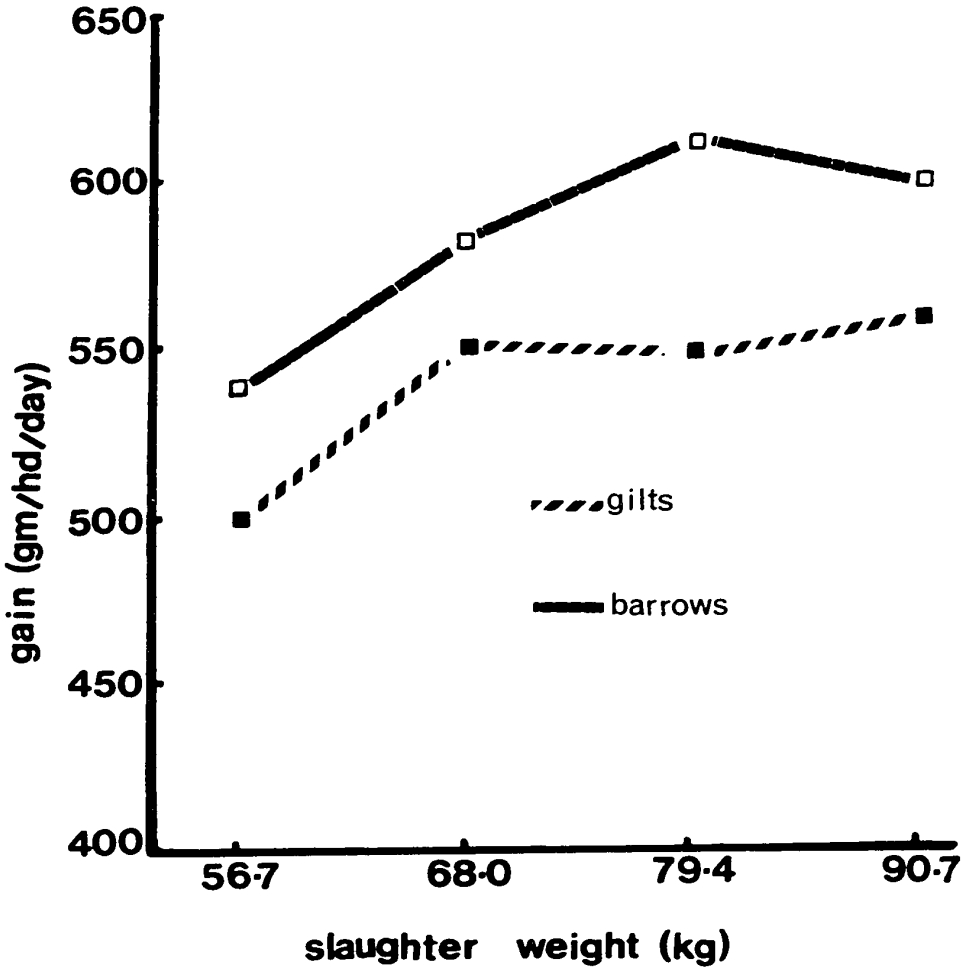


Figure 2 The cummulative rate of gain of barrows and gilts to various slaughter weights

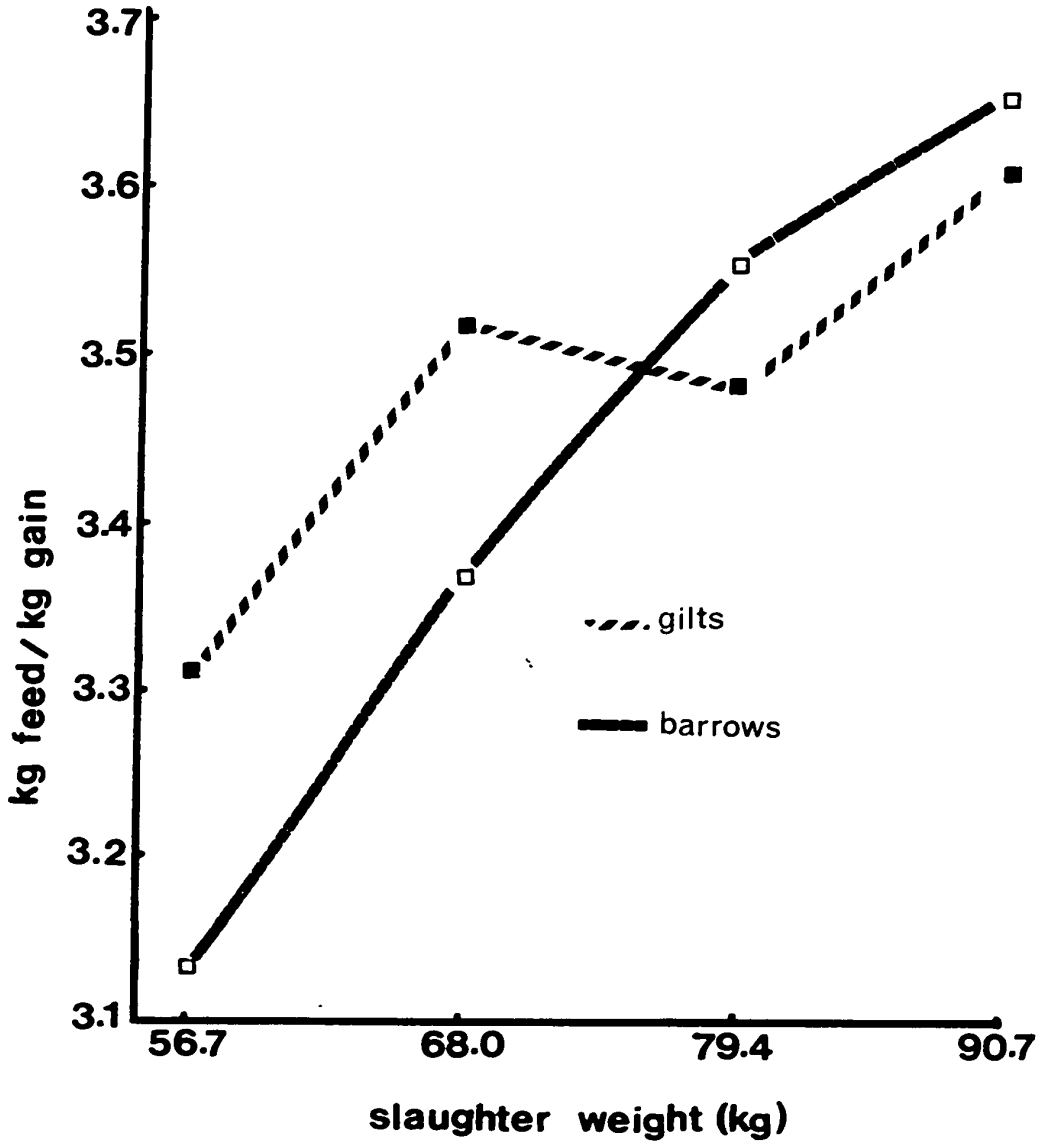


Figure 3 The cummulative feed efficiency of barrows and gilts up to various slaughter weights

required to reach slaughter weight. Furthermore, there was no significant interaction between CHQ level and slaughter weight. The mean response data are presented in Table 3. It is possible that some benefit may have been obtained if CHQ had been fed up to 23 kg live weight since some young piglets exhibited depressed growth rate, lack of appetite and mild diarrhea immediately after weaning. Such performance prevented these individuals being selected for experimental purposes. However, those individuals which remained tarifty up to 23 kg appeared to be over the critical period in that their subsequent performance was good and was not improved by CHQ treatment. Furthermore, the particularly good environmental conditions provided by daily pen cleaning in a new research piggery would also suggest it unlikely that antibacterial-like substances would display any meaningful beneficial response. The lack of response to other antibacterial agents in similar circumstances has been demonstrated by other workers (Smith et al., 1963; Holme et al., 1963b; Smith et al., 1964). On the other hand CHQ, also failed to increase the productive performance of lambs (Welch et al., 1965).

The analysis of variance for growth and performance data in relation to slaughter weights revealed several highly significant differences. The mean performance data by slaughter weight groups is summarized in Table 4. Highly significant differences ($P<.01$) were observed between slaughter weights for average daily gain, average daily feed intake and average days required from 22.7 kg to the respective slaughter weights. Multiple range test comparisons of individual means revealed that average rate of gain increased from 56.7 kg to 68.0 kg but remained constant from 68.0 to 90.7 kg. Similarily, average daily feed intake increased from 56.7 to 68.0 kg but remained constant from 68.0 to 90.7. Feed efficiency declined significantly from 68.0 to 79.4 kg live weight. As expected, there was a highly significant ($P<.01$) increase in the number of days required to reach the next higher slaughter weight.

Table 3 Mean growth performance of crossbred feeder pigs fed various levels of chlorhydroxyquinoline

Item	C.H.Q. level (gm/ton) 0	62.5	125	S.E.[2]	Significance[3] of F
No of animals	32	32	32		
Cummulative gain (kg)	51.0	50.8	50.7	0.29	N.S.
Ave daily gain (kg)	0.57	0.57	0.55	0.01	N.S.
Cummulative Feed intake (kg)	174.9	180.4	175.4	4.42	N.S.
Ave daily Feed intake (kg)	1.87	1.98	1.84		N.S.
Feed efficiency[1]	3.41	3.55	3.40	0.08	N.S.
Ave slaughter wt (kg)	74.7	74.5	74.3	0.42	N.S.
Ave days from 22.7 kg to slaughter	90	89	93		N.S.

Note [1] Kg Feed/kg gain [2] Standard error of means [3] N.S. = non significant

Table 4 Mean growth performance of crossbred feeder pigs fed to various slaughter weights

Item	Slaughter weight (kg) 56.70	68.04	79.38	90.72	S.E.[3]	Significance of F
No of animals	24	24	24	24		
Cummulative gain (kg)	33.8[a]	45.6[b]	56.3[c]	67.7d	0.33	* *[2]
Ave daily gain (kg)	0.52[a]	0.56[b]	0.58[b]	0.58[b]	0.02	* *
Cummulative Feed Intake (kg)	109.2[a]	156.1[b]	197.2[c]	245.1[d]	3.61	* *
Ave daily Feed Intake (kg)	1.66[a]	1.93[b]	2.00[b]	2.01[b]		* *
Feed efficiency[1]	3.22[a]	3.45[a]	3.53[b]	3.63[b]	0.10	*
Ave slaughter wt (kg)	57.7[a]	69.1[b]	80.0[c]	91.2[d]	0.48	* *
Ave days from 22.68 kg to slaughter	66[a]	81[b]	97[c]	117[d]		* *

Note abcd means with the same superscript are not significantly different

[1] Kg feed/kg gain

[2] * = (P<.05)
** = (P<.01)
N.S. = non significant

[3] S.E. = standard error

The cummulative efficiency of growth to the various slaughter weights is further demonstrated in Figure 4. The growth efficiency (calculated from the average daily gain divided by average daily feed intake x 100) was observed to decrease from 31.4 to 28.9 as slaughter weight increased from 56.7 to 90.7 kg. This relationship is in agreement with that established by Headley and co-workers (1961).

Summary:

1. Barrows gained significantly ($P<.01$) faster than gilts and took significantly fewer days ($P<.05$) to reach slaughter weight.
2. The amount of feed required per unit gain increased with successive increments in slaughter weight. Barrows tended to utilize feed more efficiently up to 68.0 kg while gilts became more efficient from 68.0 to 90.7 kg live weight.
3. Chlorhydroxyquinoline supplementation failed to yield any beneficial response in growth performance.
4. The average daily gain increased to a maximum at 68.0 kg live weight ($P<.01$) in response to an increase in average daily feed intake ($P<.01$)
5. The efficiency of feed utilization decreased significantly ($P<.05$) with increasing live weight.
6. Significantly ($P<.01$) more days on feed were required for animals to reach the next successively higher slaughter weight.
7. The efficiency of incremental growth decreased as live weight increased.

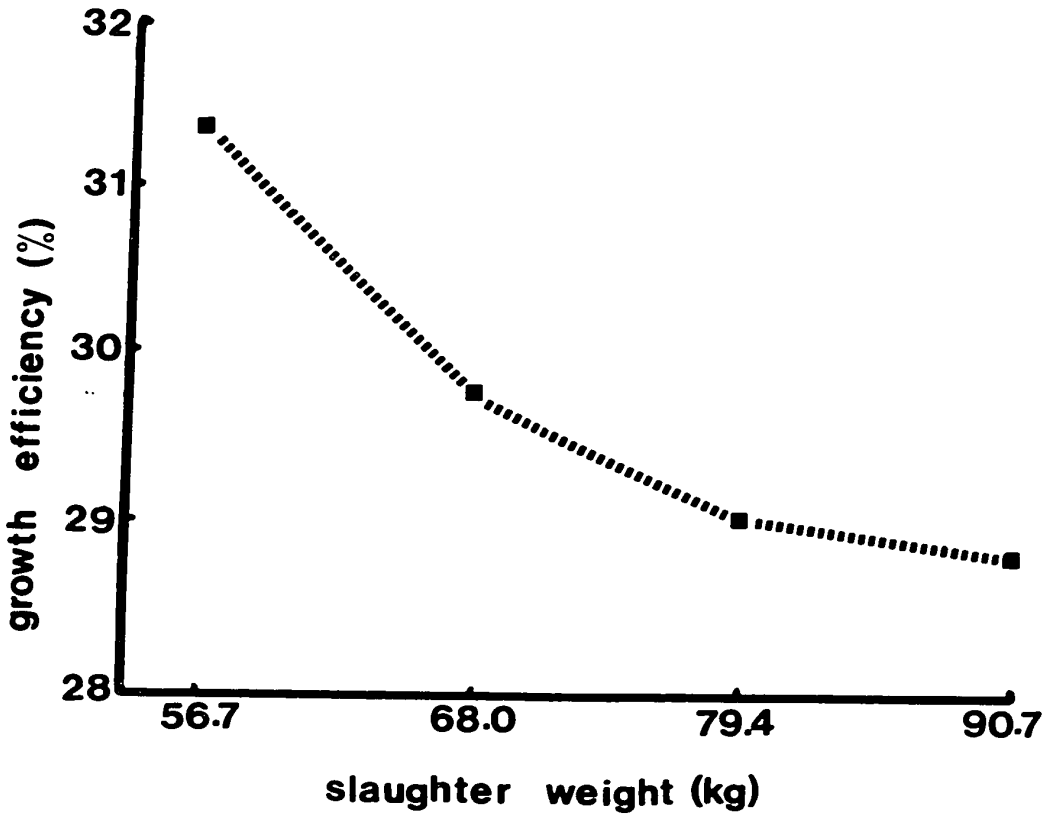


Figure 4 The mean growth efficiency of crossbred feeder pigs to various slaughter weights

4.2 CARCASS COMPOSITION

The anlaysis of variance of mean selected slaughter and carcass data for barrows and gilts revealed several meaningful differences, as shown in Table 5. Barrows displayed a slightly higher shrink during fasting than gilts but the difference was not of sufficient magnitude to reach statistical significance. This trend is a reflection of greater gut fill as a result of higher feed intake in barrows vs gilts. Likewise, barrow carcasses showed a somewhat lower chiller shrink than gilt carcasses. This might have been anticipated if barrows had been found to have a higher fat to lean ratio than gilts. The superior loin eye area ($P<.01$), and lower fat measurements ($P<.01$), together with thinner back fat measurements ($P<.01$) of gilts tends to validate the assumption that carcasses of barrows contain more fat than those of gilts.

This is further substantiated in that more excess fat was trimmed off shoulders and loins obtained from barrows as compared to gilt carcasses ($P<.01$). In contrast, specific gravity of trimmed cuts failed to reflect any meaningful differences between barrows and gilts, suggesting that the majority of extra fat in barrow carcasses was mainly subcutaneous.

Gilt carcasses yielded slightly more total prime cuts as a percentage of total side weight as compared to barrows ($P<.05$). The ham, however, was the only prime cut observed to be significantly heavier ($P<.05$) in gilt carcasses, although shoulders and loins tended to be slightly heavier also. This superiority of gilt carcasses over barrows is further demonstrated in the increased total saleable components ($P<.05$) and higher calculated value ($P<.05$) of carcasses from gilts versus barrows.

The influence of CHQ supplementation on mean slaughter and carcass data was negligible as is clearly evident from Table 6. In fact, the only significant effects were of an adverse nature. For example, loin eye area was

Table 5 Mean selected slaughter and carcass data for barrows and gilts

Item	Sex: Barrows	Gilts	S.E.	Significance of F
No. of animals	48	48		
Slaughter data				
Ave. Hot Carcass weight (kg)	54.16	54.08	0.32	N.S.
Shrink (%)				
Fasting	4.44	3.97	0.26	N.S.
Cooler	2.42	2.81	0.18	N.S.
Dressing (%)				
Hot Carcass	75.35	74.94	0.44	N.S.
Cold Carcass	73.51	72.82	0.43	N.S.
Carcass data				
Length (cm)[1]	73.66	74.47	0.19	N.S.
Width (cm)[1]	31.90	31.80	0.15	N.S.
Loin "eye" Area (sq cm)[2]	20.32	22.19	0.29	* *
Fat/lean ratio[2]	1.54	1.19	0.04	* *
Back fat thickness (cm)[3]				
shoulder	3.58	3.20	0.07	* *
mid-back	2.18	1.75	0.04	* *
loin	3.00	2.62	0.05	* *
Prime cuts[4] (kg)				
Ham (trim)	5.58(0.32)	5.70(0.36)	0.04(0.02)	* (N.S.)
Shoulder (trim)	4.64(1.06)	4.76(0.97)	0.05(0.02)	N.S.(* *)
Loin (trim)	4.22(1.80)	4.30(1.49)	0.04(0.05)	N.S.(* *)
Belly (trim)	3.19(0.39)	3.16(0.42)	0.05(0.03)	N.S.(* *)
total	17.64	17.93	0.11	N.S.
% of side	74.60	77.24	0.74	*
Specific gravity (trimmed cuts)				
Ham	1.05	1.05	0.001	N.S.
Shoulder	1.05	1.05	0.002	N.S.
Loin	1.06	1.06	0.001	N.S.
Other Components (kg)				
Leaf Fat	0.53	0.50	0.01	N.S.
Head	5.50	5.50	0.06	N.S.
Liver	1.12	1.08	0.02	N.S.
Kidneys	0.33	0.31	0.01	*
Total saleable components[5] (kg)	41.64	42.27	0.23	*
Calculated Value[6] ($)	48.90	49.71	0.27	*

Note [1] R.O.P. method

[2] Obtained from loin eye tracings with planimeter

[3] Caliper measurement on mid-line cut surface

[4] Trimmed of excess fat

[5] Prime cuts plus spare ribs, Kidneys, Liver, Shanks, Fat, Knuckles

[6] Based on 1965 prices courtesy Canada Packers Co., Montreal

Table 6 Mean selected slaughter and carcass data for various levels of C.H.Q. supplementation

Item	C.H.Q. level (gm/ton) 0	62.5	125	S.E.	Significance of F
No. of animals	32	32	32		
Slaughter data					
Ave Hot Carcass weight (kg)	54.09	54.19	54.09	0.39	N.S.
Shrink (%)					
Fasting	4.74	3.93	3.93	0.31	N.S.
Cooler	2.81	2.60	2.43	0.22	N.S.
Dressing (%)					
Hot Carcass	75.24	75.19	75.02	0.54	N.S.
Cold Carcass	73.09	73.22	73.19	0.53	N.S.
Carcass data					
Length (cm)[1]	74.30	74.30	73.66	0.24	N.S.
Width (cm)[1]	32.05	31.83	32.69	0.18	N.S.
Loin "eye" Area (sq cm)[2]	22.00[a]	21.29[ab]	20.52[b]	0.36	*
Fat/lean ratio[2]	1.35	1.38	1.36	0.04	N.S.
Back fat thickness (cm)[3]					
shoulder	3.35	3.45	3.35	0.08	N.S.
mid-back	1.88	2.11	1.96	0.06	*
loin	2.82	2.82	2.79	0.08	N.S.
Prime cuts[4] (kg)					
Ham (trim)	5.67(0.38)	5.64(0.32)	5.61(0.32)	0.05(0.03)	N.S.
Shoulder (trim)	4.71(1.05)	4.70(0.97)	4.69(1.04)	0.06(0.03)	N.S.
Loin (trim)	4.29(1.70)	4.27(1.63)	4.23(1.61)	0.03(0.06)	N.S.
Belly (trim)	3.19(0.42)	3.16(0.39)	3.17(0.40)	0.06(0.03)	N.S.
total	17.86	17.78	17.71	0.13	N.S.
% of side	75.58	76.87	75.32	0.91	N.S.
Specific gravity (trimmed cuts)					
Ham	1.05	1.05	1.05	0.002	N.S.
Shoulder	1.05	1.05	1.06	0.002	N.S.
Loin	1.06	1.06	1.06	0.001	N.S.
Other Components (kg)					
Leaf Fat	0.51	0.52	0.52	0.02	N.S.
Head	5.46	5.47	5.55	0.07	N.S.
Liver	1.06	1.12	1.12	0.02	N.S.
Kidneys	0.32	0.33	0.32	0.01	N.S.
Total saleable components[5] (kg)	42.20	41.90	41.84	0.28	N.S.
Calculated Value[6] ($)	49.61	49.20	49.11	0.33	N.S.

Note [1] R.O.P. method

[2] Obtained from loin eye tracings with planimeter

[3] Caliper measurement on mid-line cut surface

[4] Trimmed of excess fat

[5] Prime cuts plus spare ribs, Kidneys Liver, Shanks, Fat, Knuckles

[6] Based on 1965 prices courtesy Canada Packers Co., Montreal

slightly decreased and backfat measurements at the mid-back position were slightly increased in response to CHQ supplementation. However, the data does not support the findings of Hanson *et al.*, (1955) and Clausen *et al.*, (1956) who claimed that the inferior carcasses obtained with antibiotic supplementation under *ad lib* feeding was due to an increased appetite and excessive fatness.

