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To the Graduate Council:

I am submitting herewith a thesis written by Robert Lewis Saffle entitled "Fasting Effects on Dressed Yield, Shrinkage, and pH of Contractile Tissue in Swine." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

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FASTING EFFECTS ON DRESSED YIELD, SHRINKAGE, AND pH OF CONTRACTILE TISSUE IN SWINE

A THESIS

Submitted to
The Graduate Council
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

by

Robert Lewis Saffle

August 1956

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Robert Lewis Saffle

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CHAPTER I

INTRODUCTION

It is a well established fact that hogs will usually lose weight while in transit from the farm to market or slaughterhouse. This loss in weight is commonly called shrinkage or drift and is of vital importance to all persons concerned with the swine industry.

Shrinkage may be either excretory or tissue. Excretory shrinkage is defined as the loss in weight resulting from the elimination of excreta, which is usually referred to as the elimination of fill. Loss in weight due to excretion does not affect the carcass weight, therefore, the dressing percent is not changed when based on farm weight. However, tissue shrinkage is a loss in tissue weight thus lowering the carcass weight and dressing percentage.

The problem of shrinkage has long been a source of misunderstanding between farmers, transportation agents, marketing men and packers. The problem will become even more important if in the future a greater number of hogs are sold on the basis of grade and yield as is being done in such countries as Denmark and Canada.

The amount and kind of shrinkage is a difficult problem to answer because of the great variation in the dressing percentage of similar hogs. Also hogs are produced, transported and marketed under a wide variety of conditions. Examples of these various conditions are the different breeds of hog, types of ration fed, market weights, amount of fill, weather and time in transit, mode of transportation, selling direct or auction or

terminal market, etc.

If tissue shrinkage does not occur or is not affected materially by watering and feeding while in the marketing process, then "fill" is an economical waste to society.

Dowell and Bjorka in their book Livestock Marketing makes the following statement:

> The packer objects to animals with heavy fill, not only because they dress a relatively small percentage of carcass but also because they are more difficult to handle during the process of slaughtering. Packers often keep the animals they buy in holding pens for a certain length of time in order that part of the fill may be eliminated. The practice (of filling hogs) is wasteful of feed, increases marketing costs, reduces the value of animals for slaughter, and tends to lower rather than increase total net returns to producers.

The purposes of this thesis were:

1. To determine the amount of tissue shrinkage as compared to excretory shrinkage during a four day fasting regime.
2. To determine, if possible, what tissues were involved in tissue shrinkage.
3. To study the effects of fasting on the pH of contractile tissue and consequent effects of cured meat.
4. To correlate dressing percentage with various carcass measurements.
5. To study the effect of length of haul on shrinkage percentages.

CHAPTER II

REVIEW OF LITERATURE

Research work concerning the effects of pre-slaughter fasting time upon shrinkage and the pH of contractile tissue is limited. Data dealing specifically with tissue shrinkage is even more limited. No detailed shrinkage data under control laboratory conditions could be found.

Based on a study of over six million hogs, Bjorka (1938) found that excretory shrinkage took place at a rapid rate in the early part of transit, and reached a maximum en route at thirty to thirty-six hours. Excretory shrinkage was greater for light weight hogs. Shrinkage for all hogs increased as time in transit increased, even when feed and water were given. Tissue shrinkage began early in transit and continued at a fairly constant rate during transit; however, this rate decreased somewhat as time in transit increased.

Observation of light-weight hogs showed larger amounts of tissue shrinkage in the early period of transit than heavier hogs; but light-weight hogs adjusted faster and shrunk less as time in transit increased. Hogs weighing one hundred eighty to one hundred ninety-nine pounds that were in transit twelve hours, during the winter, had an average yield of seventy-eight percent, while those in transit eighty-four hours yielded an average of 74.5 percent. Hogs which weighed two hundred to two hundred nineteen pounds and were in transit twenty-five to thirty hours, forty-five to fifty hours and sixty to sixty-five hours had respectively 1.5, 2.8 and 3.0 percent tissue shrinkage.

In a study of 11,109 market hogs, Henning and Stout (1932) found that production factors, rations and distance transported did not affect the yield. Hogs which were not fed for eight hours or more before loading dressed as high as those fed just before trucking. A definite seasonal difference was noted, yields were lowest in early fall and highest in January and February. Analysis showed that hogs receiving water but no feed, slaughtered within five days after leaving the farm, yielded the same as those immediately slaughtered. While hogs held seven days dressed less and showed a downward trend for each additional day held.