As anticipated, marked differences were observed between weight classes in the majority of items investigated (Table 7). Exceptions as will be noted included fasting and cooler shrinkage, specific gravity of trimmed prime cuts, and prime cuts as percentage of side weight. The sizeable increase in loin eye area ($P<.01$) with increasing slaughter weight undoubtedly is largely responsible for the decrease in fat to lean ratio from loin tracings between 56.7 kg and higher slaughter weights ($P<.05$). However, with the exception of shoulder fat thickness, fat thickness increased considerably ($P<.01$) in carcasses from animals fed to heavier weights. In the case of shoulder back fat thickness the multiple range test revealed no meaningful increase in fat thickness between the 79.4 and 90.7 kg slaughter weight classes. The weight of prime cuts (ham, shoulder, loin and belly) increased considerably between slaughter weight classes ($P<.01$). Similarly significant increases were noted in the fat trimmed from all prime cuts. ($P<.01$). It is noteworthy also that there was a trend towards a decrease in prime cut yield as a percentage of side weight as slaughter weight increased. Although differences lacked statistical significance they tend to support the results of Brooks *et al.*, (1964) who found a continuous decline in carcass yield of lean and primal cuts as slaughter weight increased from 50 to 200 lbs.

A comparison of the productive efficiency of carcass components to various slaughter weights in terms of cummulative feed consumption is shown in Table 8 and is displayed graphically in Figure 5. The productive efficiency of

Table 7 Mean slaughter and carcass data for crossbred pigs fed to various slaughter weights

Item	Slaughter Weight (kg) 56.7	68.0	79.4	90.7	S.E.	Significance of F
No of animals	24	24	24	24		
Slaughter data						
Ave Hot Carcass Weight (kg)	39.24^{a}	48.46^{b}	59.91^{c}	68.89^{d}	0.45	* *
Shrink (%)						
Fasting	3.79	4.72	4.02	4.27	0.36	N.S.
Cooler	2.18	2.73	3.00	2.54	0.26	N.S.
Dressing (%)						
Hot Carcass	70.51^{a}	73.45^{b}	77.86^{c}	78.78^{c}	0.62	* *
Cold Carcass	68.95^{a}	71.42^{b}	75.52^{c}	76.77^{c}	0.61	* *
Carcass data						
Length (cm)[1]	69.60^{a}	73.56^{b}	75.08^{c}	78.05^{d}	0.27	* *
Width (cm)[1]	28.72^{a}	30.66^{b}	33.10^{c}	34.85^{d}	0.23	* *
Loin "eye" Area (sq cm)[2]	16.90^{a}	20.26^{b}	22.32^{c}	25.55^{d}	0.42	* *
Fat/lean ratio[2]	1.50^{a}	1.30^{b}	1.35^{b}	1.31^{b}	0.05	*
Back fat thickness (cm)[3]						
shoulder	2.96^{a}	3.35^{b}	3.63^{c}	3.66^{c}	0.10	* *
mid-back	1.57^{a}	1.83^{b}	2.21^{c}	2.31^{d}	0.07	* *
loin	2.31^{a}	2.59^{b}	3.00^{c}	3.38^{d}	0.08	* *
Prime cuts[4] (kg)						
Ham (trim)	$4.15^{a}(0.23^{a})$	$5.09^{b}(0.35^{b})$	$6.11^{c}(0.35^{b})$	$7.22^{d}(0.42^{b})$	0.06(0.3)	* *(* *)
Shoulder (trim)	$3.40^{a}(0.69^{a})$	$4.19^{b}(0.87^{b})$	$5.21^{c}(1.13^{c})$	$6.00^{d}(1.39^{d})$	0.07(0.3)	* *(* *)
Loin (trim)	$3.14^{a}(1.05^{a})$	$3.81^{b}(1.38^{b})$	$4.64^{c}(1.90^{c})$	$5.46^{d}(2.26^{d})$	0.06(0.7)	* *(* *)
Belly (trim)	$2.28^{a}(0.23^{a})$	$2.87^{b}(0.32^{b})$	$3.52^{c}(0.47^{c})$	$4.03^{d}(0.60^{d})$	0.07(0.4)	* *(* *)
total	12.97^{a}	15.95^{b}	19.49^{c}	22.71^{d}	0.15	* *
% of side	76.68	76.31	75.90	74.80	1.05	N.S.
Specific gravity (trimmed cuts)						
Ham	1.05	1.06	1.05	1.05	0.002	N.S.
Shoulder	1.05	1.05	1.05	1.06	0.003	N.S.
Loin	1.06	1.06	1.06	1.06	0.001	N.S.
Other Components (kg)						
Leaf Fat	0.32^{a}	0.42^{b}	0.56^{c}	0.79^{d}	0.02	* *
Head	4.24^{a}	5.09^{b}	6.06^{c}	6.56^{d}	0.08	* *
Liver	0.97^{a}	0.97^{b}	1.12^{c}	1.24^{d}	0.02	* *
Kidneys	0.20^{a}	0.20^{b}	0.35^{c}	0.47^{d}	0.01	* *
Total saleable components[5] (kg)	30.73^{a}	37.78^{b}	45.77^{c}	53.64^{d}	0.32	* *
Calculated Value[6] ($)	34.20^{a}	44.43^{b}	53.76^{c}	62.83^{d}	0.39	* *

Note

1 B.C.P.F method

2 Obtained from loin eye tracings with planimeter

3 Caliper measurement on mid-line cut surface

4 Trimmed of excess fat

5 Prime cuts plus spare ribs, kidneys, liver, shanks, fat, knuckles

6 Based on 1965 prices courtesy of Canada Packers Co. Montreal

- abcd means displaying different superscripts are significantly different (P = .05)

Table 8 The influence of slaughter weight on conversion of feed to saleable carcass components

Item	Slaughter Weight (kg) 56.7	68.0	79.4	90.7
No animals	24	24	24	24
Feed consumption (kg/hd)	109.19	156.10	197.16	245.13
Prime cut yield/carcass (kg)	25.94	31.90	38.98	45.42
Total saleable components (kg)	30.74	37.78	45.77	53.64
Ratios:				
Feed/prime cuts	4.21	4.89	5.06	5.40
Feed/saleable components	3.55	4.13	4.31	4.57
Efficiencies: (%)				
Prime cuts/feed consumed	23.76	20.43	19.77	18.53
Saleable comp/feed consumed	28.15	24.20	23.21	21.88

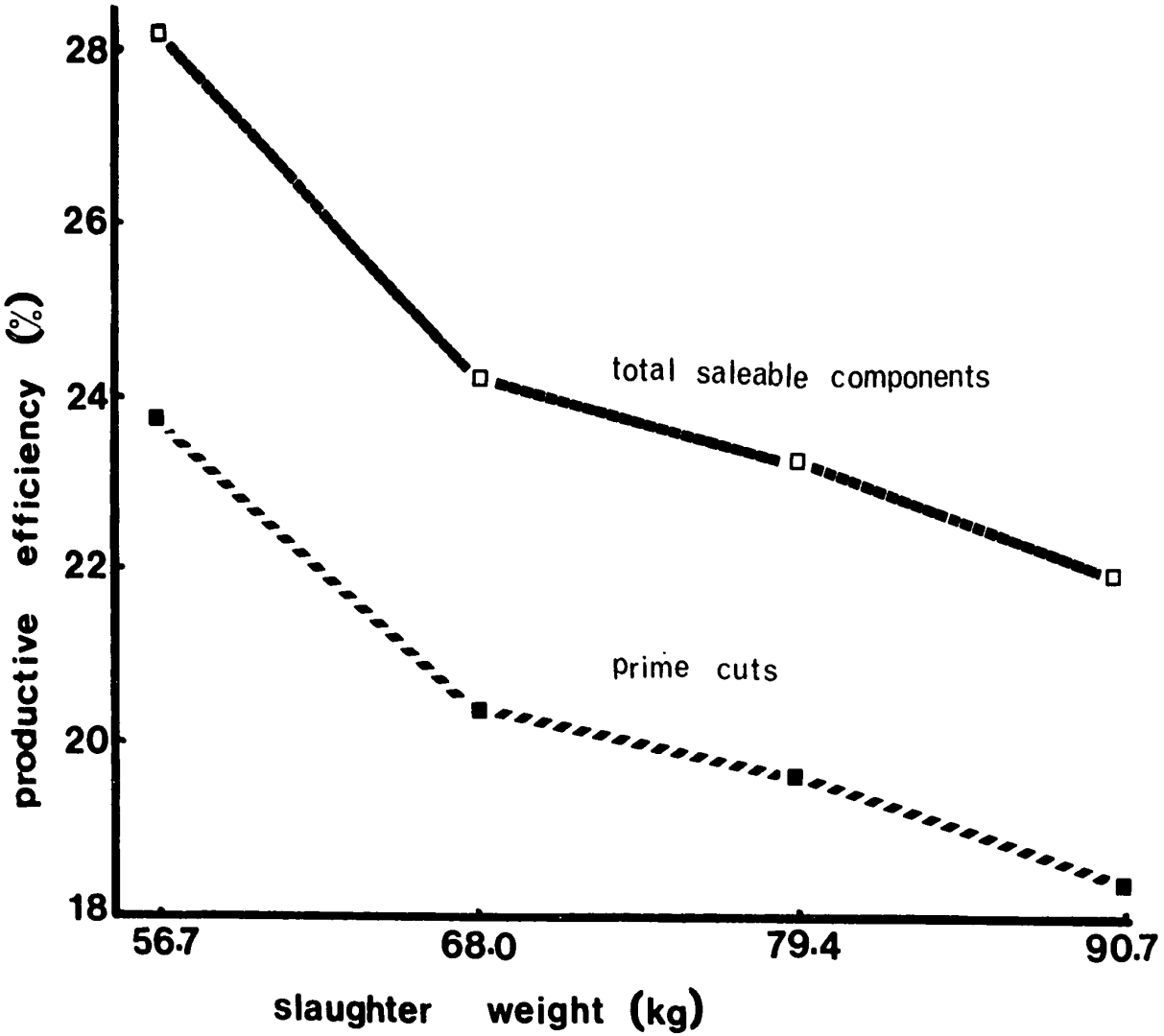


Figure 5 The productive efficiency of carcass components to various slaughter weights

prime cuts was observed to decrease from 23.8% to 18.5% as slaughter weight increased from 56.7 to 90.7 kg live weight. The decrease in productive efficiency of saleable components with increasing slaughter weight followed a similar trend. Thus, it is clearly evident that more feed input is required to produce a given weight of saleable carcass components as slaughter weight increases. This decrease in efficiency of conversion of feed to saleable components is due in part to the increased maintenance costs of heavier animals and the shift in growth gradient between fat and lean tissue.

Simple correlation coefficients were calculated for certain carcass measurement and cut-out data and are shown in Appendix Table I. The majority of selected variables were highly correlated ($P<.01$) with prime cut yield, total saleable components, total fat trim and calculated carcass value. An exception was fat/lean ratio from the loin cross section tracing, which was positively correlated with total fat trim but not of sufficient magnitude to be statistically significant. Similarily, specific gravity measurements failed to display any significant association with yield of prime cuts, or total fat trim. It should be indicated, however, that the specific gravity measurement was determined on the "trimmed" commercial cuts from the left side. Undoubtedly the relationship between specific gravity and prime cut yield as well as other carcass quality factors was influenced by the removal of excess subcutaneous fat and skin which thereby reduced the variation in specific gravity. In contrast, extremely high correlations were noted between certain linear measurements and carcass quality as indicated by prime cut yield, total fat trim and calculated value. For example, length, depth, loin eye area and loin area X carcass length demonstrated highly significant correlation coefficients ($P<.01$) in relation to prime cut yield with $r = 0.89$, 0.88, 0.83 and 0.89 respectively. Interestingly, the correlation between loin eye area X carcass length exceeded the magnitude

of each independently. Since this combination gives an approximation of the *M. longissimus dorsi* volume, the observed higher correlation would support the rationalization made by Pomeroy (1965) that it would be more sensible to combine linear measurements to give measurements of volume.

The relationships between caliper backfat measurements and fat trim from individual cuts, although highly significant ($P<.01$), were of lesser magnitude than anticipated with "r" values ranging between +0.24 and +0.74. This is further exemplified through the superiority of individual fat trim correlations with total fat trim as compared to the correlations for caliper backfat thickness and total fat trim. Thus it is understandable why estimates of body composition based on lean meter or ultrasonic measurements taken on live animals leave considerable to be desired (Harrington, 1958a,b; Stouffer, 1963).

The effect of selected independent variables on the yield of prime cuts expressed as standard partial regression coefficients is displayed in Appendix Table 2. Trimmed ham weight, and carcass weight alone accounted for 97.8% of the variation in prime cut yield. Inclusion of ham fat trim, carcass depth, carcass length, dressing % and loin eye area only increased explained variation to 98.5%.

Summary:

A. Sex:

1. Significant differences were not observed between sexes for fasting shrinkage, cooler shrinkage, dressing percentage, carcass length, carcass width and weight of total prime cuts.
2. The yield of trimmed ham was higher ($P<.05$) from gilts than barrows, while trimmed shoulders and loins tended to be heavier in gilts but the differences were not significant.

3. The yield of prime cuts (as a % of side weight) was significantly ($P<.05$) higher from carcasses of gilts than from barrows.
4. There was a significantly ($P<.01$) greater amount of fat trimmed from loins and shoulders of barrows, and from bellies of gilts, while no difference was noted in the fat trim of hams.
5. The carcasses from gilts had superior loin eye areas ($P<.01$), lower fat/lean ratios ($P<.01$), and thinner backfat ($P<.01$) than those of barrows.
6. Significant differences between sexes were not observed in specific gravity of trimmed cuts.
7. Carcasses of gilts yielded more total saleable components ($P<.05$) and hence had a higher calculated value ($P<.05$) than those of barrows.

B. Chlorhydroxyquinoline (CHQ):

The only significant difference observed in carcass quality attributable to CHQ supplementation was a decrease in loin eye area ($P<.05$).

C. Slaughter weight:

1. Significant differences were not observed between slaughter weights for fasting or cooler shrinkage, % yield of prime cuts, or specific gravity of trimmed cuts.
2. Successive increments in slaughter weight resulted in significant increases in dressing % ($P<.01$), length ($P<.01$), width ($P<.01$), loin eye area ($P<.01$), fat/lean ratio ($P<.05$), backfat thickness ($P<.01$), weight of prime cuts ($P<.01$), fat trim ($P<.01$), total saleable components ($P<.01$) and calculated carcass value ($P<.01$)

3. The productive efficiency of prime cuts and total saleable components decreased with successive increments in slaughter weight.

D. Correlation and Regression:

1. Simple correlation coefficients calculated between various carcass measurements and cut-out data were in general highly significant ($P<.01$). Exceptions were fat/lean ratio from the loin tracing and specific gravity of trimmed cuts.
2. Multiple regression analysis revealed that carcass weight and trimmed ham weight accounted for 97.8% of the variation in prime cut yield. Inclusion of five additional independent variables only slightly increased the amount of explained variation.

4.3 ANATOMICAL DISSECTION

Knowledge of the differential rate of growth of the 3 major tissues (bone, muscle and fat), and the consequent changes in proportional composition of the carcass in response to treatment is of paramount importance. According to Palsson (1955), among the numerous factors which contribute to meat quality the one of universal importance is proportional composition in terms of bone, muscle and fat. The proportional composition data obtained through anatomical dissection of hams, middles and shoulders (cut by the ROP method) obtained from the right hand side of carcasses of barrows and gilts are presented in Table 9 and in Appendix Tables 3 through 5 inclusive.

From the data presented in Appendix Table 3 it is clearly evident that there were no meaningful differences between sexes in terms of gross proportional composition of hams. Similarly, only minor differences were found to exist between sexes in terms of gross composition of middles and shoulders as shown in Appendix Tables 4 and 5. In all cases however, there was a greater amount of total dissectable muscle in cuts obtained from the carcasses of gilts vs barrows. On the other hand there was an increased amount of dissectable subcutaneous and intermuscular fat in cuts obtained from barrow vs gilt carcasses. Random variation however, was of sufficient magnitude to prevent these differences attaining statistical significance. The ratios of weights of dissectable muscle, fat and bone revealed that cuts obtained from gilt carcasses contained proportionally more dissectable muscle and less subcutaneous and intramuscular fat as compared to similar cuts from barrow carcasses. This is further demonstrated in the cummulative anatomical composition data for the total right-hand side of the carcasses (Table 9). Subcutaneous fat and skin as a percent of side weight and the ratio of subcutaneous fat to bone were found to be significantly ($P<.05$) lower for gilts as compared to barrows.

Table 9 The influence of sex on anatomical composition of the total right side of carcasses

Variable	Sex: Barrows	Sex: Gilts	S.E.[1]	Significance of F
Number of animals	12	12		
Total weight of side (kg)	22.27	22.73	0.44	N.S.
Dissection data				
Muscle:				
Total weight (kg)	8.410	8.952	0.115	* *
% of side	39.31	41.48	0.61	*
Subcutaneous fat & skin:				
Total weight (kg)	6.532	5.897	0.200	N.S.
% of side	30.37	27.22	0.84	*
Intermuscular fat:				
Total weight (kg)	3.420	3.237	0.092	N.S.
% of side	15.89	14.93	0.39	N.S.
Bones:				
Total weight (kg)	2.218	2.325	0.035	N.S.
% of side	10.43	10.93	0.18	N.S.
Ratios:				
Muscle/bone	3.78	3.81	0.07	N.S.
Subcutaneous fat/bone	2.92	2.52	0.10	*
Intermuscular fat/bone	1.53	1.38	0.05	N.S.
Muscle/subcutaneous fat	1.29	1.55	0.07	N.S.
Muscle/intermuscular fat	2.49	2.79	0.10	N.S.
Muscle/total fat	0.85	0.99	0.04	*

[1] S.E. = Standard error

This data substantiates observed differences in commercial cut-out from the left side of the carcasses and supports the findings of other workers (Lucas *et al.*, 1956; Bowland *et al.*, 1959; Buck *et al.*, 1962; Blair *et al.*, 1965) who found that carcasses from gilts were generally superior to those obtained from barrows.

The influence of CHQ supplementation on anatomical composition of the various cuts is presented in Table 10 and in Appendix Tables 6 through 8 inclusive. The ratio of intermuscular fat to bone in hams decreased significantly ($P<.05$) with increasing levels of CHQ supplementation. However, significant differences were not observed in any of the other variables studied in relation to anatomical composition in response to CHQ treatment.

The influence of slaughter weight on anatomical composition of the various cuts is presented in Table 11 and in Appendix Tables 9 to 11 inclusive. As anticipated there was a highly significant ($P<.01$) increase in the weight of all separable tissues as slaughter weight increased. However, with the exception of intermuscular fat to bone ratios in hams and muscle to bone ratio in middles, no other meaningful differences existed between ratios for the various slaughter weight classes. Although the magnitude of differences was not sufficient to be statistically significant, there was a trend toward an increased subcutaneous and intermuscular fat to bone ratio with successive increments in slaughter weight. This, together with the increase in muscle to bone ratios up to 79.4 kg followed by the decrease to 90.7 kg suggest the existance of differential growth gradients for the various tissues.

Further evidence of a differential growth gradient between muscle, fat and bone is observed when the mass of tissues at various weights are plotted as a percentage of the respective tissue mass at 56.7 kg as shown in Figure 6.

Table 10 The influence of C.H.Q. treatment on the anatomical composition of the total right side of the carcass

Variable	C.H.Q. level (gm/ton) 0	62.5	125	S.E.[1]	Significance of F
Number of animals	8	8	8		
Dissection data					
Total side wt (kg)	22.51	22.83	22.08	0.54	N.S.
Muscle:					
Total wt (kg)	8.965	8.468	8.611	0.140	N.S.
% of side	40.81	39.60	40.78	0.74	N.S.
Subcutaneous fat & skin					
Total wt (kg)	6.390	6.436	5.817	0.246	N.S.
% of side	29.05	29.86	27.48	1.02	N.S.
Intermuscular fat					
Total wt (kg)	3.354	3.354	3.277	0.112	N.S.
% of side	15.43	15.51	15.29	0.48	N.S.
Bones					
Total wt (kg)	2.223	2.274	2.318	0.043	N.S.
% of side	10.29	10.72	11.04	0.22	N.S.
Ratios:					
Muscle/bone	3.99	3.70	3.70	0.09	N.S.
Subcutaneous fat/bone	2.84	2.81	2.51	0.12	N.S.
Intermuscular fat/bone	1.50	1.46	1.39	0.07	N.S.
Muscle/subcutaneous fat	1.41	1.33	1.53	0.08	N.S.
Muscle/intermuscular fat	2.66	2.57	2.70	0.12	N.S.
Muscle/total fat	0.91	0.87	0.96	0.04	N.S.

[1] S.E. = Standard error

Table 11 The influence of slaughter weight on the anatomical composition of the total right side of the carcass

Variable	Slaughter weight (kg) 56.7	68.0	79.4	90.7	S.E.[1]	Significance of F
Number of animals	6	6	6	6		
Dissection data						
Total side wt (kg)	15.26^{a}	20.04^{b}	23.42^{c}	27.46^{d}	0.63	* *
Muscle:						
total wt (kg)	6.147^{a}	8.274^{b}	9.747^{c}	10.558^{d}	0.162	* *
% of side	40.31^{ab}	41.28^{ab}	41.61^{b}	38.38^{a}	0.86	N.S.
Subcutaneous fat & skin:						
total wt (kg)	4.440^{a}	5.634^{b}	6.639^{c}	8.146^{d}	0.284	* *
% of side	29.04	28.15	28.33	29.66	1.18	N.S.
Intermuscular fat:						
total wt (kg)	2.315^{a}	3.117^{b}	3.565^{c}	4.316^{d}	0.130	* *
% of side	15.16	15.52	15.20	15.76	0.56	N.S.
Bones:						
total wt (kg)	1.771^{a}	2.162^{b}	2.480^{c}	2.675^{d}	0.049	* *
% of side	11.61^{a}	10.79^{ab}	10.58^{bc}	9.74^{c}	0.25	*
Ratios:						
Muscle/bone	3.47^{a}	3.83^{b}	3.94^{b}	3.95^{b}	0.10	*
Subcutaneous fat/bone	2.53	2.61	2.68	3.06	0.14	N.S.
Intermuscular fat/bone	1.31	1.44	1.44	1.61	0.08	N.S.
Muscle/subcutaneous fat	1.42	1.47	1.47	1.34	0.10	N.S.
Muscle/intermuscular fat	2.67	2.69	2.75	2.47	0.14	N.S.
Muscle/total fat	0.92	0.95	0.95	0.85	0.05	N.S.

[1] S.E. = Standard error

abcd means displaying similar superscripts are not significantly different ($P<.05$)

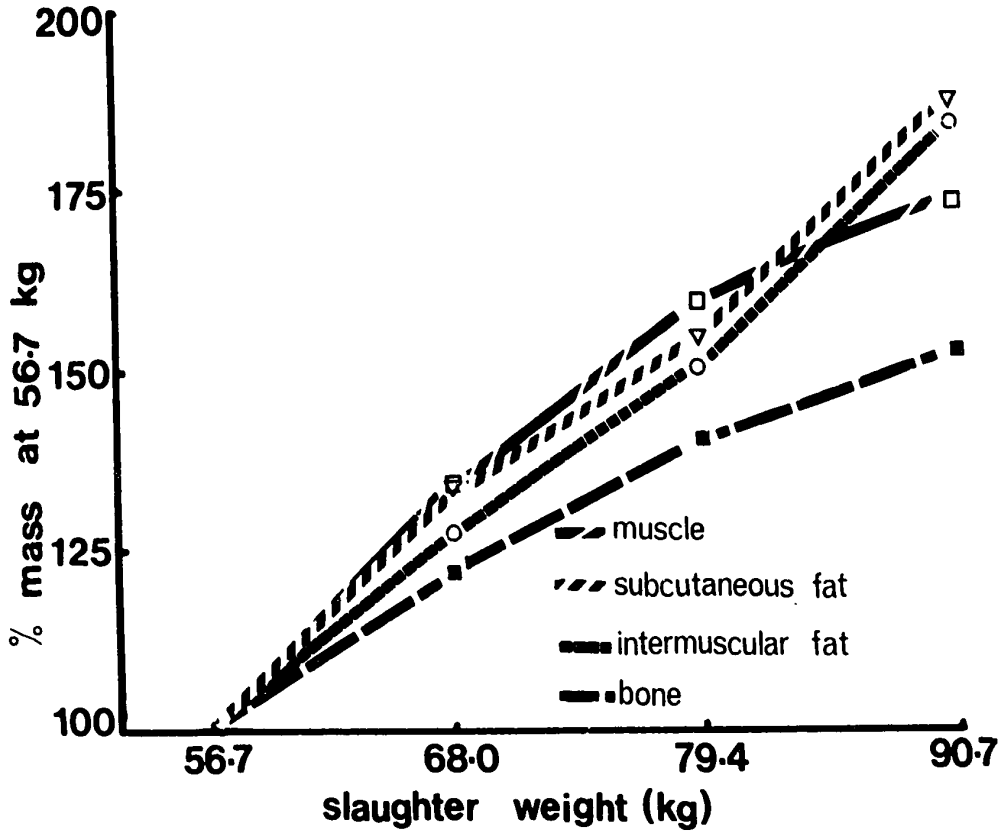


Figure 6 The proportional growth of major tissues expressed as a percentage of mass at 56.7 kg

It is apparent from Figure 6 that the rate of subcutaneous and intermuscular fat deposition increased, while the rate of muscle and bone growth was retarded between 79.4 and 90.7 kg liveweight. This shift in growth gradient is similar to that reported by McMeekan (1940) and Cuthbertson *et al.*, (1962b).

The shift toward increased fat deposition, together with a higher maintenance requirement for heavier animals resulted in a decrease in the efficiency of muscle growth as shown in Figure 7. The productive efficiency, in terms of muscle mass produced per unit weight of feed consumed, decreases markedly with successive increments in slaughter weight.

The calculation of simple correlation coefficients for selected gross dissection data and certain carcass variables revealed several highly significant relationships as shown in Appendix Table 12. The dissectable muscle, bone, subcutaneous and intermuscular fat from the individual R.O.P. cuts were highly correlated with the respective tissue weights in the total right hand side ($P<.01$), with observed "r" values ranging between +0.56 and +0.98. The highest correlations were between muscle content of the middle R.O.P. cut and total dissectable muscle from the side ($r = +0.98$), while correlations with muscle content of ham and shoulder were similar ($r = +0.97$). Correlation of bone content of individual cuts with total bone content of the side revealed a higher relationship with bone content of middles ($r = +0.94$) than with bone content of hams ($r = +0.89$) or shoulders ($r = +0.78$). Likewise, subcutaneous fat and skin in the total side displayed a higher correlation with subcutaneous fat and skin in middles ($r = +0.97$) as compared to hams ($r = +0.89$) or shoulders ($r = +0.92$). Intermuscular fat content of total side was not as highly associated with intermuscular fat content of individual cuts

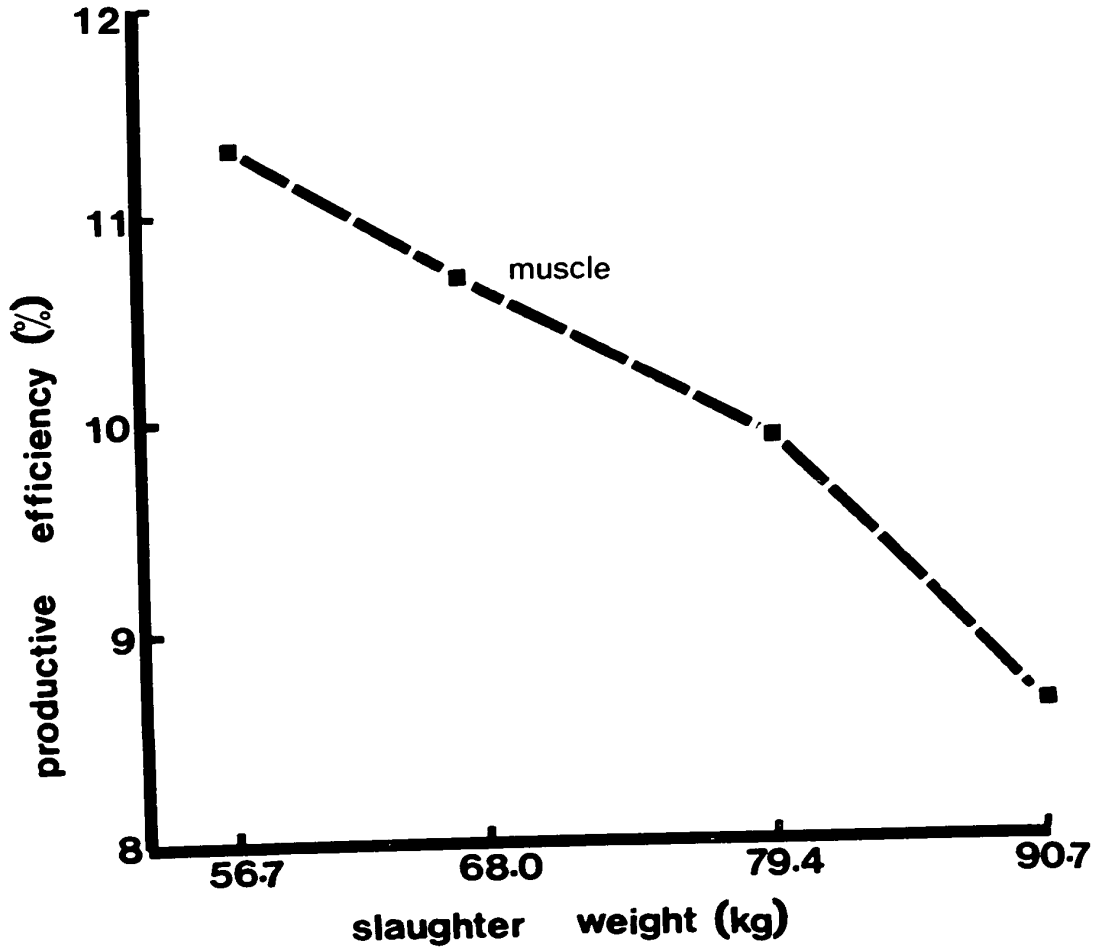


Figure 7 The productive efficiency of muscle growth to various slaughter weights

as indicated by somewhat lower correlation coefficients. (Ham, r = +0.73; middle, r = +0.75; shoulder, r = +0.69).

The association between caliper backfat measurements and dissectable subcutaneous fat content of individual cuts ranged between r = +0.57 and r = +0.81. Caliper backfat measurements at the loin position yielded higher correlation coefficients with subcutaneous fat and skin content of ham and shoulder, (r = +0.77 and r = +0.81 respectively) while the mid-back measurement was superior in the case of middles (r = +0.68). Similarily, the loin backfat measurement was found to be more closely associated with total subcutaneous fat content of the side (r = +0.74) than measurements at the mid-back (r = +0.72) or shoulder position (r = +0.61). This tends to support McMeekan's (1940) suggestion that backfat measurements at the loin position would be more accurate predictors of total fat content since it is the latest region of the body to develop.

The ratios of lean/fat obtained from ham grid photos, and fat/lean from the loin eye tracings were found to have low and insignificant correlations with separable tissue content of individual R.O.P. cuts or total right side of the carcass. Conversely, loin eye area, and loin eye area X carcass length yielded highly significant correlations with the composition of each cut as well as that of the total side. Also, as observed in the commercial cut-out of the left side of the carcass, loin eye area X carcass length was more closely associated with the composition of each cut and total side than was loin eye area alone.

As anticipated, carcass weight was highly correlated with total dissectable fat, muscle and bone from each R.O.P. cut as well as from the total side.

Standard partial regression analysis of selected variables with total dissectable fat as the dependent variable is summarized in Appendix Table 13. The analysis revealed that over 89% of the variation in total dissectable fat was attributable to variations in ham subcutaneous fat plus skin and carcass weight. The inclusion of leaf fat weight and caliper backfat thickness (loin) account for a small improvement in predictive accuracy, but ham intermuscular fat, fat/lean ratio from loin tracing and specific gravity of the ham accounted for very little of the variation in total dissectable fat.

Summary:

Anatomical dissection data revealed that:

1. There was a significantly ($P<.01$) greater amount of total dissectable muscle in gilt carcasses than barrow carcasses.
2. Carcasses from barrows yielded a significantly ($P<.05$) higher subcutaneous fat/bone ratio, and lower muscle/subcutaneous fat, and muscle/total fat, than did carcasses from gilts.
3. CHQ supplementation resulted in a significant ($P<.05$) decrease in the ratio of intermuscular fat/bone. Significant differences were not observed for any other variables in response to CHQ supplementation.
4. There was a highly significant ($P<.01$) increase in the weight of all separable tissues with successive increments in slaughter weight.
5. There was a significant ($P<.05$) increase in the ratio of intermuscular fat/bone, and subcutaneous fat/bone as slaughter weight increased from 79.4 to 90.7 kg. The muscle/bone ratio increased significantly ($P<.05$) with successive increments in slaughter weight from 56.7 to 79.4 kg, but was not increased between 79.4 and 90.7 kg.

6. The rate of subcutaneous and intermuscular fat deposition increased while the rate of muscle and bone growth decreased between 79.4 and 90.7 kg liveweight.
7. The productive efficiency, in terms of muscle mass produced per unit weight of feed consumed, decreased markedly with successive increments in slaughter weight.
8. The dissectable muscle, bone, subcutaneous fat, and intermuscular fat from the individual R.O.P. cuts were highly correlated ($P<.01$) with the respective tissue weights in the total right side of the carcass. (Appendix Table 12).
9. The ratios of lean/fat obtained from ham grid photos, and fat/lean from the loin eye tracings yielded low and insignificant correlations with separable tissue content of individual R.O.P. cuts or total right side. (Appendix Table 12).
10. The loin eye area, and loin eye area X carcass length yielded highly significant ($P<.01$) correlations with the composition of each R.O.P. cut as well as that of the total side. (Appendix Table 12).
11. The carcass weight was highly correlated ($P<.01$) with total dissectable fat, muscle and bone from each R.O.P. cut as well as from the total side. (Appendix Table 12).
12. Standard partial regression analysis of selected independent variables revealed that over 89% of the variation in total dissectable fat was attributable to variations in ham subcutaneous fat plus skin, and carcass weight. The predictive accuracy was increased to 92.0% by the inclusion of leaf fat weight and caliper backfat (loin) measurements. Intermuscular fat, specific gravity and fat/lean from the loin tracing accounted for very little of the variation in total dissectable fat. (Appendix Table 13).

4.4 PROPORTIONAL GROWTH OF INDIVIDUAL MUSCLES

The relative weights of the various individual muscles are summarized by treatments in Appendix Tables 14, 15, and 16.

Sex differences were not as pronounced in the present study as those reported in earlier studies. (McMeekan, 1940a; Pomeroy and Cuthbertson, 1962b). However, there was a general trend toward heavier weights for similar muscles obtained from gilts as compared to barrows. The magnitude of these differences attained statistical significance in the case of *pectineus* ($P<.01$); *psoas major* and *iliacus* ($P<.05$); *Gastrocnemius, Soleus* and *superficial digital flexor* ($P<.05$); *Coraco brachialis* ($P<.05$); and *rectus capitus dorsalis* (minor and major) ($P<.05$). Thus, it is apparent that gilts have superior muscling at the same live weight as compared to barrows. *Longissimus dorsi* fiber diameter failed to reveal any differences between sexes.

Chlorohydroxyquinoline supplementation had no meaningful beneficial influence on individual muscle growth as is evident from Appendix Table 15. Although statistically significant differences were noted for *Sartorius* ($P<.05$); *flexor digitalis longus* ($P<.05$); *trapezius* ($P<.05$); *supraspenatus* ($P<.05$); *Lateral head triceps* ($P<.05$); *Coraco-brachialis* ($P<.01$); and *obliquus capitus* (anterior and posterior) ($P<.05$), there was no consistent trend in direction or magnitude of differences. Thus, it would seem likely that observed differences were probably due to chance variation.

The influence of slaughter weight on muscle development is clearly evident from the data presented in Appendix Table 16. As anticipated, individual muscle weight increased directly with successive increments in slaughter weight. The majority of differences between muscle weight at various slaughter weights were highly significant ($P<.01$).

The application of Duncan's multiple range test to various mean muscle weights revealed several muscles which did not substantially increase in weight between 79.4 and 90.7 kg, while others demonstrated continued growth as slaughter weight increased.

The variation in individual muscle growth is further demonstrated in the comparison of the proportional growth of selected muscles from ham, middle and shoulder regions of the carcass expressed as a percentage of their mass at 56.7 kg as presented in figures 8, 9, and 10 respectively. The widely divergent growth gradient for muscles within each region are readily apparent. Cuthbertson and Pomeroy (1962b) reported that there was no outstanding differences in the development of muscle groups within the hip and thigh region. Likewise their data showed that groups of muscle within the shoulder girdle showed little variation in development with age, but within those groups which make up the muscles of the shoulder there was greater variation with age. The general pattern of growth gradients for musculature, as proposed by McMeekan, (1940a) and generally supported by Cuthbertson and Pomeroy (1962b), could be misleading in view of the divergence observed in individual muscle growth gradients in the present study. Furthermore, because of the increase in intramuscular fat (marbling) at heavier weights (Harrington, 1958a,b) it is likely that the apparent late development of certain individual muscles such as *latissimus dorsi*, *pannicalus*, and *gluteus accessorius* is partially a reflection of an increase in intramuscular fat. It is noteworthy that there was a trend toward an increased content of extractable lipid from *longissimus dorsi* as slaughter weight increased as shown in Table 17. This trend, together with an apparent decrease in moisture content with successive increments in slaughter weight agrees in principle but is of greater magnitude than that previously

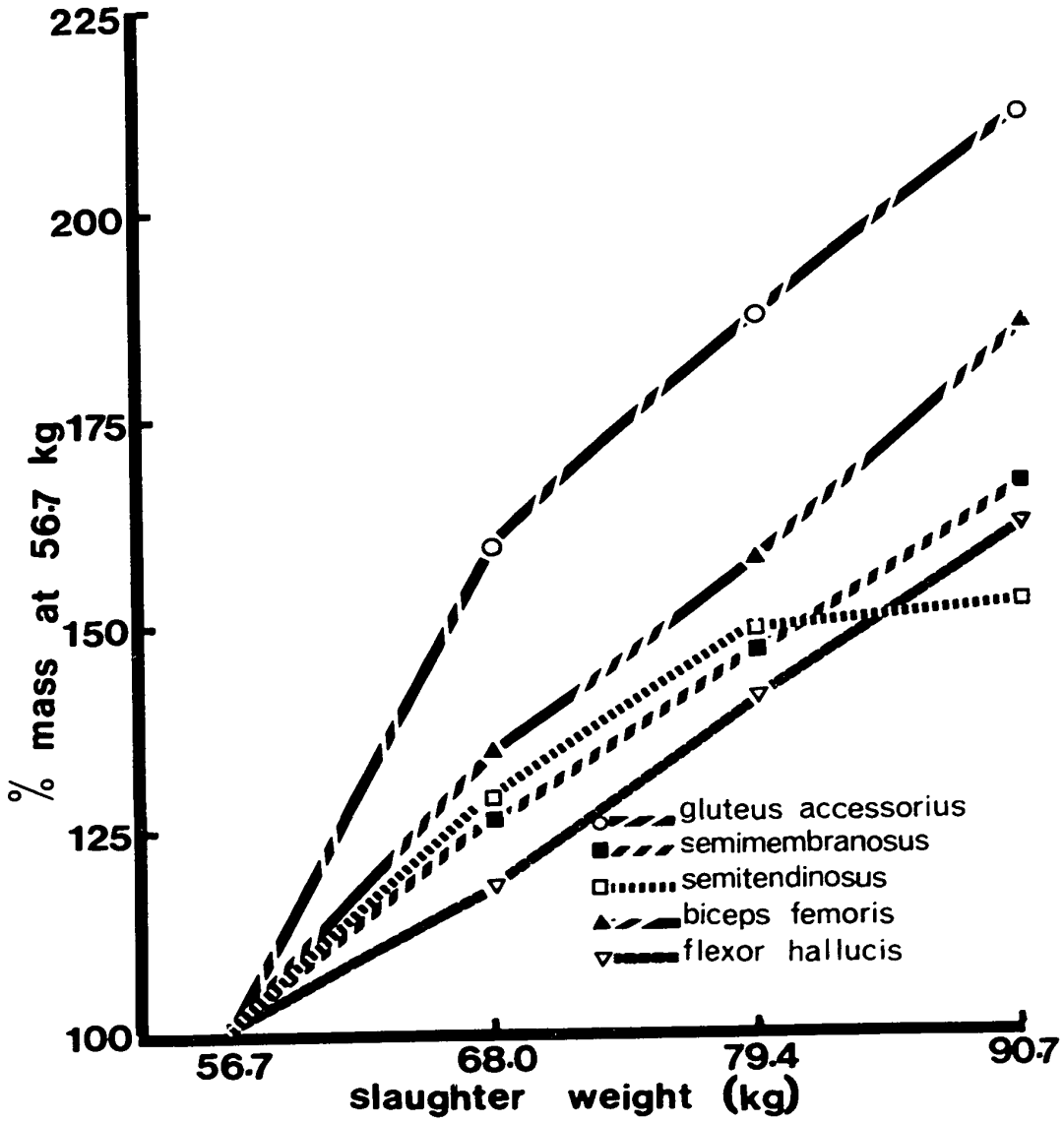


Figure 8 The proportional growth of selected muscles from the ham region expressed as a % of mass at 56.7 kg

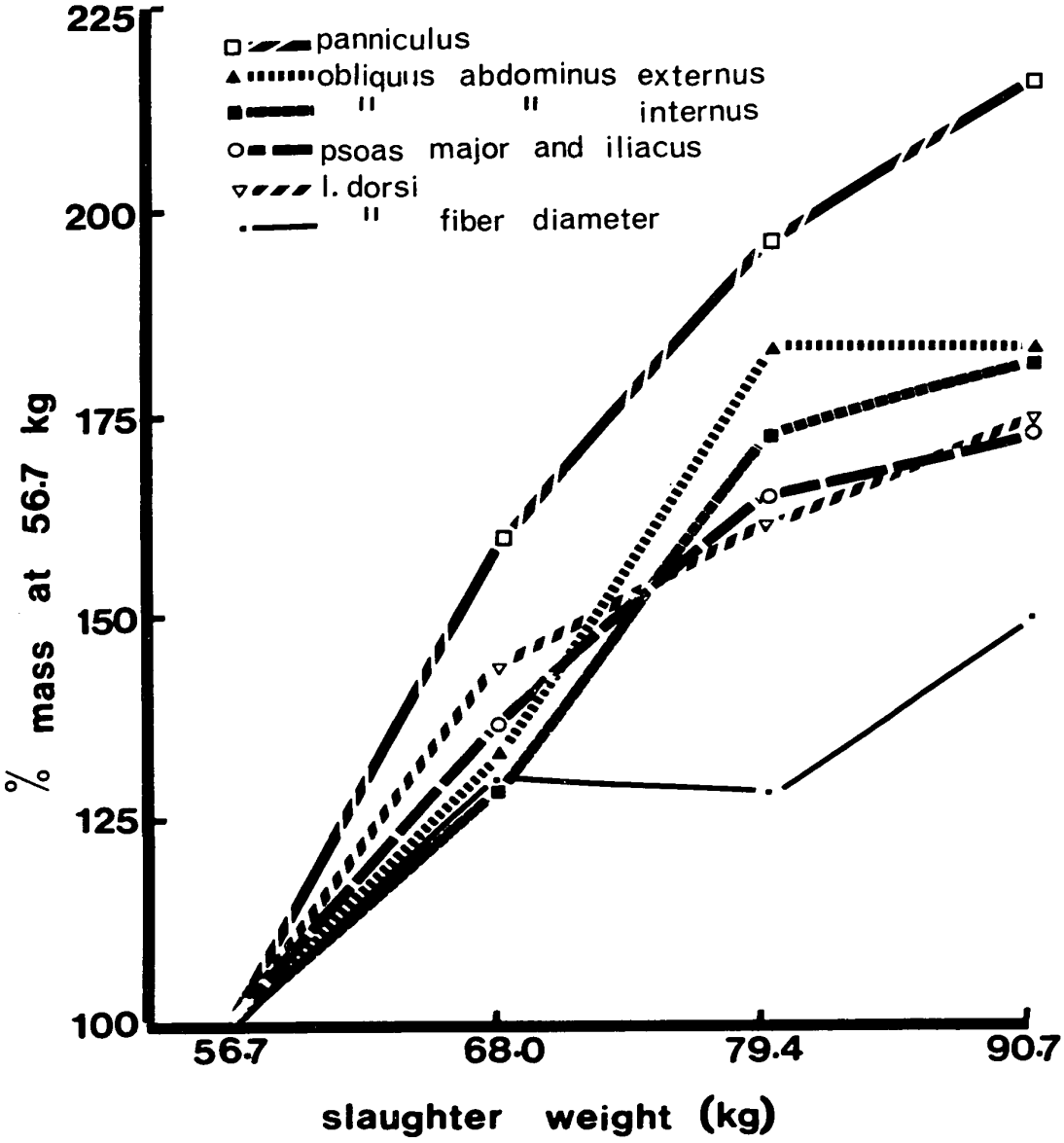


Figure 9 The proportional growth of selected muscles from the middle region expressed as a % of mass at 56.7 kg