Ashby (1933) reported a great variation in shrinkage. Market hogs that weighed two hundred twenty pounds and were shipped one hundred twenty-eight miles by rail had an average excretory shrinkage of 1.19 percent. The shrinkage ranged from a minus 2.09 to minus 6.44 percent. While those hogs trucked one hundred twenty-seven miles had an average excretory shrinkage of 1.20 percent with a range of plus 1.82 to a minus 6.4 percent.

Wiley (1931) found considerable variation in excretory shrinkage from month to month with a range of 1.65 to 2.38 percent. The lowest shrinkage was in January and February and highest in June, July and August. Shrinkage of hogs in mixed carloads, those also containing sheep or cattle, was higher than in straight shipments. Distance to market on a class interval of twenty-five miles gave a very erratic curve which showed only a general trend for shrinkage to increase as time in transit increased. Shrinkage increased as the maximum temperature increased, except in very cold weather, where it had a tendency to increase as the maximum temperature dropped below fifteen to twenty degrees Fahrenheit.

In the above experiments good present day laboratory techniques and controls were not used. Tissue shrinkage was calculated as the difference in the carcass weight of hogs of similar live weight purchased and slaughtered locally in comparison with hogs which were transported before killing. The difference between the tissue shrinkage and the total shrinkage was assumed to be excretory shrinkage.

Pomeroy (1941) reared five litter mates to a weight of three hundred thirty pounds. He then killed one hog and put the other four on a submaintance ration of straw and water. The four hogs were killed at approximately equal weight intervals from three hundred thirty pounds to the reduced weight of two hundred pounds. He found t hat tissues were affected in inverse order of their development. Fat was used as an energy source before muscle and bone. The tissue affected first was kidney fat, next subcutaneous fat, then early developing caul, mesenteric and intermuscular fat. Next came the muscle tissue. Followed by bone which was affected the least.

Aunan and Winters (1949) reported a positive highly significant correlation of .659 between dressing percentage and average back fat. This is in accord with work of Loeffel, Denick and Peters (1943), Robinson (1946) and Zeller and Hetzer (1944), who found that as the weight and fat increased the dressing percentage increased.

Based on a study of two hundred seven hogs, Zobrisky, Brady and Lasley (1953), found total fat highly associated with back fat thickness and to a lesser extent with body width and length.

Cole et al. (1953) found a highly significant correlation existed between type and dressing percentage of hogs of the same weight and age.

Longer hogs with deeper chest measurements had the lowest dressing percentage. In this same study chuffy hogs had 32.2 percent less of their kill weight made of viscera than longer, rangy hogs.

Bowman (1954), reported that as the carcass weight increased back fat thickness, carcass length and dressing percentage increased. Depth of chest measurements did not show the same clear cut trend. This measurement was taken as the distance from the lower edge of the vertebral foramen to the lower edge of the sternum.

Bull and Longwell (1929), based on a study of eighty hogs, reported no significant difference in dressing percentage between chuffy, intermediate and rangy types of hogs of the same weight, but a great variation within each group. No significant difference was found in depth of chest between groups. Depth of chest was measured from the outside edge of the skin of the back fat to the ventral edge of the sternum.

Bate-Smith (1937-1949) reported the major factor affecting pH in meat is the formation of lactic acid from glycogen in the tissue. The precise pH of the muscle immediately prior to cessation of the circulation depends on the recent history of muscular activity. A resting muscle has a neutral reaction and normally contains a considerable amount of glycogen. After death the pH decreased with the production of lactic acid. When the muscle is fatigued, shortly before death, its glycogen reserve is depleted; therefore, during rigor mortis there is less lactic acid formed. Consequently the muscle is ultimately less acid. It was found that if the animals were not fed during the resting period, replenishment of glycogen in the muscle took place very slowly from the liver. If the animals were

fed, the glycogen was supplied from the blood to the muscle and this replacement was more rapid.

Callow (1938, 1939) found that carcasses from fatigued pigs have muscular tissue with a higher pH than from well-rested animals. Groups of pigs, which although rested for a period from two and a half to seventeen hours and were then walked one half mile to the slaughter house had an anverage pH of 6.00 to 6.18. Similar groups carried the short distance by truck had an average pH of 5.75 to 5.83. Callow further reported that muscles vary in their sensitivity to fatigue, for example, the pH of the psoas major was 5.72 while a pH of 5.48 was obtained for the longissimus dorsi.