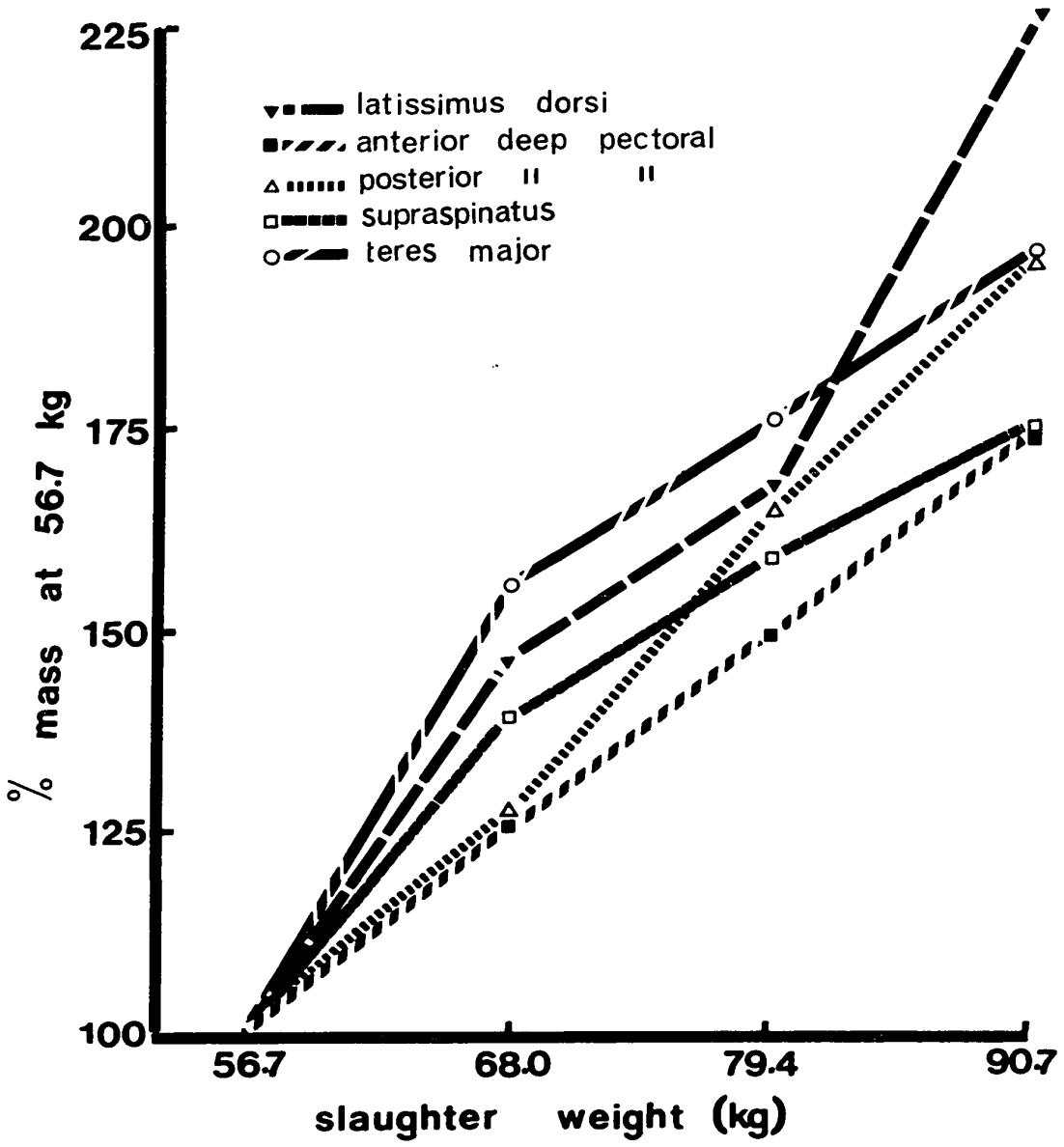


Figure 10 The proportional growth of selected muscles from the shoulder region expressed as a % of mass at 56.7 kg

reported by Lawrie *et al.*, (1964). Visual observation of various muscles suggested a considerable variation in intramuscular fat content between muscles over the range of slaughter weights studied. Unfortunately, no quantitative measurements of "marbling" were obtained.

Since musculature within different regions of the body develop at differential rates, it would be erroneous to use any one muscle, or even small groups of muscles, to provide a predictive index of the entire muscle mass of a carcass. This would be especially true where certain cuts have been used to provide an index as a basis upon which to measure the influence of various nutritional factors on carcass composition. This lends support to the studies reported by Callow (1962) where it was reasoned that there were no adequate short cuts in studies designed to measure meat quality. He states as follows: "It will be necessary to dissect the whole side or carcass joint by joint, tissue by tissue, and muscle by muscle."

In spite of the above comments, reasonably high correlations were found between certain selected muscle weights and total dissectable muscle content of the side as shown in Appendix Table 17. It is obvious however, that higher correlations are common to heavier individual muscles. An exception is the weight of *psoas major* plus *iliacus* (Appendix Table 12) which displayed a highly significant correlation of r = +0.94 with total dissectable muscle of the entire side. Nevertheless, higher correlations were observed between the weights of either *semimembranosus*, (r = +0.94) or *Biceps femoris* (r = +0.95) and total dissectable muscle in the side.

The selected muscles also displayed highly significant correlations with the weight of individual R.O.P. cuts (r = +0.68 to +0.97), However, the weights of individual cuts themselves were found to display correlations of nearly equal magnitude with the composition of the total side as was found for individual muscles. (r = +0.81 to +0.96). The somewhat lower correlations

observed for *obliquus abdominus* with the weight of individual R.O.P. cuts and the composition of the total side (r = +0.55 to +0.77) is probably a reflection of divergent growth patterns of this individual muscle as displayed in Figure 9.

The correlation between specific gravity or the reciprocal of specific gravity and composition of the total side was generally low. Only in the case of the ham were the correlations with total fat, muscle and bone found to be of significant magnitude (r = -0.41 to -0.54). Specific gravity of the middle yielded a significant negative correlation only with total subcutaneous fat and skin (r = -0.42) and intermuscular fat (r = -0.51), while specific gravity of the shoulder was associated significantly only with total intermuscular fat content of the side (r = -0.42). Contrary to reports by Harrington (1958) the use of the reciprocal of specific gravity did not increase the correlation. However, it is noteworthy that a significant correlation existed between the reciprocal of specific gravity in the middle and percentage drip loss on cooking (r = +0.41). Percentage drip loss was not found to be significantly associated with total intermuscular fat content of the total side (r = -0.09) but approached a significant correlation with total dissectable muscle of the side (r = -0.32).

The effect of selected independent variables on the total dissectable muscle expressed in terms of standard partial regression is summarized in Appendix Table 18. The inclusion of only carcass weight and dissectable muscle in the ham accounted for 96.6% of the variation in total dissectable muscle. Incorporation of *longissimus dorsi* fiber diameter, ham specific gravity, [illegible] weight, loin "eye" area X carcass length and ham weight in the equation did not result in a meaningful improvement in the predictive accuracy. [illegible]

cimus dorsi fiber diameter yielded the lowest standard partial regression coefficient thus indicating it to be the least important of all independent variables. Similarily, ham specific gravity and *psoas major* weight also demonstrated very low partial regression coefficients. Interestingly, loin "eye" area X carcass length (an approximation of *longissimus dorsi* volume) yielded a standard partial regression coefficient equal to that obtained for carcass weight. (0.31). This tends to support Pomeroy's (1965) suggestion that it would be more sensible to combine measurements to give measures of volume.

Summary:

A. Sex:

1. Individual muscles from gilts tended to be heavier than those dissected from barrows at the same slaughter weight. However, the magnitude of these differences only attained statistical significance in the case of *pectineus* (P<.01); *psoas major* and *iliacus* (P<.05); *gastrocnemius*, *soleus* and *superficial digital flexor* (P<.05); *Coraco brachialis* (P<.05); and *rectus capitus dorsalis* (minor and major) (P<.05). (Appendix Table 14).

2. Significant differences were not observed in *longissimus dorsi* fiber diameters between sexes.

B. Chlorhydroxyquinoline (CHQ):

CHQ supplementation had no meaningful beneficial influence on individual muscle growth (Appendix Table 15)

C. Slaughter weight:

1. As anticipated, the majority of individual mean trimmed muscle weights increased in proportion to successive increments in slaughter weight (Appendix Table 16)

2. Multiple range test of mean muscle weights revealed several muscles which did not substantially increase in weight between 79.4 and 90.7 kg. (Appendix Table 16)
3. The proportional growth of selected muscles from different regions of the carcass, expressed as a percentage of their mass at 56.7 kg revealed widely divergent growth gradients (Figures 8, 9 and 10).

D. Correlation and Regression:

1. In spite of the differential growth of individual muscles, high correlations were found between certain selected muscles and total dissectable muscle content of the side (Appendix Table 17).
2. The mean weight of selected muscles was found to be highly correlated with the weight of individual R.O.P. cuts (r = +0.68 to +0.97) (Appendix Table 17)
3. The correlation between specific gravity or the reciprocal of specific gravity and composition of the total side was generally low. (Appendix Table 17)
4. The effect of selected independent variables on the total dissectable muscle expressed in terms of standard partial regression revealed that 96.6% of the variation in total dissectable muscle was attributable to carcass weight and dissectable muscle content of the ham. (Appendix Table 18)
5. Loin "eye" area X carcass length (an estimate of *longissimus dorsi* volume) yielded a standard partial regression equal to that obtained for carcass weight (0.31). *Longissimus dorsi* fiber diameter, ham specific gravity, and *psoas major* weight displayed low and insignificant standard partial regression coefficients.

4.5 ORGANOLEPTIC ASSESSMENT

The mean data obtained in cooking trials with sample loin roasts from barrows and gilts together with taste panel evaluations are summarized in Table 12. Analysis of variance indicated that no significant differences existed between sexes for any of the cooking or eating characteristics studied. Cooking losses amounted to almost 25% of the initial weight of loin roasts. Evaporation losses ranged from 15.6 to 16.3% for roasts from barrows versus gilts respectively. Drip loss was considerably lower and ranged from 8.2 to 7.8% for roast from barrows and gilts respectively. Although not significant, there was an apparent trend towards an inverse relationship between evaporation and drip losses with roasts from gilts displaying higher evaporative losses and lower drip losses. Such a trend might have been anticipated in view of the variation in fat to lean ratio between the two sexes.

CHQ supplementation had little effect on cooking or eating quality of loin roasts (Table 13). Although differences in evaporative loss and meat to juice ratio were of sufficient magnitude to be statistically significant, they may be unrealistic since roasts from each CHQ treatment were cooked and sampled on different days. Even though the cooking procedure was standardized slight variations in "degree of doneness" may have been sufficient to account for the observed differences in evaporative loss and expressable fluid.

The influence of slaughter weight on cooking and eating characteristics is outlined in Table 14. Once again, as in the case of barrows versus gilts there was a trend toward an inverse relationship between evaporative loss and drip loss during the cooking process. Even though not statistically significant, the data indicate a slight decrease in evaporative loss together with an increase in drip loss as slaughter weight increased. This could be a reflection of the increased amount of intermuscular and/or intramuscular fat to lean at the heavier slaughter weights. Taste panel flavour score differences revealed that the most

Table 12 The influence of sex on cooking and eating characteristics of pork loin roasts

Variable	Sex		S.E.[5]	Significance of F
	Barrows	Gilts		
No of animals	48	48		
Cooking				
Evaporation loss (%)	15.6	16.3	0.40	N.S.
Drip loss (%)	8.2	7.8	0.42	N.S.
Taste Panel				
Juiciness score[1]	5.6	5.7	0.16	N.S.
Flavour score[1]	5.6	5.6	0.12	N.S.
Tenderness				
1. Swallowing[2] chew count	21.3	21.8	0.62	N.S.
2. Complete mastication[3] chew count	63.0	63.2	2.23	N.S.
Physical				
Meat/juice ratio X 100[4]	15.6	16.3	0.78	N.S.

1 Average for all tasters (6) based on range from 1-10 (**Appendix** Table 19)

2 Average number of chews to point of swallowing

3 Average number of chews to completely masticate

4 Area of meat/juice taken from hydraulic press (2500 psi for 5 min) of cube of meat on filter paper

5 S.E. = Standard error

Table 13 The effect of CHQ treatment on cooking and eating characteristics of pork loin roasts

Variable	CHQ level (gm/ton) 0	62.5	125	S.E.[5]	Significance of F
Number of animals	32	32	32		
Cooking					
Evaporation loss (%)	16.1[ab]	16.8[a]	15.0[b]	0.48	*
Drip loss (%)	8.1	7.6	8.3	0.52	N.S.
Taste panel					
Juiciness score[1]	5.4	5.9	5.7	0.20	N.S.
Flavour score[1]	5.7	5.4	5.6	0.14	N.S.
Tenderness					
1. Swallowing[2] chew count	22.2	22.4	20.0	0.76	N.S.
2. Complete mastication[3] chew count	63.2	64.6	61.4	2.73	N.S.
Physical					
Meat/juice ratio X 100[4]	16.4[a]	10.2[b]	13.6[c]	0.96	* *

[1] Average for all tasters (6) based on range from 1-10 (Appendix Table 19)

[2] Average number of chews to the point of swallowing

[3] Average number of chews to completely masticate

[4] Area of meat/juice taken from hydraulic press (2500 psi for 5 min) of cube of meat on filter paper

[5] S.E. = Standard error

Table 14 The influence of slaughter weight on cooking and eating characteristics of pork loin roasts

Variable	Slaughter weight (kg) 56.7	68.0	79.4	90.7	S.E.[5]	Significance of F
Number of animals	24	24	24	24		
Cooking						
Evaporation loss (%)	16.9	16.1	15.8	15.0	0.56	N.S.
Drip loss (%)	7.4	8.2	7.9	8.6	0.60	N.S.
Taste panel						
Juiciness score[1]	5.8	5.7	5.8	5.3	0.23	N.S.
Flavour score[1]	5.3[a]	5.6[a]	6.0[b]	5.4[a]	0.16	*
Tenderness						
1. Swallowing[2] chew count	21.3	21.4	21.4	22.0	0.87	N.S.
2. Complete mastication[3] chew count	64.8	62.2	63.3	62.0	3.15	N.S.
Physical						
Meat/juice ratio X 100[4]	13.3	13.1	15.0	12.0	1.10	N.S.

1 Average for all tasters (6) based on range from 1-10 (Appendix Table 19)

2 Average number of chews to the point of swallowing

3 Average number of chews to completely masticate

4 Area of meat/juice taken from hydraulic press (2500 psi for 5 min) of cube of meat on filter paper

5 S.E. = Standard error

flavourful roasts were obtained from carcasses in the 79.4 kg slaughter weight group while those from the 56.7 kg group were the least flavourful.

Summary:

1. Significant differences in organoleptic properties of loin roasts were not observed between sexes, or levels of CHQ supplementation.
2. Cooking losses amounted to about 25% of the initial weight of loin roasts.
3. Evaporation losses during cooking were about twice as large as drip losses.
4. There was an apparent trend toward an inverse relationship between evaporation and drip losses during cooking, although neither was of sufficient magnitude to attain statistical significance between sexes.
5. CHQ supplementation failed to yield any meaningful response in organoleptic properties of loin roasts.
6 Slight differences in evaporation loss on cooking and meat/juice ratio from pressed cooked meat samples were attributed to variations in the degree of "doneness".
7. A slight but insignificant decrease in evaporation loss, together with an increase in drip loss was found to be associated with successive increments in slaughter weight.
8. The flavour score for loin roasts was significantly ($P<.05$) higher at 79.4 kg than at any other slaughter weight.
9. Significant differences in tenderness were not observed between sexes, CHQ levels or slaughter weights.

4.6.1 MUSCLE

General

The summary of chemical analysis of the various samples selected from representative barrow and gilt carcasses are summarized in Table 15. The ultimate pH of *M. longissimus dorsi* was found to be significantly higher for barrows as compared to gilts (P<.05). Likewise extractable lipid from *M. longissimus dorsi* from barrows tended to be higher than that from gilts but lack statistical significance. The crude protein content of *M. semitendinosus* was found to be considerably higher in barrows as compared to gilts. (P<.01). Furthermore, analysis of variance revealed that there was a significant (P<.05) interaction between sex and treatment and sex and slaughter weight for the sarcoplasmic fraction of *M. longissimus dorsi*. No significant difference was observed in stroma and myofibrillar fractions of either muscle between sexes. Barrows, however, demonstrated a significantly higher (P<.01) nitrogen content in the combined stromal and myofibrillar fractions extracted from *M. semitendinosus*.

Analysis of variance revealed that CHQ treatment had very little influence on the actual chemical composition of either *longissimus dorsi* or *semitendinosus* muscles. One exception was the dry matter content of *longissimus dorsi* muscle which was shown to increase (P<.05) with increasing levels of CHQ. (Table 16).

The average ultimate pH of *M. longissimus dorsi* tended to decrease as slaughter weight increased as shown in Table 17 (P<.05). Dry matter percentage was also observed to increase with successive increments in slaughter weight (P<.01). Although not statistically significant, there was a trend toward an apparent increase in extractable lipid from *longissimus dorsi* as slaughter weight increased. This trend is similar to that reported by Lawrie *et al.*, (1964)

Table 15 The influence of sex on various chemical analysis of *M. longissimus dorsi* and *M. semitendinosus*

Item	Sex		S.E.[3]	Significance of F
	Barrows	Gilts		
No of animals	12	12		
M. longissimus dorsi				
pH	5.65	5.54	0.03	*
Extractable lipid (%)	5.55	4.61	0.54	N.S.
Dry matter (%)	26.30	26.39	0.18	N.S.
Crude protein (%)[1]	80.47	77.66	1.05	N.S.
Sarcoplasmic fraction (%)[2]	5.08	5.06	0.01	N.S.
Sarcoplasmic N content (%)	11.46	11.21	0.19	N.S.
Stroma + myofibrillar fraction (%)	21.23	21.58	0.30	N.S.
Stroma + myofibrillar N content (%)	13.20	12.70	0.22	N.S.
M. semitendinosus				
Dry matter (%)	24.50	26.48	0.61	N.S.
Crude protein (%)[1]	79.94	70.63	1.50	* *
Sarcoplasmic fraction (%)[2]	4.73	4.88	0.14	N.S.
Sarcoplasmic N content (%)	11.19	10.69	0.21	N.S.
Stroma + myofibrillar fraction (%)[2]	19.92	21.60	0.63	N.S.
Stroma + myofibrillar N content (%)	12.79	11.30	0.24	* *

1 Dry matter basis (N X 6.25)

2 Wt of extractable dry matter/wet sample wt X 100

3 S.E. = Standard error

Table 16 The influence of CHQ treatment on various chemical analysis of *M. longissimus dorsi* and *M. semitendinosus*

Item	CHQ level (gm/ton) 0	62.5	125	S.E.[3]	Significance of F
No of animals	8	8	8		
M. longissimus dorsi					
pH	5.62	5.56	5.60	0.04	N.S.
Extractable lipid (%)	5.77	4.90	4.57	0.67	N.S.
Dry matter (%)	25.78[a]	26.21[a]	27.05[b]	0.22	*
Crude protein (%)[1]	78.78	79.08	79.34	1.29	N.S.
Sarcoplasmic fraction (%)[2]	4.92	5.02	5.26	0.10	N.S.
Sarcoplasmic N content (%)	11.50	11.34	11.18	0.24	N.S.
Stroma + myofibrillar fraction (%)[2]	20.87	21.57	21.79	0.37	N.S.
Stroma + myofibrillar N content (%)	12.85	12.97	13.03	0.27	N.S.
M. semitendinosus					
Dry matter (%)	26.15	24.91	25.42	0.75	N.S.
Crude protein (%)[1]	72.62	75.17	78.06	1.84	N.S.
Sarcoplasmic fraction (%)[2]	4.71	4.87	4.83	0.18	N.S.
Sarcoplasmic N content (%)	10.79	10.94	11.10	0.25	N.S.
Stroma + myofibrillar fraction (%)	21.43	20.28	20.58	0.78	N.S.
Stroma + myofibrillar N content (%)	11.62	12.02	12.49	0.29	N.S.