It should be noted that the preceeding experiments were planned to determine the effects of fatigue on pH and not necessairly the effects of fasting.

McCarthy and Mackintosh (1953) in a study of four hogs, found the variation in the pH of the hams to be from 4.8 to 6.5. The ultimate pH of psoas major appeared to have a higher pH value than the hams.

Rose and Peterson (1951) reported that reserve carbohydrate in both muscle and liver of rats was somewhat depleted by starvation and seriously depleted by exercise. Maximum depletion resulted from a combination of the above.

Wilcox et al. (1953), based on a study of five swine that were fasted for sixteen hours before slaughter, reported an average liver weight of three pounds. They found the liver had an average of 0.86 percent glycogen while the muscle contained 0.18 percent.

Ingraham (1948) reported that forty-six different species of bacteria have been isolated from hams and bacons. Of these forty-six species, fifteen were unable to grow at a pH of 5.5 and the rate of growth of the remaining species increased 5.5 times with an increase of 1.0 pH to a pH of 6.5. Ingraham also stated that during the reorganization of the bacon industry in Northern Ireland in 1934, much ham spoilage occurred. The essential change of this reorganization was to ship hogs alive to the slaughter plant for immediate killing, instead of slaughtering the hogs at the farm. A change to feeding and resting the hogs before slaughter reduced ham spoilage. Ingraham found that the hams of fatigued animals which were rested twenty-two hours before slaughter had a pH of 5.91, after forty-six hours the value decreased to 5.78, and after a total resting period of seventy hours before slaughter the pH was lowered to 5.59.

Jones (1952) found that when the pH of meat was below 4.5 all bacteria growth was inhibited with one or two exceptions. The bacteria were not necessairly destroyed but did remain dormant.

Duisberg and Miller (1942) found as the pH approached 7, the color fixation was normal but the meat became undesirable, tender and gelatinous.

CHAPTER III

SOURCE OF MATERIAL AND PROCEDURE

Data reported in this thesis were obtained from eighty-four hogs comprising thirteen litters. Sixty-seven of these hogs were obtained within a radius of fifteen miles of the University of Tennessee. These were termed the short haul litters. The remaining nineteen hogs were purchased at one farm, one hundred sixty miles from the University, and were termed long haul litters.

All hogs had been ear notched shortly after birth, which provided a true identification of litter mates. The breeds represented were Duroc, Hampshire, Yorkshire and Hampshire x Yorkshire.

The same scale was taken to each farm and all hogs were weighed to the nearest one-half pound. Hogs of each litter were identified by painting numbers on each individual's back.

For the short haul, litters having at least five hogs per litter were selected. For the long haul, litters of at least four hogs were obtained. One hog per litter from the short haul group was slaughtered immediately upon arrival at the University abbatoir. It was impossible to slaughter any of the long haul pigs at zero hours of fasting, because of the time consumed in transit, therefore, the first hog was not slaughtered until the end of the first fasting period. The remaining hogs were given water but no feed. Thereafter one hog of each litter was killed at the end of the twenty-fourth, forty-eighth, seventy-second and ninety-sixty hour of fasting. Selections for fasting intervals were made at random.

Hogs were slaughtered and dressed a modified shipper style, that is, the carcass was split; however, the head, leaf fat and ham facing were not removed. Weights were obtained of the gastro-intestional tract (esophagus, stomach, small and large intestine, pancreas, ruffle fat and bung) both full and empty, viscera (gastro-intestional tract plus the heart, liver, caul fat, trachea and spleen), heart, liver, tongue, spleen, stomach, small intestine and large intestine. The last three were weighed and recorded with all the contents. The stomach, small intestine and large intestine were then emptied of all contents, flushed out and weights recorded.

All weights recorded for both the slaughter data and the cutting data were taken to the nearest ounce.

The carcasses were chilled in a thermostatically controlled cooler at thirty-four to thirty-six degrees Fahrenheit for approximately forty-eight hours. After chilling, each carcass was weighed as a modified shipper style carcass. The carcasses were re-weighed as a packer style carcass, which involved the removal of the head, leaf fat and ham facing. Both sides of the carcasses were then cut up by the same individual into wholesale cuts according to the cutting procedure as outlined by the Second Annual Reciprocal Meat Conference (1949). The procedure used was as follows: the hind foot was removed at the bony projection on the inside of the hock or approximately one-half inch above the knee joint. The rough shoulders were taken off between the junction of the second and third thoracic vertebra and at right angles to the general line of the back. Trimming of the rough shoulder was accomplished by lifting the neck bones, removing excess brisket flap and cutting off the jowl at the shoulder crease, parallel to

the shoulder cut. The clear plate was removed by leaving approximately one-fourth inch of fat on the shoulder.