1 Dry matter basis (N X 6.25)

2 Wt of extractable dry matter/wet sample wt X 100

3 S.E. = Standard error

Table 17 The influence of slaughter weight on various chemical analysis of *M. longissimus dorsi* and *M. semitendinosus*

Item	Slaughter Weight (kg) 56.7	68.0	79.4	90.7	S.E.[3]	Significance of F
No of animals	6	6	6	6		
M. longissimus dorsi						
pH	5.70[a]	5.65[a]	5.57[a]	5.46[b]	0.04	*
Extractable lipid (%)	4.50	5.00	5.33	5.50	0.77	N.S.
Dry matter (%)	25.98[a]	25.10[b]	27.65[c]	26.66[d]	0.25	* *
Crude protein (%)[1]	80.62	77.63	78.74	79.28	1.49	N.S.
Sarcoplasmic fraction (%)[2]	4.75[a]	5.19[b]	5.17[b]	5.15[b]	0.12	N.S.
Sarcoplasmic N content (%)	10.81[a]	11.44[b]	11.26[b]	11.83[b]	0.27	N.S.
Stroma + myofibrillar fraction (%)[2]	21.22[ab]	19.91[a]	22.96[b]	21.53[ab]	0.42	*
Stroma + myofibrillar nitrogen content (%)	13.37	12.66	12.89	12.88	0.31	N.S.
M. semitendinosus						
Dry matter (%)	24.28	24.58	26.85	26.26	0.87	N.S.
Crude protein (%)[1]	78.53	76.03	73.68	72.90	2.12	N.S.
Sarcoplasmic fraction (%)[2]	4.57	5.13	4.77	4.75	0.20	N.S.
Sarcoplasmic N content (%)	10.50	11.20	10.88	11.18	0.29	N.S.
Stroma + myofibrillar fraction (%)[2]	20.02	19.45	22.09	21.50	0.90	N.S.
Stroma + myofibrillar nitrogen content (%)	12.56	12.16	11.78	11.66	0.34	N.S.

[1] Dry matter basis (N X 6.25)

[2] Wt of extractable dry matter/wet sample wt X 100

[3] S.E. = Standard error

A comparison of the mean % of sarcoplasmic proteins in *M. longissimus dorsi* by slaughter weight groups showed the proportion to be lowest at 56.7 kg. Likewise, the nitrogen content (%) of the sarcoplasmic protein fraction was lower at 56.7 kg than for subsequent slaughter weights. Although, there was a significant ($P<.05$) difference in stroma plus myofibrillar protein fraction (%) of *M. longissimus dorsi* between slaughter weights, the qualitative implications were not readily apparent. Interestingly, however, a similar trend was apparent in the case of the stroma plus myofibrillar fraction from *M. semitendinosus*, with the lowest proportion occurring at 68.0 kg and the highest at 79.5 kg slaughter weights. Levels were similar at 56.7 kg and 90.7 kg for both *M. semitendinosus* and *M. longissimus dorsi* (Table 17). It is conceivable that this observed trend could be ascribed to intramuscular structural changes taking place during muscular growth.

The crude protein content (%N X 6.25) of *M. semitendinosus* displayed a decreasing trend with successive increments in slaughter weight, but the magnitude of variation was sufficient to prevent attaining statistical significance. The crude protein content (%N X 6.25) for *M. longissimus dorsi* failed to show the same trend.

Starch-gel electrophoresis

A total of seventeen different bands were distinguishable from the amido-black stained starch gels of the sarcoplasmic fractions of *M. longissimus dorsi* and *M. semitendinosus*. Eleven were observed to migrate toward the cathode, while only six moved in the direction of the anode. Average densicord readings expressed as a percentage of the total for the various bands are shown by treatment groups in Tables 18 and 19. Application of Duncan's multiple range test revealed several significant ($P<.05$) differences as indicated by superscripts in Tables 18 and 19.

Table 18 Mean densitometer readings from starch-gel electrophoresis of [illegible] expressed as a percentage of total

Item	No. of Animals	ANODE 1	2	3	4	5	6	7	8	Peak Number 9	10	11	Insert ↓ 6	5	4	3	2	CATHODE 1
Sex																		
Barrows	[illegible]	2.0	1.1	18.6	3.6	[illegible]	4.9[a]	5.6[a]	14.1[a]	4.1	6.7	4.9	5.4	3.8	8.7	3.8	3.5	3.6[a]
Gilts	12	1.9	1.2	19.1	[illegible]	3.5	6.1[b]	4.6[b]	12.5[b]	4.5	6.5	5.2	5.9	4.0	9.6	3.4	3.5	2.6[b]
SE		0.24	0.24	1.30	[illegible]	0.24	0.32	0.10	0.49	0.15	0.47	0.51	0.36	0.44	0.35	0.32	0.22	0.13
[illegible] level (gm/ton)																		
0	8	1.6	2.6	21.8	2.6[a]	2.8	4.8[a]	6.2[a]	16.1[a]	3.6[a]	6.7	5.0	5.0	3.8	8.7	3.0	2.7	3.0
62.5	8	2.0	1.5	18.0	2.9[a]	[illegible]	5.8[b]	[illegible][b]	12.7[b]	4.5[ab]	6.9	4.6	6.6	4.2	9.5	3.8	4.1	2.8
125	8	[illegible]	1.1	[illegible]	4.6[b]	[illegible]	6.0[b]	4.4[b]	11.6[b]	4.8[b]	6.3	5.4	5.3	3.9	9.3	4.0	3.7	3.7
SE		0.29	0.30	[illegible]	0.19	0.29	0.50	0.13	0.60	0.18	0.58	0.62	0.44	0.54	0.43	0.39	0.27	0.16
Slaughter weight (kg)																		
[illegible]	6	[illegible]	1.1	[illegible]	4.4[a]	4.6	6.1	[illegible][a]	13.6	4.01	5.6	3.8	5.1[a]	3.9	8.4	3.3	3.4	3.1
68.[illegible]	6	[illegible]	1.1	19.2	3.1[ab]	[illegible]	5.1	5.4[a]	13.9	4.5	7.0	5.6	4.3[a]	4.2	9.3	3.8	3.2	2.7
[illegible]	6	[illegible]	[illegible]	[illegible]	4.0[b]	3.1	5.2	4.9[a]	13.5	4.3	7.3	5.3	6.1[b]	4.2	[illegible]	3.9	3.9	3.8
90.[illegible]	6	[illegible]	1.1	[illegible]	[illegible]	3.1	5.6	4.6[a]	12.8	4.4	6.6	5.3	7.0[c]	3.4	9.8	3.5	3.4	3.0
SE		[illegible]	[illegible]	[illegible]	0.22	[illegible]	0.46	0.15	0.69	0.21	0.67	0.72	0.51	0.62	0.49	0.45	0.31	0.19
Mean		[illegible]	[illegible]	[illegible]	3.36	[illegible]	[illegible]	5.10	13.47	4.32	6.62	5.02	5.64	3.93	[illegible]	3.60	3.49	3.13

[illegible] significantly different (P [illegible] .05)

Table 19 Mean densitometer readings from starch-gel electrophoresis of [illegible] expressed as a percentage of total

Item	No. of Animals	ANODE 1	2	3	4	5	6	7	Peak Number 8	9	10	11	Insert ↓	6	5	4	3	2	CATHODE 1
Sex																			
barrows	12	0.4	[illegible]	14.3	2.4	3.1	4.2	4.5	11.6	4.4	7.3	6.4		12.3[a]	4.6	10.9	3.9	4.2	3.8
gilts	12	0.1	[illegible]	13.9	2.5	[illegible]	4.5	5.9	11.0	5.1	7.5	6.9		9.7[b]	4.2	12.8	3.2	4.4	3.4
Sx		0.10	0.15	0.50	0.16	0.2[illegible]	0.30	0.26	0.96	0.22	0.40	0.27		0.88	0.54	0.91	0.49	0.34	0.25
DES level (gm/ton)																			
0	8	0.2	2.9	12.6	2.6	3.2	4.7	4.3	9.5[a]	3.9[a]	6.8[a]	5.6[a]		12.6[a]	5.6	12.7	4.8[a]	4.6	3.3
62.5	8	[illegible]	3.0	13.[illegible]	2.3	3.1	3.9	4.8	10.8[b]	5.0[b]	8.8[b]	5.4[ab]		11.8[a]	4.0	12.4	3.2[b]	4.0	3.2
125	8	0.4	3.4	13.3	2.6	3.4	4.5	5.0	13.5[c]	5.3[b]	6.6[a]	8.0[b]		8.6[b]	3.6	10.5	2.7[b]	4.3	4.2
Sx		0.19	0.18	0.[illegible]	0.20	0.28	0.35	0.32	1.18	0.26	0.49	0.33		1.08	0.66	1.[illegible]	0.60	0.41	0.30
Slaughter weight (kg)																			
46.2	6		3.4	14.9[a]	2.9	3.0	5.2[a]	5.3	12.8	4.2	5.9[a]	5.7		7.9[a]	4.6	11.2	3.8	4.0	4.1
68.0	6	0.[illegible]	3.3	13.[illegible][a]	2.7	3.4	5.5[a]	5.5	10.4	4.2	6.2[a]	7.3		10.4[b]	4.4	12.0	3.5	3.5	3.3
79.[illegible]	6		3.3	12.0[b]	2.3	3.3	3.8[b]	4.0	11.0	5.4	8.0[b]	7.0		11.8[bc]	4.4	12.4	2.7	5.1	3.5
90.[illegible]	6	0.3	[illegible]	12.6[b]	1.9	2.5	3.9[b]	4.0	11.9	5.3	9.3[c]	6.8		13.9[c]	4.2	11.3	4.1	4.5	3.4
Sx		[illegible]	0.21	0.83	0.23	0.32	0.42	0.36	1.36	0.30	0.57	0.38		1.25	0.76	1.28	0.70	0.47	0.35
X̄		[illegible]	3.3[illegible]	13.04	2.48	3.26	4.3[illegible]	4.70	11.27	4.77	7.37	6.67		11.03	4.41	11.85	3.54	4.30	3.59

[illegible] with the same superscripts are not significantly different (P<.05)

Sex differences included a higher concentration in *M. longissimus dorsi* band 6 (anodic) from barrows as compared to gilts. Similarily, bands 7,8 (anodic) and 1 (cathodic) exhibited higher concentrations in *M. semitendinosus* sarcoplasmic fraction from barrows versus gilts. The reverse was observed for band 6 (anodic) in that higher amounts were detected in the sarcoplasmic fraction from *M. semitendinosus* of gilts.

The influence of CHQ was apparent from densicord readings for both *M. longissimus* dorsi and *M. semitendinosus* sarcoplasmic fraction. Significant ($P<.05$) increases in concentration were observed for *M. longissimus dorsi* bands 8, 9, 10, 11, (anodic) while 6 and 3 (cathodic) decreased with CHQ supplementation. Similarily, bands 4, 6, and 9 (anodic) were of higher concentration in the sarcoplasmic fraction from *M. semitendinosus* in response to CHQ supplementation. However, bands 7 and 8 (anodic) showed the opposite trend.

Heavier slaughter weights influenced a higher concentration in bands 10 (anodic), 6 (cathodic) with *M. longissimus dorsi* and in band 6 (cathodic) with *M. semitendinosus* sarcoplasmic fractions. Conversely, the percentage of total densicord readings for bands 3 and 6 (anodic) with *M. longissimus dorsi*, and bands 4 and 7 (anodic) with *M. semitendinosus* decreased.

The aforementioned differences between electrophoretic patterns for sarcoplasmic proteins from the two muscles studied is further demonstrated graphically in Figure 11. A typical superimposed densicord plot of the electrophoretic separation of *M. semitendinosus* and *M. longissimus dorsi* sarcoplasmic protein fractions from animal 561 is displayed in Figure 12. No attempt was made to further characterize or identify the various protein bands, since no strong association between the electrophoretic patterns and organoleptic assessment or other qualitative factors was readily discernable.

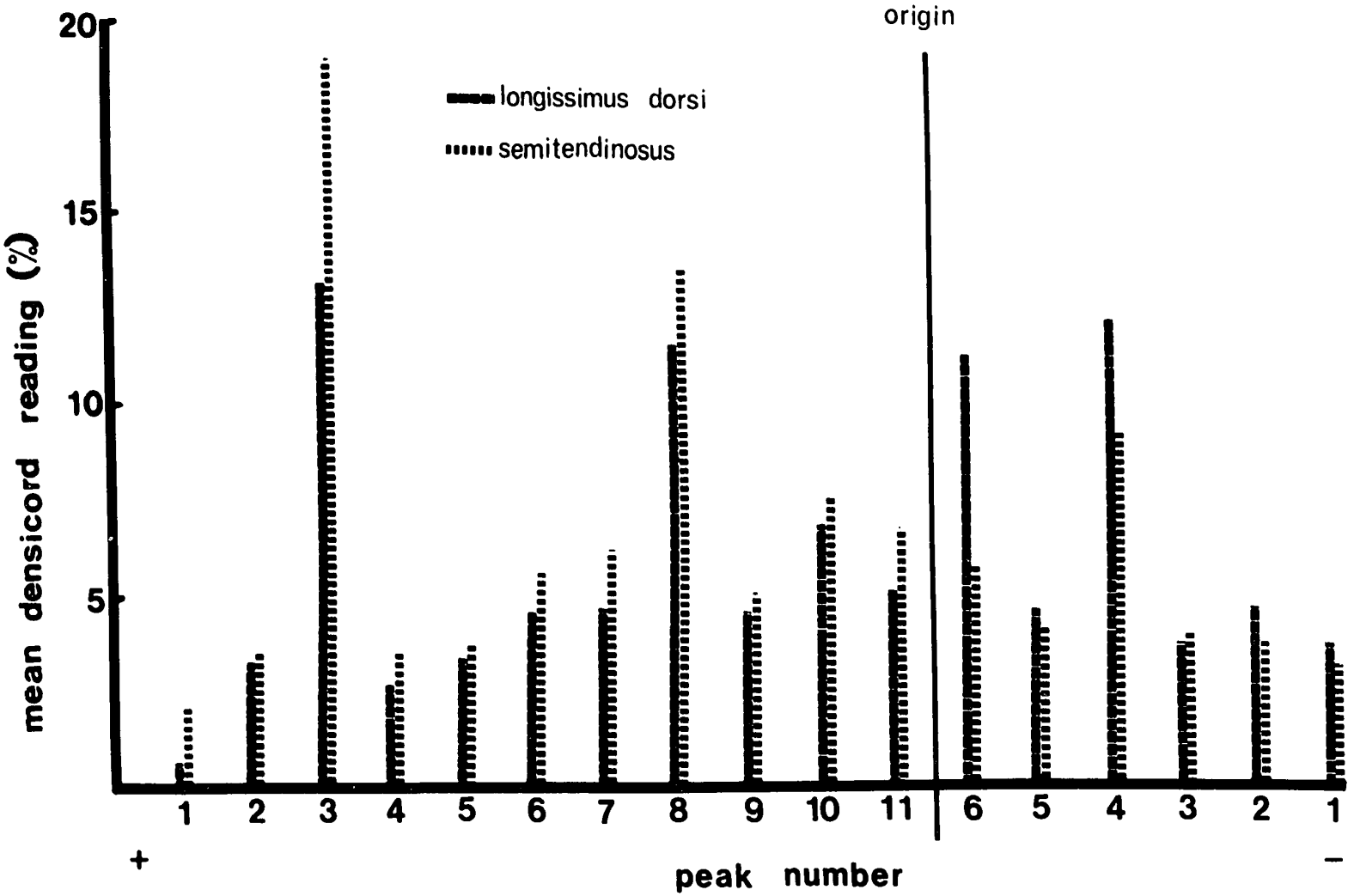


Figure 11 Mean densicord readings from starch-gel electrophoresis of *M. semitendinosus* and *M. longissimus dorsi* sarcoplasmic fraction expressed as a % of the total

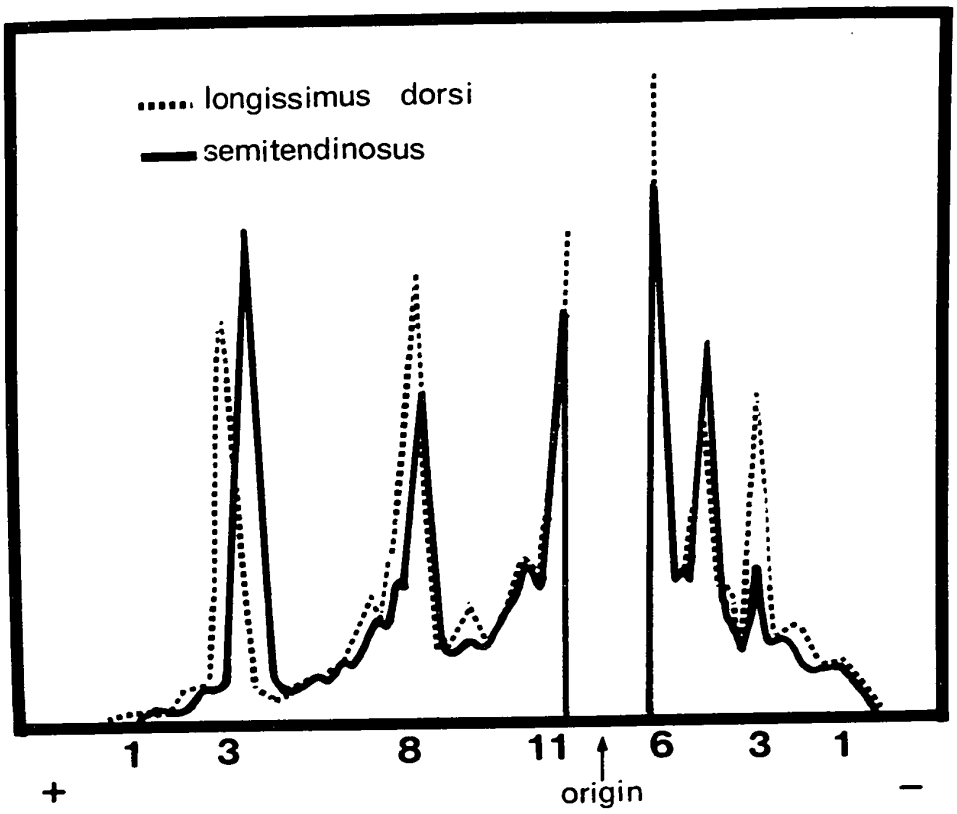


Figure 12 The superimposed densicord plot of *M. longissimus dorsi* and *M. semitendinosus* electrophoretic separation of sarcoplasmic proteins from animal 561

Summary:

A. Sex:

1. The ultimate pH of *M. longissimus dorsi* was significantly (P<.05) higher in carcasses of barrows than those of gilts. (Table 15)
2. The *Longissimus dorsi* from barrows contained slightly (P<.05) more extractable lipid and crude protein than that of gilts. (Table 15)
3. Significant differences were not observed between sexes in sarcoplasmic or stroma plus myofibrillar fractions of *M. longissimus dorsi* (Table 15)
4. Barrows displayed a significantly higher (P<.01) nitrogen content in the combined stroma plus myofibrillar fractions extracted from *M. semitendinosus*. (Table 15)
5. Electrophoresis separation of sarcoplasmic proteins revealed that the *longissimus dorsi* from barrows contained a higher concentration of band 6 (anodic) than that of gilts. (Table 19)
6. Electrophoretic separation of sarcoplasmic proteins from *semitendinosus* indicated higher concentrations of band 7, 8 (anodic) and 1 (cathodic), and lower concentrations of band 6 (anodic) for barrows as compared to gilts (Table 18).

B. Chlorhydroxyquinoline (CHQ):

1. The dry matter content of *longissimus dorsi* was found to increase (P<.05) with increasing levels of CHQ supplementation.
2. Electrophoretic separation of sarcoplasmic proteins from *longissimus dorsi* revealed increases in bands 8, 9, 10 and 11 (anodic) while 6 and 3 (cathodic) decreased in response to CHQ supplementation.
3. Electrophoretic separation of sarcoplasmic proteins from *M. semitendinosus* showed that bands 4, 6 and 9 (anodic) increased but that band 7 and 8 (anodic) decreased in response to CHQ supplementation.

C. Slaughter weight:

1. The average ultimate pH of *M. longissimus dorsi* tended to decrease with successive increments in slaughter weight, but the difference was significant ($P<.05$) only between 79.4 and 90.7 kg.
2. There was a significant increase ($P<.01$) in dry matter percentage of *M. longissimus dorsi* with each successive increase in slaughter weight.
3. The extractable lipid content of *M. longissimus dorsi* tended to increase with slaughter weight but failed to attain statistical significance.
4. The proportion of stroma plus myofibrillar protein was observed to be lowest at 68.0 kg and highest at 79.4 kg slaughter weight.
5. The crude protein content (%N X 6.25) of *M. semitendinosus* tended to decrease with successive increments in slaughter weight, but differences were not found to be statistically significant.
6. Electrophoretic separation of sarcoplasmic proteins indicated higher concentrations in bands 10 (anodic), 6 (cathodic) with *M. longissimus dorsi*, as well as band 6 (cathodic) with *M. semitendinosus* as slaughter weight increased.
7. Decreased concentrations in bands 3 and 6 (anodic) with *M. longissimus dorsi*, and bands 4 and 7 (anodic) with *M. semitendinosus* were observed to be associated with increasing slaughter weight.

4.6.2 FAT

Gas chromatographic analysis of the methyl esters of fatty acids extracted from *M. longissimus dorsi* intramuscular fat and intermuscular fat surrounding *M. semitendinosus* are summarized in Table 20 and 21 respectively. Although a total of twenty-four different peaks were observed, three saturated fatty acids (myristic (C_{14}), palmitic (C_{16}) and stearic (C_{18})) and three unsaturated fatty acids (palmitoleic ($C=_{16}$), oleic ($C=_{18}$) and linoleic ($C2=_{18}$)) were found to account for over 90% of the total based on peak areas. This is in general agreement with data reported by Jurgens *et al.*, (1970), Elliot *et al.*, (1970) and Sink *et al.*, (1964).

The total saturated fatty acids (myristic, palmitic, and stearic) and the unsaturated fatty acids (palmitoleic, oleic and linoleic) as well as the saturated/unsaturated ratio were calculated to facilitate interpretation of the data.

No significant differences were observed between sexes in the proportion of the individual component fatty acids found in *M. longissimus dorsi* intramuscular fat. However, there was a slightly higher ($P<.05$) amount of oleic acid present in barrow vs gilt intramuscular fat. This substantiates the observation of Jurgens *et al.*, (1970), who reported significantly ($P<.01$) more oleic acid in *M. longissimus dorsi* intramuscular fat of barrows as compared to gilts. A comparison of the total saturated/unsaturated fatty acid ratio (S/U) revealed a higher ratio for gilts than barrows (1.24 vs 1.15). This again confirms the findings of Jurgens *et al.*, (1970) who noted that *longissimus dorsi* intramuscular fat of gilts was more highly saturated than that of barrows. In contrast, the backfat of barrows was reported to contain higher levels of total saturated fatty acids than that of gilts.

Table [illegible] Mean Proportions of various fatty acid components of *M. longissimus dorsi* intramuscular fat (Weight %)

Treatment	No. of Animals	Components									Total		
		Group A[1]	C_{14}	Group B[2]	C_{16}	$C^{=}_{16}$	Group C[3]	C_{18}	$C^{=}_{18}$	$C^{2=}_{18}$	Group D[4]	Saturated[5]	Unsaturated[6]	S/U
Sex														
[illegible]	12	1.98	3.38	1.42	36.66	4.18	1.01	10.12	36.55	2.84	1.50	50.16	43.57	1.15
[illegible]	12	1.83	4.48	.65	37.61	4.36	1.15	10.36	33.75	3.34	1.57	51.45	41.45	1.24
SE			0.53		0.89	0.20		0.93	1.20	0.26				
CoQ level (gm ton)														
0	8	2.61	3.88	1.70	38.22	4.38	1.23	10.80	32.26	2.85	1.64	52.90	39.49	1.34
62.5	8	1.69	4.21	1.27	35.65	4.16	0.91	10.34	27.82	3.03	1.55	49.20	35.01	1.41
125	8	1.59	3.23	1.69	37.54	4.27	1.09	9.57	35.36	3.39	1.44	50.31	43.02	1.17
SE			0.61		1.09	0.25		1.14	1.47	0.32				
Slaughter weight (kg)														
96.7	6	2.61	3.86	2.23	37.33	4.12	1.55	11.77	31.33[a]	2.68	1.77	52.96	38.13	1.39
98.0	6	2.48	3.17	1.59	37.31	3.66	1.03	10.50	34.91[ab]	3.44	1.66	50.98	42.01	1.21
99.4	6	1.66	3.55	1.14	36.48	3.98	0.87	10.17	37.27[b]	3.14	1.33	50.20	44.39	1.13
99.7	6	1.66	3.14	1.23	37.42	5.31	0.86	8.52	37.09[b]	3.10	1.38	49.08	45.50	1.08
SE			0.71		1.26	0.29		1.31	1.70	0.36				
	X		3.43		37.14	4.27		10.24	35.15	3.10				

[1] Group A = unidentified peaks with retention times below that observed for myristic acid (C_{14})

[2] Group B = unidentified peaks with retention times between myristic (C_{14}) and palmitic acid (C_{16})

[3] Group C = unidentified peaks with retention times between palmitoleic ($C^{9=}_{16}$) and stearic acid (C_{18})

[4] Group D = unidentified peaks with retention times greater than oleic ($C^{9=}_{18}$)

[5] Total saturated = myristic (C_{14}), palmitic (C_{16}) and stearic (C_{18})

[6] Total unsaturated = palmitoleic ($C^{9=}_{16}$), oleic ($C^{9=}_{18}$) and linoleic ($C^{9,12=}_{18}$)

Table 2. Mean proportions of various fatty acid components in intermuscular fat adjacent to *M. semitendinosus* (Wt %)

Treatment	No. of Animals	Group A[1]	C_{14}	Group B[2]	C_{16}	$C{=}_{16}$	Group C[3]	C_{18}	$C{=}_{18}$	$C^{2=}{}_{18}$)	Group D[4]	Total Saturated[5]	Total Unsaturated[6]	S/U
Sex														
Barrows	12	8.64[a]	4.22	3.97	33.19	3.58	1.77	9.17	28.74[a]	4.70	3.96	46.58	36.92	1.26
Gilts	12	6.36[b]	3.84	2.13	32.67	4.10	1.46	9.98	34.49[b]	5.22	2.63	46.48	43.81	1.06
SE			0.52		1.19	0.32		0.74	1.49	0.46				
DES level (gm ton)														
0	8	6.33	4.09	3.54	31.94	3.98	1.80	10.28	29.53	4.53	3.54	46.61	38.04	1.22
6.25	8	8.01	3.70	1.99	34.32	3.76	1.30	9.63	34.99	5.37	1.90	47.65	44.12	1.08
12.5	8	6.22	4.09	3.71	32.52	3.62	1.74	8.81	30.33	4.99	4.45	45.32	38.94	1.16
SE			0.64		1.46	0.40		0.91	1.82	0.57				
Slaughter Weight (kg)														
90.7	6	7.52	4.53	4.13	33.62	4.59	1.91	8.13	26.84[a]	4.73	3.68	46.28	36.16	1.28
98.9	6	6.18	4.20	2.85	29.96	3.01	1.58	10.57	34.11[b]	4.69	4.71	44.73	41.81	1.07
107.0	6	6.96	3.80	2.84	33.84	3.81	1.60	9.57	32.12[ab]	5.05	2.71	47.21	40.98	1.15
115.2	6	8.62	3.57	2.41	34.31	3.74	1.37	10.03	33.39[b]	5.38	2.09	47.91	42.51	1.13
SE			0.74		1.68	0.46		1.05	2.10	0.66				
	X		6.03		32.93	3.79		9.58	31.62	4.97				

[1] Group A unidentified components relative retention times below that observed for myristic acid (C_{14})

[2] Group B unidentified components with retention times between myristic (C_{14}) and palmitic acid (C_{16})

[3] Group C unidentified components with retention times observed between palmitoleic ($C^{2}{}_{16}$) and stearic acid (C_{18})

[4] Group D unidentified components with retention times above that observed for linoleic ($C^{2}{}_{18}$)

[5] Total saturated fatty acids = sum of myristic (C_{14}), palmitic (C_{16}) and stearic (C_{18})

[6] Total unsaturated fatty acids = sum of palmitoleic ($C^{=}{}_{16}$), oleic ($C^{=}{}_{18}$) and linoleic ($C^{2=}{}_{18}$)

Intermuscular fat adjacent to *M. semitendinosus* from barrows was found to contain significantly higher ($P<.01$) levels of short chain fatty acids (Group A) than that of gilts. In contrast to the oleic acid content of *M. longissimus dorsi* intramuscular fat, the level of oleic acid was found to be lower ($P<.05$) in intermuscular fat surrounding *M. semitendinosus* of barrows as compared to gilts. The resultant S/U was higher for barrow vs gilt intermuscular fat. (1.26 vs 1.06). Once again, this is in contrast to previously observed sex differences in *M. longissimus dorsi* intramuscular fat.

No meaningful differences in fatty acid components were found to be associated with chlorhydroxyquinoline supplementation.

The oleic acid content of *M. longissimus dorsi* intramuscular fat was observed to increase with slaughter weight. The maximum increment ($P<.05$) occurred between 56.7 and 79.4 kg. Concomittant increases in other unsaturated fatty acids with higher slaughter weights, although not of sufficient magnitude to attain statistical significance, resulted in a decrease in the S/U ratio with increasing slaughter weight. (1.39, 1.21, 1.13 and 1.08 for 56.7, 68.0, 79.4 and 90.7 kg respectively). This decrease in the degree of saturation of intramuscular fat with increasing slaughter weight is in contrast to reported increases in the degree of saturation of backfat (Elson *et al.*, 1963, Allen *et al.*, 1967 and Elliot *et al.*, 1970) and intramuscular fat (allen *et al.*, 1967) at heavier weights. This apparent confliction of results can probably be ascribed to the dietary influences on fatty acid composition such as reported by other workers (Jurgens *et al.*, 1970; Elliot *et al.*, 1970), since the increase in the proportion of corn and rice meal from grower to finisher diets (Table 1) would result in an increase in the intake of unsaturated fatty acids.

As in the case of *M. longissimus dorsi* intramuscular fat, there was an increase in oleic acid content of intermuscular fat surrounding *M. semitendinosus* as slaughter weight increased. The maximum increment in oleic acid content of intermuscular fat surrounding *M. semitendinosus* was observed to be between 56.7 and 68.0 kg. This, together with the fact that animals were switched from the grower to the finisher formulation at 56.7 kg supports the contention that dietary influences were largely responsible for the observed decrease in S/U as slaughter weight increased.

The relative proportions of the six major fatty acids found in *M. longissimus dorsi* intramuscular fat and *M. semitendinosus* intermuscular fat are shown graphically in Figure 13. The general pattern was similar for samples from both locations, although slightly greater proportions of palmitic, palmitoleic, stearic and oleic were found in *longissimus dorsi* intramuscular fat.

Summary:

1. The oleic acid level in *M. longissimus dorsi* intramuscular fat was slightly higher in barrows as compared to gilts.
2. The ratio of saturated/unsaturated fatty acids in *M. longissimus dorsi* intramuscular fat was higher for gilts than barrows.
3. The oleic acid content of intermuscular fat surrounding *M. semitendinosus* was lower in barrows as compared to gilts.
4. The ratio of saturated/unsaturated fatty acids in intermuscular fat surrounding *M. semitendinosus* was higher for barrows than gilts.
5. The level of short chain (Group A) fatty acids were higher in intermuscular fat surrounding *M. semitendinosus* of barrows as compared to gilts.

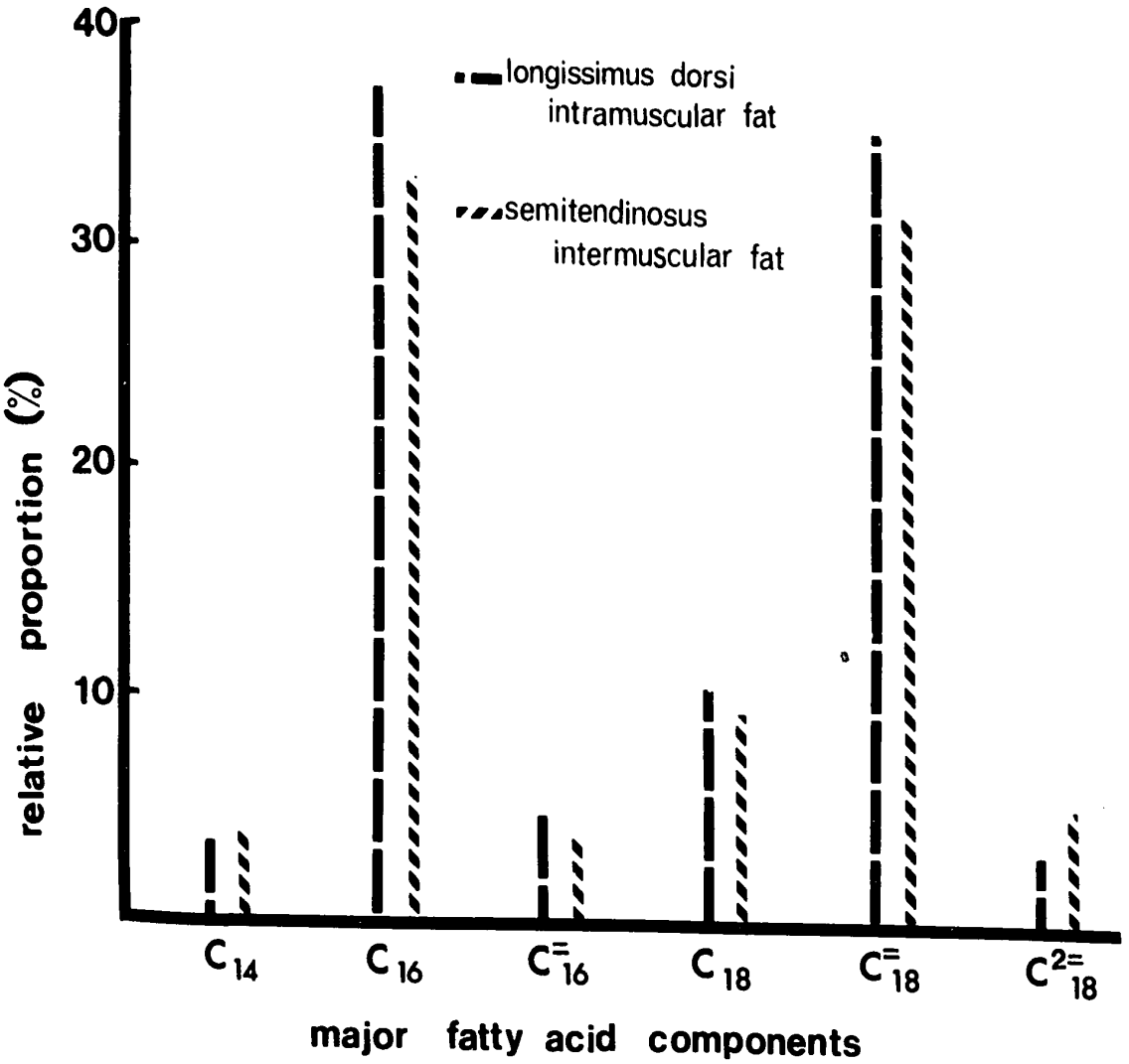


Figure 13 The relative proportions of the major fatty acid components of *longissimus dorsi* intramuscular fat and *semitendinosus* intermuscular fat (Weight %)

6. No meaningful differences in fatty acid composition associated with chlorhydroxyquinoline supplementation were observed.
7. The oleic acid contents of both *M. longissimus dorsi* intramuscular fat and intermuscular fat surrounding *M. semitendinosus* were found to increase with slaughter weight.
8. The ratio of saturated/unsaturated fatty acids in *M. longissimus dorsi* intramuscular fat decreased as slaughter weight increased.

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APPENDIX

Appendix Table 1

Simple correlation between certain carcass measurements and commercial cut-out data

r = .205 (P<.05) r = .267 (P<.01)

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1	Cold carcass wt																											
2	Carcass length	.84																										
3	Carcass depth	.85	.81																									
4	Loin eye area	.79	.72	.72																								
5	Loin eye area X carcass length	.84	.82	.77	.98																							
6	Fat/lean (loin tracing)	-.11	.24	-.11	-.49	-.46																						
7	Trimmed Ham wt	.94	.87	.89	.81	.87	-.21																					
8	Trimmed loin wt	.94	.87	.84	.80	.86	-.21	.94																				
9	Trimmed shoulder wt	.94	.83	.85	.81	.86	-.26	.93	.90																			
10	Fat trim - loin	.79	.69	.77	.53	.59	.20	.71	.72	.69																		
11	Fat trim - ham	.38	.36	.37	.35	.37	-.06	.28	.28	.36	.48																	
12	Fat trim - shoulder	.85	.74	.82	.65	.71	-.01	.84	.79	.81	.76	.33																
13	Specific gravity - ham	-.14	-.02	-.16	-.01	-.02	-.12	-.19	-.18	-.14	-.14	.18	-.13															
14	Specific gravity - loin	-.01	.04	-.03	.11	.10	-.18	-.03	-.06	.03	-.01	.09	-.02	.81														
15	Specific gravity - shoulder	.09	.11	.05	.16	.16	.13	.07	.05	.08	.02	.07	.07	.74	.75													
16	Caliper backfat - shoulder	.49	.35	.42	.19	.19	.13	.40	.41	.41	.60	.26	.46	-.12	-.13	-.05												
17	Caliper backfat - mid-back	.56	.43	.59	.35	.39	.32	.53	.50	.59	.72	.24	.60	-.15	-.06	-.02	.66											
18	Caliper backfat - loin	.65	.47	.65	.43	.46	.22	.62	.57	.65	.74	.27	.69	-.30	-.20	-.09	.63	.75										
19	Shank wt	.81	.75	.71	.66	.72	.19	.83	.80	.78	.63	.35	.71	-.11	-.06	.06	.32	.40	.49									
20	Heart wt	.55	.50	.42	.51	.54	-.27	.55	.52	.51	.38	.18	.46	.00	.16	.12	.16	.24	.20	.36								
21	Leaf fat wt	.85	.80	.80	.69	.75	-.06	.86	.84	.79	.74	.34	.80	-.15	-.08	.11	.44	.54	.60	.71	.40							
22	Kidney wt	.86	.81	.80	.68	.75	.05	.86	.85	.80	.75	.16	.81	-.18	-.10	.07	.47	.57	.61	.73	.43	.99						
23	Knuckle wt	.77	.74	.70	.58	.64	-.06	.74	.72	.76	.63	.31	.66	-.05	.03	.07	.41	.40	.46	.54	.46	.66	.66					
24	Carcass value	.97	.90	.88	.81	.89	-.21	.98	.97	.96	.75	.33	.84	-.17	-.02	.07	.44	.55	.62	.83	.56	.87	.88	.76				
25	Total saleable components	.97	.90	.89	.81	.89	-.20	.98	.97	.96	.75	.31	.85	-.17	-.02	.08	.44	.55	.63	.84	.56	.88	.88	.77	.99			
26	Total fat trim	.84	.74	.82	.61	.67	.11	.77	.77	.77	.97	.59	.87	-.10	.00	.05	.58	.70	.74	.70	.42	.80	.81	.67	.81	.81		
27	Prime cut yield	.97	.89	.88	.81	.89	.21	.98	.96	.96	.74	.32	.84	-.17	-.02	.06	.44	.55	.63	.82	.55	.86	.87	.77	.99	.99	.81	

Appendix Table 2 The effect of selected independent variables on prime cut yield expressed in terms of standard partial regression coefficients

Variable	Equation 1	2	3	4	5	6
Ham fat trim	-0.02					
Carcass depth	0.06	0.06				
Dressing percentage	-0.07	-0.07	-0.06			
Loin eye area	0.08	0.08	0.08	0.07		
Carcass length	0.11	0.10	0.11	0.11	0.11	
Trimmed ham weight	0.42	0.45	0.48	0.50	0.54	0.62
Carcass weight	0.42	0.41	0.41	0.34	0.36	0.38
Explained variation (%)	98.0	98.5	98.4	98.3	98.1	97.8

Appendix Table 3 The influence of sex on anatomical composition of hams

Variable	Sex		S.E.[2]	Significance of F
	Barrows	Gilts		
Number of animals	12	12		
Dissection of ham[1]				
Freezer shrinkage (%)	0.6	1.3	0.22	N.S.
Weight before dissection (kg)	5.520	5.739	0.063	N.S.
Subcutaneous fat and skin (kg)	1.509	1.462	0.045	N.S.
Total bones (kg)	0.545	0.565	0.007	N.S.
Total muscles (kg)	2.795	2.935	0.081	N.S.
Intermuscular fat (kg)	0.408	0.418	0.006	N.S.
Remainder (%)	2.82	3.95	0.410	N.S.
Ratios:				
Muscle/bone	5.12	5.17	0.15	N.S.
Subcutaneous fat/bone	2.75	2.56	0.10	N.S.
Intermuscular fat/bone	0.74	0.73	0.01	N.S.
Muscle/subcutaneous fat	1.87	2.05	0.08	N.S.
Muscle/intermuscular fat	6.96	7.08	0.24	N.S.
Muscle/total fat	1.47	1.58	0.06	N.S.

1 Hams from right side of carcasses cut by the R.O.P. method

2 S.E. = Standard error

Appendix Table 4 The influence of sex on anatomical composition of middles

Variable	Sex: Barrows	Sex: Gilts	S.E.[2]	Significance of F
Number of animals	12	12		
Dissection of middle[1]				
Freezer shrinkage (%)	1.14	2.03	0.39	N.S.
Weight before dissection (kg)	10.531	10.465	0.132	N.S.
Subcutaneous fat and skin (kg)	3.901	3.430	0.169	N.S.
Total bones (kg)	0.964	1.018	0.022	N.S.
Total muscles (kg)	3.224	3.508	0.047	* *
Intermuscular fat (kg)	1.991	1.874	0.084	N.S.
Remainder (%)	4.06	5.57	1.15	N.S.
Ratios:				
Muscle/bone	3.33	3.40	0.06	N.S.
Subcutaneous fat/bone	4.03	3.34	0.07	*
Intermuscular fat/bone	2.04	1.82	0.09	N.S.
Muscle/subcuteaneous fat	0.83	1.07	0.07	*
Muscle/intermuscular fat	1.65	1.90	0.08	N.S.
Muscle/total fat	0.55	0.67	0.02	*

[1] Middles from the right side of carcasses cut by the R.O.P. method

[2] S.E. = Standard error

Appendix Table 5 The influence of sex on anatomical composition of shoulders

Variable	Sex		S.E.[2]	Significance of F
	Barrows	Gilts		
Number of animals	12	12		
Dissection of shoulder[1]				
Freezer shrinkage (%)	2.52	0.86	0.55	N.S.
Weight before dissection (kg)	5.403	5.436	0.079	N.S.
Subcutaneous fat and skin (kg)	1.122	1.004	0.036	N.S.
Total bones (kg)	0.709	0.742	0.022	N.S.
Total muscles (kg)	2.391	2.509	0.039	*
Intermuscular fat (kg)	1.020	0.944	0.052	N.S.
Remainder (%)	2.98	4.35	0.80	N.S.
Ratios:				
Muscle/bone	3.41	3.38	0.15	N.S.
Subcutaneous fat/bone	1.59	1.36	0.11	N.S.
Intermuscular fat/bone	1.44	1.26	0.05	*
Muscle/subcutaneous fat	2.16	2.52	0.09	*
Muscle/intermuscular fat	2.41	2.71	0.15	N.S.
Muscle/total fat	1.13	1.29	0.05	*

1 Shoulders from right side of carcasses cut by the R.O.P. method

2 S.E. = Standard error

Appendix Table 6 The influence of CHQ treatment on the anatomical composition of hams

Variable	CHQ level (gm/ton) 0	62.5	125	S.E.[1]	Significance of F
Number of animals	8	8	8		
Dissection of ham[2]					
Freezer shrinkage (%)	0.71	1.04	1.10	0.27	N.S.
Weight before dissection (kg)	5.772	5.514	5.604	0.077	N.S.
Subcutaneous fat and skin (kg)	1.548	1.470	1.441	0.055	N.S.
Bones (kg)	0.541	0.557	0.567	0.009	N.S.
Muscles (kg)	2.956	2.774	2.866	0.099	N.S.
Intermuscular fat (kg)	0.420	0.414	0.407	0.007	N.S.
Remainder (%)	3.38	3.12	3.66	0.50	N.S.
Ratios:					
Muscle/bone	5.41	4.98	5.05	0.18	N.S.
Subcutaneous fat/bone	2.82	2.63	2.53	0.13	N.S.
Intermuscular fat/bone	0.77[a]	0.73[b]	0.70[c]	0.01	*
Muscle/subcutaneous fat	1.92	1.93	2.03	0.10	N.S.
Muscle/intermuscular fat	6.99	6.82	7.25	0.30	N.S.
Muscle/total fat	1.50	1.50	1.58	0.08	N.S.