The ham was removed by cutting between the second and third sacral vertebrae at right angles with the line of the shank. These hams were trimmed by removing the flank corner following the natural seam on the flank side, and removing the tail bones along with any excess fat in this area.

The rough loin was separated from the rough belly by cutting along a straight line made by snugging the psoas major muscle at the posterior end of loin and just missing the ventral portion of the back bone at the anterior edge of the loin. This cut was made with the flat side of blade bone paralled to the table. The back fat was removed from the loin leaving one-fourth inch of fat on the loin. The spare ribs were removed by scoring the secondary flank muscle along the center line and taking out all of the soft cartilages. The belly was further trimmed by squaring the ends and cutting just above the teat line. Lean trim and fat trim were separated.

The measurement data taken immediately following the chilling process, as shown in Figure 1, were length of carcass, depth of back fat thickness at three different locations, and depth, width and length of chest. Length of carcass was taken as the distance from the anterior edge of the first rib next to the spinal processes to the anterior edge of the aitch bone. The back fat thickness was measured at the first and last thoracic vertebra and the last lumbar vertebra. These measurements were taken from the outside edge of the skin to the natural separation line between

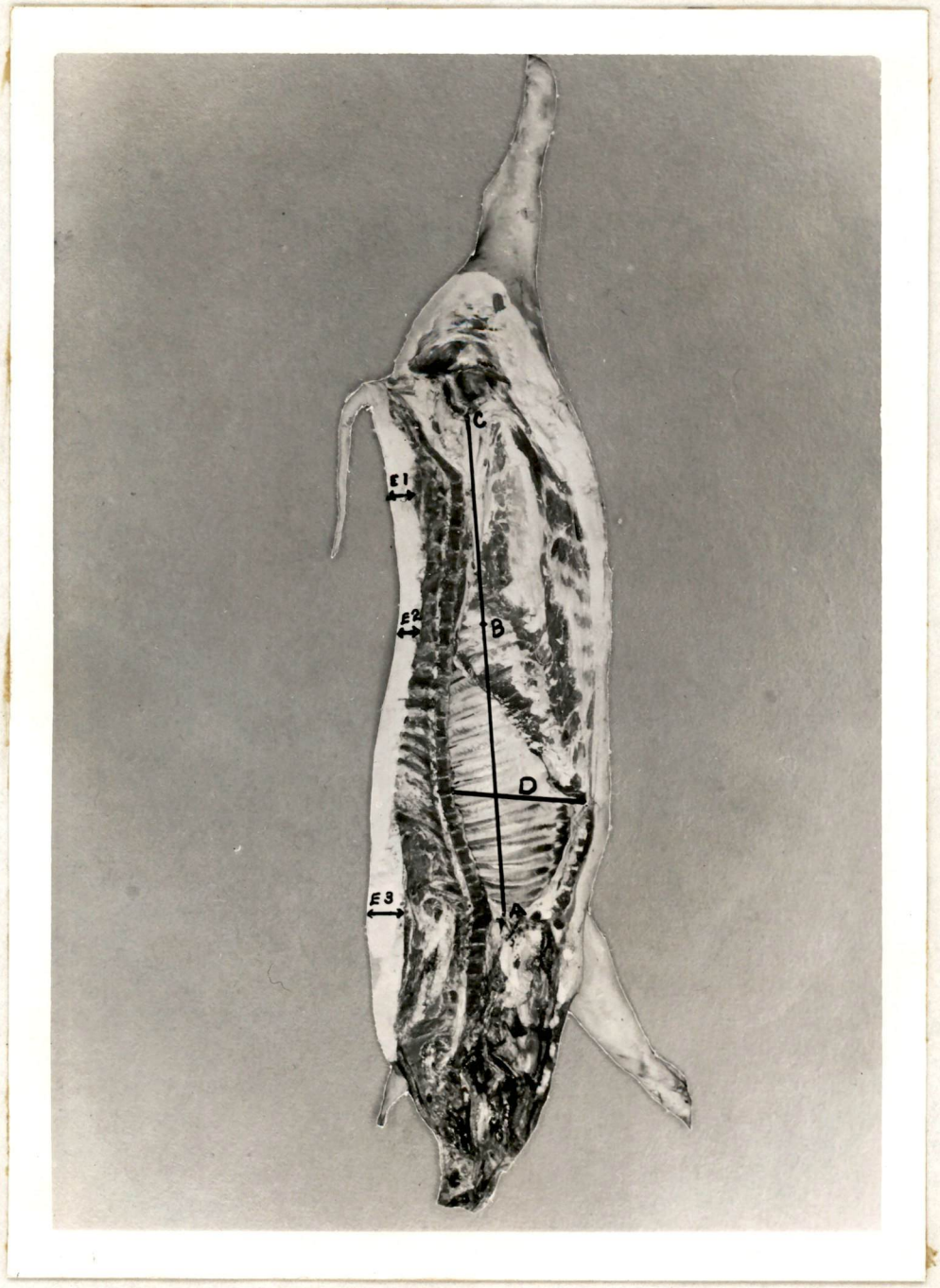


Figure 1. Carcass Measurement Guide: Length of Carcass, Line A to C; Length of Chest, Line A to B; Chest Depth, Line D; Backfat Thickness, Average of E_1, E_2, E_3.

back fat and under-lying tissue. Depth of chest was measured as the distance from the vertebral foramen of the seventh rib to the ventral edge of the sternum. The width of chest was measured horizontally from between the seventh and eighth rib of one side to the same point on the opposite side. Length of chest was taken as the distance from the anterior edge of the first rib to the posterior edge of the last rib.

The hams were marked for identification at the time of cutting and then cured with the following mixture:

1. Eight pounds of salt
2. Two pounds of sugar
3. One and a half ounces of sodium nitrite
4. One-half ounce of sodium nitrate.

The hams received ten percent by weight, of the above mixture applied in three applications, receiving one-third at each application. Applications of the cure mix were repeated every seven to nine days. Two days for each pound of ham, or a maximum time of thirty-five days, were allowed for curing.