[1] S.E. = Standard error

[2] Ham cut from right side of carcasses cut by R.O.P. method

Appendix Table 7 The influence of C.H.Q. treatment on anatomical composition of middles

Variable	0	62.5	125	S.E.[1]	Significance of F
Number of animals	8	8	8		
Dissection of middle[2]					
Freezer shrinkage (%)	0.68	1.57	2.51	0.48	N.S.
Wt before dissection (kg)	10.744	10.576	10.174	0.162	N.S.
Subcutaneous fat & skin (kg)	3.757	3.904	3.336	0.207	N.S.
Bones (kg)	0.989	0.982	1.004	0.027	N.S.
Muscles (kg)	3.457	3.443	3.436	0.058	N.S.
Intermuscular fat (kg)	1.892	1.772	1.803	0.102	N.S.
Remainder (%)	5.09	4.04	5.33	1.41	N.S.
Ratios:					
Muscle/bone	3.45	3.35	3.30	0.07	N.S.
Subcutaneous fat/bone	3.76	3.96	3.34	0.09	N.S.
Intermuscular fat/bone	2.02	1.91	1.86	0.11	N.S.
Muscle/Subcutaneous fat	0.92	0.85	1.07	0.08	N.S.
Muscle/Intermuscular fat	1.74	1.76	1.82	0.10	N.S.
Muscle/Total fat	0.60	0.57	0.65	0.03	N.S.

[1] S.E. = Standard error

[2] Middle from the right side of carcasses cut by the R.O.P. method

Appendix Table 8 The influence of C.H.Q. treatment on the anatomical composition of shoulders

Variable	C.H.Q. level (gm/ton) 0	62.5	125	S.E.[1]	Significance of F
Number of animals	8	8	8		
Dissection of shoulder[2]					
Freezer shrinkage (%)	1.26	1.57	2.24	0.67	N.S.
Wt before dissection (kg)	5.406	5.419	5.434	0.097	N.S.
Subcutaneous fat & skin (kg)	1.085	1.062	1.040	0.044	N.S.
Bones (kg)	0.693	0.736	0.747	0.027	N.S.
Muscles (kg)	2.563	2.379	2.409	0.048	N.S.
Intermuscular fat (kg)	0.940	1.040	0.968	0.064	N.S.
Remainder (%)	2.31	3.73	4.96	1.10	N.S.
Ratios:					
Muscle/bone	3.66	3.22	3.31	0.18	N.S.
Subcutaneous fat/bone	1.57	1.43	1.42	0.10	N.S.
Intermuscular fat/bone	1.35	1.40	1.30	0.06	N.S.
Muscle/subcutaneous fat	2.36	2.25	2.40	0.11	N.S.
Muscle/intermuscular fat	2.71	2.40	2.55	0.18	N.S.
Muscle/total fat	1.25	1.15	1.23	0.06	N.S.

[1] S.E. = Standard error

[2] Shoulders from the right side of carcasses cut by the R.O.P. method

Appendix Table 9 The influence of slaughter weight on the anatomical composition of hams

Variable	Slaughter wt (kg) 56.7	68.0	79.4	90.7	S.E.[1]	Significance of F
Number of animals	6	6	6	6		
Dissection of ham[2]						
Freezer shrinkage (%)	1.08	0.83	0.94	0.94	0.31	N.S.
Wt before dissection (kg)	4.126^{a}	5.213^{b}	6.143^{c}	7.038^{d}	0.089	* *
Subcutaneous fat & skin (kg)	1.076^{a}	1.296^{b}	1.586^{c}	1.989^{d}	0.064	* *
Total bones (kg)	0.438^{a}	0.526^{b}	0.618^{c}	0.638^{d}	0.010	* *
Total muscles (kg)	2.111^{a}	2.754^{b}	3.164^{c}	3.432^{d}	0.114	* *
Intermuscular fat (kg)	0.319^{a}	0.365^{b}	0.440^{c}	0.530^{d}	0.008	* *
Remainder (%)	2.42^{a}	3.17^{ab}	3.48^{ab}	4.48^{b}	0.58	*
Ratios:						
Muscle/bone	4.84	5.23	5.13	5.38	0.21	N.S.
Subcutaneous fat/bone	2.47	2.47	2.57	3.12	0.15	N.S.
Intermuscular fat/bone	0.73^{a}	0.69^{a}	0.71^{a}	0.83^{b}	0.02	* *
Muscle/subcutaneous fat	1.98	2.13	2.00	1.72	0.12	N.S.
Muscle/intermuscular fat	6.74	7.58	7.21	6.55	0.34	N.S.
Muscle/total fat	1.53	1.66	1.56	1.36	0.09	N.S.

[1] S.E. = Standard error

abcd means displaying similar superscripts are not significantly different ($P<.05$)

[2] Hams from the right side of carcasses cut by the R.O.P. method

Appendix Table 10 The influence of slaughter weight on the anatomical composition of middles

Variable	Slaughter weight (kg) 56.7	68.0	79.4	90.7	S.E.[1]	Significance of F
Number of animals	6					
Dissection of middle[2]						
Freezer shrinkage (%)	2.73	1.38	1.07	1.16	0.55	N.S.
Wt before dissection (kg)	7.178^{a}	9.711^{b}	11.399^{c}	13.706^{d}	0.187	* *
Subcutaneous fat & skin (kg)	2.599^{a}	3.388^{ab}	3.919^{b}	4.757^{c}	0.239	* *
Total bones (kg)	0.747^{a}	0.954^{b}	1.070^{c}	1.195^{d}	0.031	* *
Total muscles (kg)	2.365^{a}	3.276^{b}	4.035^{c}	4.225^{c}	0.066	* *
Intermuscular fat (kg)	1.303^{a}	1.798^{b}	2.113^{bc}	2.515^{c}	0.118	* *
Remainder (%)	3.30	4.19	3.51	8.27	1.60	N.S.
Ratios:						
Muscle/bone	3.07^{a}	3.32^{b}	3.64^{c}	3.45^{c}	0.07	*
Subcutaneous fat/bone	3.50^{a}	3.58^{a}	3.67^{a}	4.00^{b}	0.10	*
Intermuscular fat/bone	1.75	1.88	1.98	2.12	0.13	N.S.
Muscle/subcutaneous fat	0.91	0.94	0.99	0.95	0.09	N.S.
Muscle/intermuscular fat	1.78	1.78	1.86	1.68	0.11	N.S.
Muscle/total fat	0.60	0.61	0.64	0.58	0.03	N.S.

[1] S.E. = Standard error

abcd means displaying similar superscripts are not significantly different ($P<.05$)

[2] Middle cut from right side of carcasses cut by the R.O.P. method

Appendix Table 11 The influence of slaughter weight on the anatomical composition of shoulders

Variable	Slaughter weight (kg) 56.7	68.0	79.4	90.7	S.E.[1]	Significance of F
Number of animals	6	6	6	6		
Dissection of shoulder[2]						
Freezer shrinkage (%)	1.46	1.34	2.12	1.84	0.78	N.S.
Weight before dissection (kg)	3.958[a]	5.113[b]	5.885[c]	6.723	0.112	* *
Subcutaneous fat & skin (kg)	0.766[a]	0.950[b]	1.134[c]	1.400	0.050	* *
Total bones (kg)	0.586[a]	0.682[a]	0.791[bc]	.842	0.032	* *
Total muscles (kg)	1.744[a]	2.358[b]	2.687[c]	3.012	0.055	* *
Intermuscular fat (kg)	0.694[a]	0.954[b]	1.011[b]	1.271	0.074	* *
Remainder (%)	4.24	3.30	4.45	2.94	1.20	N.S.
Ratios:						
Muscle/bone	3.00	3.57	3.59	3.59	0.21	N.S.
Subcutaneous fat/bone	1.33	1.45	1.44	1.67	0.10	N.S.
Intermuscular fat/bone	1.19	1.42	1.28	1.50	0.07	N.S.
Muscle/subcutaneous fat	2.31	2.49	2.37	2.17	0.13	N.S.
Muscle/intermuscular fat	2.52	2.62	2.69	2.40	0.21	N.S.
Muscle/total fat	1.19	1.26	1.26	1.13	0.07	N.S.

[1] S.E. = Standard error

[abcd] means displaying similar superscripts are not significantly different ($P<.05$)

[2] Shoulders from right side of carcasses cut by the R.O.P. method

Appendix table 12   Simple correlation between selected gross dissection data and certain carcass variables

r = .404 (P<.05)   r = .515 (P<.01)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1 Carcass wt																										
2 Ham - muscle	[illegible]																									
3 Ham - bone	[illegible]	[illegible]																								
4 Ham - subcutaneous fat & skin	[illegible]	[illegible]	[illegible]																							
5 Ham - intermuscular fat	[illegible]	[illegible]	.81	[illegible]																						
6 Middle - muscle	[illegible]	[illegible]	[illegible]	.82	[illegible]																					
7 Middle - bone	[illegible]	[illegible]	[illegible]	.81	[illegible]	.90																				
8 Middle - subcutaneous fat & skin	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.68	.68																			
9 Middle - intermuscular fat	[illegible]	[illegible]	[illegible]	[illegible]	.86	[illegible]	[illegible]	.63																		
10 Shoulder - muscle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.74																	
11 Shoulder - bone	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.63	[illegible]																
12 Shoulder - subcutaneous fat & skin	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.84	.81	[illegible]															
13 Shoulder - intermuscular fat	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.70	.72	.72														
14 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.18	[illegible]	.19	-.03													
15 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.61	.62	[illegible]	.31												
16 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.68	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.69											
17 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.31	[illegible]	.28	.73	.72										
18 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.43	[illegible]									
19 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.70	.76	.71	[illegible]	.34	.31	[illegible]	.99								
20 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.19	-.14	.08	-.08	-.10	[illegible]	.08	[illegible]	-.30							
21 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.88	[illegible]	[illegible]	[illegible]	[illegible]	.47	.46	[illegible]	.90	.92	[illegible]						
22 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.60	[illegible]	.88	[illegible]	.71	.73	.26	[illegible]	.58	.63	.88	.89	-.38	.86					
23 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.80	[illegible]	[illegible]	.69	.22	.61	.72	.74	.73	.78	-.10	.63	.70				
24 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.86	.85	.06	.66	.72	.78	.74	.77	.07	.63	.81	-.79			
25 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.63	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.12	.70	[illegible]	[illegible]	.84	.85	-.37	.78	.92	-.72	.84		
26 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.78	[illegible]	[illegible]	[illegible]	.59	.59	.64	.91	.93	[illegible]	.91	.94	-.76	.81	.93	

Appendix Table 13 The effect of selected independent variables on the total dissectable fat expressed in terms of standard partial regression coefficients

Variable	Equation 1	2	3	4	5	6
Fat/lean from loin tracing	0.04					
Ham intermuscular fat	-0.11	-0.09				
Specific gravity of ham	-0.13	-0.14	-0.12			
Caliper backfat (loin)	0.12	0.14	0.16	0.19		
Leaf fat weight	0.31	0.32	0.31	0.31	0.26	
Ham subcutaneous fat and skin	0.37	0.35	0.30	0.24	0.36	0.59
Carcass weight	0.29	0.25	0.21	0.30	0.38	0.37
Explained variation	93.3	93.2	93.0	92.0	90.7	89.1

Appendix Table 14 Mean weight (g) of trimmed muscle dissected from the right hand side of carcasses from barrows and gilts

	Muscle	Sex		S.E.	Significance of F
		Barrows	Gilts		
No of animals		12	12		
1	*Panniculus*	106.4	210.0	14.4	N.S.
2	*Gracilis*	106.8	113.4	4.8	N.S.
3	*Sartorious*	8.9	11.4	0.2	N.S.
4	*Semimembranosus*	475.5	504.8	11.6	N.S.
5	*Adductor*	155.1	159.6	8.8	N.S.
6	*Semitendinosus*	205.2	212.2	22.5	N.S.
7	*Pectineus*	38.7	43.4	0.8	* *
8	*Biceps femoris*	645.2	683.5	10.7	N.S.
9	*Rectus femoris*	148.7	153.4	4.7	N.S.
10	*Vastus lateralis, medialis and intermedius*	368.8	374.9	9.4	N.S.
11	*Quadratus femoris*	10.2	10.7	0.6	N.S.
12	*Obturator externus*	5.4	5.8	0.6	N.S.
13	*Obturator internus + Sacro Coccygeus*	54.7	57.2	1.2	N.S.
14	*Glutens medius + Sacro Coccygei*	283.5	292.2	4.7	N.S.
15	*Gluteus accessorius*	69.6	67.6	2.1	N.S.
16	*Gluteus profundus*	41.4	42.4	1.3	N.S.
17	*Gemellus*	3.4	3.3	0.3	N.S.
18	*Tensor fasciæ latæ*	85.3	92.9	5.5	N.S.
19	*Psoas major + iliacus*	188.6	202.4	2.8	*

Appendix Table 14 (cont'd)

20	*Psoas minor*	17.0	17.4	1.2	N.S.
21	*Quadratus lumborum*	13.4	15.1	1.5	N.S.
22	*Peroneus tertius + long digital extensor*	37.9	34.5	2.1	N.S.
23	*Tibialis anterior*	14.0	14.9	0.5	N.S.
24	*Peroneus longus*	14.5	16.5	1.9	N.S.
25	*Lateral digital extensor*	16.6	16.7	0.6	N.S.
26	*Extensor hallucis longus*	1.6	1.7	0.1	N.S.
27	*Gastrocnemius, soleus and superficial digital flexor*	264.4	278.2	3.3	*
28	*Poplieteus*	22.0	23.2	0.8	N.S.
29	*Tibialis posterior*	8.1	7.6	0.9	N.S.
30	*Flexor digitalis longus*	11.7	14.4	0.6	*
31	*Flexor hallucis*	49.8	50.9	0.8	N.S.
32	*Obliquus abdominus externus*	90.7	101.3	5.8	N.S.
33	*Obliquus abdominus internus*	114.0	104.5	5.9	N.S.
34	*Rectus abdominus*	144.6	155.0	5.2	N.S.
35	*Transversus abdominus*	125.0	129.5	5.0	N.S.
36	*Serratus dorsalis posterior*	18.9	17.5	1.4	N.S.
37	*Retractor costae*	3.7	2.0	0.7	N.S.
38	*Transversus thoracis*	13.7	12.5	1.4	N.S.
39	*Diaphram* (part only)	38.0	40.6	3.0	N.S.
40	*Longissmus costarum*	46.9	50.0	1.8	N.S.
41	*Serratus dorsalis anterior*	9.8	10.3	0.4	N.S.
42	*Spinales et semispinales*	107.6	111.0	6.7	N.S.
43	*Longissimus dorsi*	844.6	965.7	28.4	*

Appendix Table 14 (cont'd)

44	*Multifidus dorsi*	136.6	217.8	39.0	N.S.
45	*Rectus thoracis*	4.9	5.1	0.7	N.S.
46	*Intercostals*	467.0	477.6	8.6	N.S.
47	*Trapezius*	87.0	86.7	1.3	N.S.
48	*OMO-transversarius*	8.3	10.2	1.5	N.S.
49	*Rhomboideus*	40.8	37.2	1.2	N.S.
50	*Latissimus dorsi*	189.0	190.8	9.5	N.S.
51	*Brachiocephalicus*	58.9	57.7	6.5	N.S.
52	*Superficial pectorals*	91.4	104.8	5.0	N.S.
53	*Anterior deep pectoral*	133.4	126.6	5.6	N.S.
54	*Posterior deep pectoral*	223.4	240.2	8.0	N.S.
55	*Serratus ventralis*	358.1	400.1	14.6	N.S.
56	*Deltoid*	27.7	26.9	1.3	N.S.
57	*Supraspinatus*	194.3	209.9	4.4	*
58	*Infraspinatus*	155.0	163.2	3.7	N.S.
59	*Teres minor*	17.0	22.0	5.7	N.S.
60	*Teres major*	47.8	58.1	4.3	N.S.
61	*Tensor fascia antibrachii*	19.2	19.7	3.7	N.S.
62	*Long and lateral head triceps*	358.1	371.6	6.6	N.S.
63	*Medial head triceps*	29.9	29.4	2.4	N.S.
64	*Subscapularis*	61.9	70.6	4.2	N.S.
65	*Coraco-brachialis*	8.5	9.5	0.2	*
66	*Biceps brachii*	37.2	42.8	3.0	N.S.
67	*Brachialis*	44.9	44.6	1.0	N.S.
68	*Anconis*	11.5	11.6	0.4	N.S.

Appendix Table 14 (cont'd)

69	*Extensor carpi radialis*	53.9	56.3	1.6	N.S.
70	*Extensor carpi obliquus*	4.6	3.0	0.7	N.S.
71	*Common digital extensor and extensor of 2nd digit*	15.0	12.8	2.4	N.S.
72	*Extensor of 4th digit*	8.0	10.7	1.0	N.S.
73	*Extensor of 5th digit*	3.5	7.1	1.3	N.S.
74	*Pronator teres*	1.9	1.5	0.6	N.S.
75	*Flexor carpi radialis*	8.9	9.2	0.3	N.S.
76	*Flexor carpi ulnaris*	4.2	4.3	0.2	N.S.
77	*Ulnaris lateralis*	4.1	5.2	0.5	N.S.
78	*Superficial digital flexor*	22.8	24.1	0.9	N.S.
79	*Deep digital flexor*	49.3	49.9	1.2	N.S.
80	*Sterno cephalicus, OMO-hyoideus and sterno-thryo hyoideus*	36.1	48.1	6.9	N.S.
81	*Scalenus ventralis*	13.5	12.6	1.1	N.S.
82	*Scalenus dorsalis*	11.2	12.1	1.7	N.S.
83	*Longus colli*	24.6	25.6	1.4	N.S.
84	*Splenius*	87.3	74.7	5.9	N.S.
85	*Longissimus capitis and atlantis*	15.3	16.5	1.5	N.S.
86	*Complexus*	128.0	129.2	11.1	N.S.
87	*Rectus capitus ventralis (minor and major)*	2.9	5.2	0.8	N.S.
88	*Obliquus Capitus (anterior and posterior)*	11.3	9.9	2.0	N.S.
89	*Rectus Capitus dorsalis (minor and major)*	9.5	5.0	1.2	*
90	*Interspinalis*	26.3	25.3	1.1	N.S.
91	*Multifidus dorsalis*	9.8	7.0	2.2	N.S.

Appendix Table 15 The influence of CHQ supplementation on the mean weight (g) of trimmed muscle

	Muscle	CHQ level (gm/ton) 0	62.5	125	S.E.	Significance of F
	No of animals	8	8	8		
1	*Panniculus*	204.8	204.6	207.7	17.6	N.S.
2	*Gracilis*	110.5	107.8	112.0	5.8	N.S.
3	*Sartorious*	11.9	9.1	9.6	0.2	N.S.
4	*Semimembranosus*	491.9	501.1	477.5	14.3	N.S.
5	*Adductor*	159.4	153.7	159.1	10.8	N.S.
6	*Semitendinosus*	216.6	199.8	209.6	27.5	N.S.
7	*Pectineus*	41.2	39.4	42.6	1.0	N.S.
8	*Biceps femoris*	675.8	664.5	652.8	13.3	N.S.
9	*Rectus femoris*	152.1	148.1	153.0	5.8	N.S.
10	*Vastus lateralis, medialis and intermedius*	387.5	360.2	368.0	11.5	N.S.
11	*Quadratus femoris*	10.0	10.6	10.9	0.8	N.S.
12	*Obturator externus*	5.4	5.5	5.8	0.7	N.S.
13	*Obturator internus + Sacro Coccygeus*	57.4	53.7	56.7	1.5	N.S.
14	*Glutens medius + Sacro Coccygei*	299.0	281.8	287.2	5.8	N.S.
15	*Gluteus accessorius*	68.3	67.4	70.0	2.5	N.S.
16	*Gluteus profundus*	42.6	42.9	40.3	1.6	N.S.
17	*Gemellus*	3.3	3.2	3.6	0.3	N.S.
18	*Tensor fascia lata*	104.2	79.6	83.4	6.7	N.S.
19	*Psoas major + iliacus*	197.8	189.0	199.7	3.4	N.S.