After the curing process was completed, hams were soaked in vats of lukewarm water (one hundred ten degrees Fahrenheit) for approximately two and a half hours.

After the soaking process the hams were placed in the smokehouse over night, and then smoked with Hickory sawdust for forty-eight hours at a controlled temperature of one hundred ten degrees Fahrenheit. After the smoking period the hams were placed in a thirty-four to thirty-six degree Fahrenheit cooler and allowed to chill for twenty-four hours.

Equipment used to run pH readings consisted of a Beckman Model H-2 glass electrode pH meter, sensitive to 0.03 pH unit, with a calibration of 0.1 unit. The pH determinations were made and recorded of samples of the forty-eight hour chilled ham and the chilled smoked ham.

All percentages reported in this thesis were based on the off-feed weight.

CHAPTER IV

RESULTS AND DISCUSSION

The eighty four hogs used in this thesis comprised thirteen litters which came from five different farms. At least one hog from each litter was represented during each fasting period. Admitting the possibility of variation within litters, it was beleived that the effects of feeding, handling, type of hogs and enviromment factor were minimized by using litter mates.

As shown in Table I, the average off feed weight of the groups ranged from two hundred fifteen to two hundred twenty pounds. The average backfat thickness varied from 1.69 to 1.74 inches, while the length of side ranged from 28.7 to 29.1 inches.

The shrinkage data presented in Table I shows that one-half of the total shrinkage occurred during the first twenty hours for those hogs fasted a total of ninety-six hours. By the end of the forty-eighth hour eighty-eight percent of the total shrinkage had occurred.

Again observing Table I, on hogs killed packer style, there was a trend to lower yields for those hogs which were fasted ninety-six hours as compared to hogs killed immediately off feed. However, in studying Table II, there is no significant difference between the dressing percentage and the length of time off feed. In this table the fasting periods were broken down into short haul, long haul and combined short and long hauls. A significant difference in yield was noted between litters with the exception of the group comprising the long haul. All of these hogs,

TABLE I

SLAUGHTER DATA

Hours Off Feed	Number Of Animals	Average Length (Inches)	Average Fat Back (Inches)	Average Off Feed Weight (Pounds)	Average Kill Weight (Pounds)	Total Average Shrinkage In Percent	Dressing Percentage[a] SS[b]	PS[c]
0	13	29.1	1.70	220	220	0	77.08	70.13
24	18	28.8	1.74	217	208	4.15	76.87	69.97