Appendix Table 15 (cont'd)

20	*Psoas minor*	18.2	18.2	15.2	1.5	N.S.
21	*Quadratus lumborum*	16.0	12.2	14.6	1.8	N.S.
22	*Peroneus tertius + long digital extensor*	36.5	36.5	35.5	2.6	N.S.
23	*Tibialis anterior*	15.1	14.4	13.9	0.6	N.S.
24	*Peroneus longus*	15.1	14.5	16.9	2.3	N.S.
25	*Lateral digital extensor*	17.0	16.0	17.0	0.8	N.S.
26	*Extensor hallucis longus*	1.6	1.7	1.6	0.1	N.S.
27	*Gastrocnemius, soleus and superficial digital flexor*	274.9	267.9	271.2	4.0	N.S.
28	*Poplieteus*	22.9	21.8	23.2	1.0	N.S.
29	*Tibialis posterior*	7.4	9.4	6.7	1.1	N.S.
30	*Flexor digitalis longus*	14.6[a]	10.7[b]	13.8[a]	0.8	*
31	*Flexor hallucis*	50.4	49.7	51.1	1.1	N.S.
32	*Obliquus abdominus externus*	104.0	96.0	88.0	7.0	N.S.
33	*Obliquus abdominus internus*	103.3	103.3	121.1	7.3	N.S.
34	*Rectus abdominus*	155.8	146.4	147.2	8.3	N.S.
35	*Transversus abdominus*	138.7	125.3	117.8	6.1	N.S.
36	*Serratus dorsalis posterior*	20.9	17.5	16.3	1.7	N.S.
37	*Retractor costae*	3.2	2.3	2.9	0.8	N.S.
38	*Transversus thoracis*	11.3	14.8	13.1	1.7	N.S.
39	*Diaphram* (part only)	34.6	42.4	40.8	3.7	N.S.
40	*Longissmus costarum*	52.2	48.5	44.8	2.2	N.S.
41	*Serratus dorsalis anterior*	9.6	10.4	10.1	0.5	N.S.
42	*Spinales et semispinales*	118.1	101.4	108.4	8.2	N.S.
43	*Longissimus dorsi*	952.5	909.2	853.8	35.4	N.S.

Appendix Table 15 (cont'd)

44	*Multifidus dorsi*	162.7	145.6	223.4	47.8	N.S.
45	*Rectus thoracis*	3.7	5.5	5.8	0.9	N.S.
46	*Intercostals*	473.4	462.1	481.4	10.6	N.S.
47	*Trapezius*	101.6[a]	78.9[b]	80.1[b]	1.6	* *
48	*OMO-transversarious*	12.5	7.4	7.9	1.8	N.S.
49	*Rhomboideus*	42.1	36.8	38.3	1.5	N.S.
50	*Latissimus dorsi*	218.6	183.1	168.0	11.6	N.S.
51	*Brachiocephalicus*	56.0	56.9	62.0	8.0	N.S.
52	*Superficial pectorals*	108.7	98.6	87.0	6.2	N.S.
53	*Anterior deep pectoral*	130.5	128.9	130.6	6.8	N.S.
54	*Posterior deep pectoral*	239.3	219.9	236.3	9.9	N.S.
55	*Serratus ventralis*	402.2	263.3	371.9	17.9	N.S.
56	*Deltoid*	28.3	27.7	25.8	1.6	N.S.
57	*Supraspinatus*	217.3[a]	198.0[b]	191.0[b]	5.4	*
58	*Infraspinatus*	163.9	155.1	158.4	4.5	N.S.
59	*Teres minor*	26.8	14.9	16.8	7.0	N.S.
60	*Teres major*	55.8	51.5	51.5	5.3	N.S.
61	*Tensor fascia antibrachii*	15.5	19.4	23.4	4.5	N.S.
62	*Long and lateral head triceps*	390.7[a]	354.1[b]	349.7[b]	8.0	*
63	*Medial head triceps*	30.6	25.5	32.9	2.0	N.S.
64	*Subscapularis*	64.0	64.3	70.5	5.2	N.S.
65	*Coraco-brachialis*	9.8[a]	8.1[b]	9.2[a]	0.2	* *
66	*Biceps brachii*	39.7	41.4	38.9	3.6	N.S.
67	*Brachialis*	45.8	43.9	44.5	1.3	N.S.
68	*Anconis*	10.9	10.9	12.9	0.5	N.S.

Appendix Table 15 (cont'd)

69	*Extensor carpi radialis*	58.6	52.8	53.9	1.9	N.S.
70	*Extensor carpi obliquus*	3.6	4.4	3.3	0.9	N.S.
71	*Common digital extensor and extensor of 2nd digit*	16.7	13.2	11.8	3.0	N.S.
72	*Extensor of 4th digit*	9.6	7.7	10.6	1.2	N.S.
73	*Extensor of 5th digit*	5.6	3.8	6.4	1.6	N.S.
74	*Pronator teres*	1.4	1.4	2.4	0.7	N.S.
75	*Flexor carpi radialis*	9.6	8.1	9.4	0.4	N.S.
76	*Flexor carpi ulnaris*	4.4	4.2	4.2	0.2	N.S.
77	*Ulnaris lateralis*	6.0	4.0	4.0	0.6	N.S.
78	*Superficial digital flexor*	22.9	21.9	25.7	1.1	N.S.
79	*Deep digital flexor*	49.4	47.8	51.6	1.4	N.S.
80	*Sterno cepnalicus, OMO-hyoideus and sterno-thryo hyoideus*	31.2	56.6	38.5	8.5	N.S.
81	*Scalenus ventralis*	12.8	12.3	14.1	1.3	N.S.
82	*Scalenus dorsalis*	10.1	13.2	11.8	2.1	N.S.
83	*longus colli*	24.8	26.1	24.4	1.7	N.S.
84	*Splenius*	79.6	82.0	81.4	7.3	N.S.
85	*Longissimus capitis and atlantis*	15.7	13.7	18.3	1.8	N.S.
86	*Complexus*	128.1	130.8	126.9	13.5	N.S.
87	*Rectus capitus ventalis (minor and major)*	5.0	1.9	5.2	1.0	N.S.
88	*Obliquus Capitus (anterior and posterior)*	4.1[a]	11.2[ab]	16.5[b]	2.4	*
89	*Rectus Capitus dorsalis (minor and major)*	9.9	5.8	6.1	1.5	N.S.
90	*Interarticularis*	23.8	26.0	27.6	1.3	N.S.
91	*Multifidus cervicis*	11.8	11.8	10.2	2.7	N.S.

Appendix Table 16 The mean weight of trimmed muscle at various slaughter weights

		Slaughter weight					Significance of F
		56.7	68.0	79.4	90.7	S.E.	
	No. of animals	6	6	6	6		
1	*Panniculus*	122.4^{a}	196.0^{b}	241.1^{bc}	263.4^{c}	20.3	*
2	*Gracilis*	79.4^{a}	103.9^{b}	120.6^{bc}	136.4^{c}	6.7	* *
3	*Sartorious*	6.6^{a}	8.9^{b}	10.9^{c}	14.4^{d}	0.2	*
4	*Semimembranosus*	362.5^{a}	458.1^{b}	533.2^{c}	606.8^{d}	16.5	* *
5	*Adductor*	120.7^{a}	157.5^{ab}	165.5^{b}	185.7^{b}	12.4	* *
6	*Semitendinosus*	157.7^{a}	202.4^{a}	236.2^{a}	238.4^{b}	31.8	* *
7	*Pectineus*	29.0^{a}	40.5^{b}	46.7^{c}	48.0^{c}	1.1	* *
8	*Biceps femoris*	447.3^{a}	635.3^{b}	741.4^{c}	833.4^{d}	15.2	* *
9	*Rectus femoris*	108.6^{a}	143.2^{b}	175.2^{c}	177.2^{c}	6.7	* *
10	*Vastus lateralis, medialis and intermedius*	274.2^{a}	350.9^{b}	408.0^{c}	454.4^{d}	13.3	* *
11	*Quadratus femoris*	8.0^{a}	9.9^{a}	10.8^{ab}	13.2^{b}	0.9	* *
12	*Obturator externus*	4.1^{a}	5.1^{ab}	6.4^{ab}	6.8^{b}	0.8	*
13	*Obturator internus + Sacro Coccygeus*	39.2^{a}	54.9^{b}	59.4^{b}	70.1^{c}	1.8	* *
14	*Glutens medius + Sacro Coccygei*	198.6^{a}	277.7^{b}	320.8^{c}	360.2^{d}	6.7	* *
15	*Gluteus accessorius*	41.6^{a}	66.1^{b}	78.2^{c}	88.4^{d}	3.0	* *
16	*Gluteus profundus*	29.4^{a}	38.4^{b}	52.0^{c}	47.9^{c}	1.9	* *
17	*Gemellus*	2.4^{a}	3.0^{ab}	3.9^{b}	4.3^{b}	0.4	* *
18	*Tensor fascia lata*	55.6^{a}	81.7^{ac}	111.0^{b}	108.1^{bc}	7.8	* *
19	*Psoas major + Iliacus*	136.2^{a}	186.1^{b}	224.6^{c}	235.2^{c}	4.0	* *

Appendix Table 16 (cont'd)

20	*Psoas minor*	10.0^{a}	17.5^{b}	21.2^{b}	20.5^{b}	1.7	*
21	*Quadratus lumborum*	10.4	13.3	13.8	19.6	2.1	N.S.
22	*Peroneus tertius + long digital extensor*	28.0^{a}	33.6^{ab}	38.7^{bc}	44.3^{c}	3.0	* *
23	*Tibialis anterior*	10.5^{a}	13.9^{b}	15.5^{bc}	17.9^{c}	0.7	* *
24	*Peroneus longus*	11.4	14.6	16.6	19.4	2.7	N.S.
25	*Lateral digital extensor*	11.7^{a}	15.9^{b}	17.7^{b}	21.4^{c}	0.9	* *
26	*Extensor hallucis longus*	1.3^{a}	1.5^{ab}	1.7^{b}	2.1^{c}	0.1	* *
27	*Gastrocnemius, soleus and superficial digital flexor*	199.8^{a}	253.1^{b}	287.4^{c}	345.0^{d}	4.6	* *
28	*Poplieteus*	16.5^{a}	21.4^{b}	23.9^{b}	28.8^{c}	1.1	* *
29	*Tibialis posterior*	4.8^{a}	5.4^{b}	7.7^{b}	13.5^{b}	1.3	*
30	*Flexor digitalis longus*	10.0^{a}	14.1^{b}	14.3^{b}	13.5^{b}	0.9	*
31	*Flexor hallucis*	38.6^{a}	45.4^{b}	54.7^{c}	62.9^{d}	1.2	* *
32	*Obliquus abdominus externus*	64.0^{a}	85.3^{a}	117.3^{b}	117.3^{b}	8.2	* *
33	*Obliquus abdominus internus*	75.1^{a}	96.4^{a}	129.2^{b}	136.3^{b}	8.4	* *
34	*Rectus abdominus*	114.4^{a}	149.1^{b}	171.3^{c}	164.3^{c}	9.2	* *
35	*Transversus abdominus*	100.8^{a}	117.2^{a}	149.3^{b}	141.9^{b}	7.0	*
36	*Serratus dorsalis posterior*	11.6^{a}	16.4^{ab}	20.6^{bc}	24.2^{c}	1.9	*
37	*Retractor costae*	1.8	2.9	3.8	2.7	1.0	N.S.
38	*Transversus thoracis*	10.8^{a}	8.0^{a}	19.9^{b}	13.6^{ab}	2.0	*
39	*Diaphram (part only)*	23.1^{a}	42.6^{b}	44.7^{b}	46.7^{b}	4.3	*
40	*Longissmus costarum*	36.7^{a}	41.6^{ab}	52.1^{b}	63.6^{c}	2.6	* *
41	*Serratus dorsalis exterior*	6.5^{a}	9.3^{b}	12.2^{c}	12.2^{c}	0.5	* *
42	*Spinales et semispinales*	76.2^{a}	105.0^{ab}	116.6^{bc}	139.5^{c}	9.5	*
43	*Longissimus dorsi*	623.3^{a}	899.2^{b}	1006.7^{bc}	1091.5^{c}	40.8	* *

Appendix Table 16 (cont'd)

44	*Multifidus dorsi*	111.2	146.9	281.5	169.2	55.2	N.S.
45	*Rectus thoracis*	3.2	5.1	6.2	5.5	1.0	N.S.
46	*Intercostals*	343.6^{a}	435.6^{b}	512.6^{c}	597.4^{d}	12.2	* *
47	*Trapezius*	57.9^{a}	73.5^{b}	102.4^{c}	113.6^{d}	1.9	* *
48	*OMO-tranversarius*	6.8	7.3	8.8	14.1	2.1	N.S.
49	*Rhomboideus*	27.7	36.9^{b}	44.2^{c}	47.4^{c}	1.8	* *
50	*Latissimus dorsi*	118.7	172.7^{b}	199.2^{c}	269.0^{c}	13.4	* *
51	*Brachiocephalicus*	50.9	60.2	50.8	71.3	9.2	N.S.
52'	*Superficial pectorals*	81.3	97.9	100.6	112.6	7.1	N.S.
53	*Anterior deep pectoral*	94.5^{a}	118.7^{ab}	141.5^{bc}	165.2^{c}	7.9	* *
54	*Posterior deep pectoral*	157.7^{a}	200.7^{b}	260.6^{c}	308.3^{d}	11.4	* *
55	*Serratus ventralis*	257.0^{a}	342.8^{b}	436.2^{c}	480.5^{c}	20.7	* *
56	*Deltoid*	15.8^{a}	28.0^{b}	31.2^{b}	34.1^{b}	1.8	* *
57	*Supraspinatus*	140.9^{a}	196.9^{b}	223.5^{c}	247.2^{d}	6.2	* *
58	*Infraspinatus*	117.6^{a}	146.1^{b}	171.9^{c}	201.0^{d}	5.2	* *
59	*Teres major*	10.0	17.3	21.2	29.5	8.1	N.S.
60	*Tensor fascia antibrachii*	33.6^{a}	52.5^{ab}	59.2^{b}	66.4^{b}	6.1	*
61	*Tensor fascia antibrachii*	14.2	22.0	17.7	23.8	5.2	N.S.
62	*Long and lateral head triceps*	258.2^{a}	344.0^{b}	395.3^{c}	461.7^{d}	9.3	* *
63	*Medial head triceps*	24.0	30.4	27.4	36.9	3.3	N.S.
64	*Subscapularis*	48.5	68.1	73.0	75.4	6.0	N.S.
65	*Coraco-brachialis*	6.2^{a}	9.3^{b}	9.5^{b}	11.1^{c}	0.2	* *
66	*Biceps brachii*	28.0^{a}	36.7^{b}	49.9^{b}	45.4^{b}	4.2	*
67	*Brachialis*	33.2^{a}	43.2^{b}	48.4^{c}	54.2^{d}	1.5	* *
68	*Anconis*	8.5^{a}	11.7^{b}	13.0^{b}	13.2^{b}	0.5	* *

Appendix Table 16 (cont'd)

69	*Extensor carpi radialis*	41.8[a]	53.6[b]	59.6[b]	65.5[c]	2.2	* *
70	*Extensor carpi obliquus*	2.4	3.0	3.5	6.6	1.0	N.S.
71	*Common digital extensor and extensor of 2nd digit*	11.5	15.1	16.2	12.7	3.5	N.S.
72	*Extensor of 4th digit*	6.5	8.8	9.8	12.3	1.4	N.S.
73	*Extensor of 5th digit*	4.6	3.9	6.5	6.1	1.8	N.S.
74	*Pronator teres*	0.8	1.2	1.9	3.0	0.8	N.S.
75	*Flexor carpi radialis*	6.4[a]	8.9[b]	10.0[bc]	10.9[c]	0.4	* *
76	*Flexor carpi ulnaris*	3.2[a]	4.3[b]	4.8[b]	4.9[b]	0.3	*
77	*Ulnaris lateralis*	3.2	4.9	5.7	4.9	0.7	N.S.
78	*Superficial digital flexor*	18.6[a]	22.5[b]	26.1[c]	26.8[c]	1.2	*
79	*Deep digital flexor*	35.9[a]	48.0[b]	55.9[c]	58.7[c]	1.6	* *
80	*Sterno cephalicus, OMO-hyoideus and sterno-thryo hyoideus*	28.0	48.4	52.1	40.0	9.8	N.S.
81	*Scalenus ventralis*	10.7	15.1	16.1	10.4	1.5	N.S.
82	*Scalenus dorsalis*	7.5	11.6	13.5	14.2	2.4	N.S.
83	*Longus colli*	18.6[a]	23.1[ab]	29.9[c]	28.6[c]	1.9	* *
84	*Splenius*	59.9	78.3	96.7	89.1	8.4	N.S.
85	*Longissimus capitis and atlantis*	9.1[a]	17.4[b]	19.6[b]	17.5[b]	2.1	*
86	*Complexus*	104.2	129.6	127.8	152.8	15.6	N.S.
87	*Rectus capitus ventalis (minor and major)*	3.0	5.8	4.4	2.9	1.1	N.S.
88	*Obliquus Capitus (anterior and posterior)*	10.4	12.0	12.8	7.1	2.8	N.S.
89	*Rectus Capitus dorsalis (minor and major)*	9.1	6.4	7.5	6.0	1.8	N.S.
90	*Interspinalis*	21.3	27.5	27.2	27.4	1.6	N.S.
91	*Multifidus cervicis*	6.1	7.8	9.6	10.4	3.1	N.S.

Appendix Table 37 — Simple correlation between selected measurements of carcass quality

r = .404 (P<.05) r = .515 (P<.01)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1 Ham weight																											
2 Middle weight	.95																										
3 Shoulder weight	.94	.94																									
4 Specific gravity - Ham	.41	.49	-.52																								
5 Specific gravity - Middle	.26	.19	.10	.74																							
6 Specific gravity - Shoulder	.22	.22	-.29	.78	.73																						
7 Reciprocal of Sp. G. - Ham	.34	.41	.45	.95	-.79	-.77																					
8 Reciprocal of Sp. G. - Middle	.11	.26	.11	.66	-.93	-.70	.69																				
9 Reciprocal of Sp. G. - Shoulder	.23	.29	.28	-.74	-.73	-.97	.72	.75																			
10 % evaporation in cooking	.06	.04	.05	.11	.03	-.07	.18	.05	.04																		
11 % drip loss in cooking	-.27	.15	-.30	.01	-.21	-.16	.02	.41	.26	.23																	
12 Muscle fat (Ham grill)	.19	.17	.12	-.12	.18	-.04	.15	.22	.06	.37	-.10																
13 [illegible] carcass weight	.93	.93	.88	.38	.18	-.17	.31	.02	.17	.11	-.28	.16															
14 [illegible] weight	.97	.94	.95	-.41	.25	.29	.32	.09	.28	.15	-.32	.20	.93														
15 [illegible] weight	.95	.93	.94	.43	.28	.15	.29	.01	.16	.02	-.34	.14	.92	.94													
16 [illegible] weight	.70	.72	.68	.30	.17	.18	.32	.06	.19	.19	-.18	.16	.74	.72	.62												
17 [illegible] weight	.83	.82	.79	.14	.12	.12	.25	.19	.13	-.08	-.31	.18	.79	.80	.85	.56											
18 [illegible] weight	.86	.82	.82	.27	.22	.17	.24	.10	.20	-.002	-.17	.10	.71	.80	.85	.53	.78										
19 [illegible] weight	.86	.80	.79	-.18	-.02	.12	.14	-.13	.12	.13	-.29	.25	.85	.88	.86	.72	.70	.81									
20 Muscle bone (Ham)	.41	.41	.40	.09	-.02	.12	.06	.12	-.13	.04	-.24	.08	.48	.51	.51	.46	.54	.46	.58								
21 Muscle bone (Shoulder)	.18	.35	.34	.16	.08	.21	.23	.13	-.16	.10	-.16	.43	.37	.38	.46	.17	.48	.42	.44	.47							
22 Muscle bone (Middle)	.52	.51	.44	.15	.11	-.18	.38	.17	.40	.06	-.11	.14	.61	.53	.48	.62	.49	.45	.63	.25	.03						
23 Total diss. subcutaneous fat & skin	.81	.91	.86	.51	.42	-.19	.46	.30	.23	.08	-.10	.22	.78	.76	.84	.55	.74	.79	.63	.28	.39	.41					
24 Total diss. intermuscular fat	.87	.92	.89	-.56	-.51	-.42	.49	.37	.42	.01	-.09	.06	.81	.87	.78	.60	.72	.67	.63	.35	.22	.40	.79				
25 Total diss. bone	.91	.90	.95	-.52	-.24	-.32	.45	.08	.29	.04	-.31	.12	.88	.94	.88	.71	.69	.71	.78	.32	.15	.46	.73	.85			
26 Total diss. muscle	.86	.93	.94	.41	.21	-.28	.15	.05	.26	.07	-.32	.20	.94	.98	.95	.77	.82	.81	.91	.54	.39	.61	.76	.82	.93		
27 Muscle bone	.68	.61	.57	.09	.15	-.06	.07	-.002	.10	.12	-.25	.33	.71	.66	.70	.58	.73	.64	.78	.73	.71	.66	.54	.47	.44	.73	

Appendix Table 18 The effect of selected independent variables on the total dissectable muscle expressed in terms of standard partial regression coefficients

Variable	Equation 1	2	3	4	5	6
Longissimus fiber diameter	-0.03					
Ham specific gravity	-0.04	-0.04				
Psoas major weight	0.08	0.08	0.09			
Loin eye area X carcass length	0.31	0.27	0.25	0.26		
Ham weight	-0.38	-0.34	-0.35	-0.37	-0.09	
Carcass weight	0.31	0.31	0.37	0.42	0.37	0.32
Dissectable muscle in ham	0.71	0.70	0.68	0.72	0.73	0.68
Explained variation (%)	97.6	97.6	97.5	97.4	96.6	96.6

Appendix Table 19 PALATABILITY SCORE CARD FOR PORK

JUDGE'S NAME _____ DATE _____

AGE _____

Score	Description
10	Perfect
9	excellent
8	very good
7	good
6	high average
5	Average
4	low average
3	fair
2	poor
1	very poor

Note: Concentrate on, and score, only one quality plate at one time. That is, use a different plate of meat for judging each quality factor.

Juiciness and Flavor:

Give your impression of juiciness after two chews, then assess flavor.

Tenderness:

Indicate the number of chews on a given sample to the point at which; 1- You would normally swallow; 2- An insoluble residue or no insoluble residue remains.

Standardize your own technique for assessing all quality factors. It is not necessary that it be the same as that of any other judge, but it should be the same for you at each sampling period.

SAMPLE NUMBER	1	2	3	4	5	6	7	8
Juiciness								
Flavor of lean								
Tenderness 1 (no of chews)								
Tenderness 2 (no of chews)								

Please check to be sure that you have judged each quality for every sample; each of the above squares should contain a number.

Order of preference:

Comments: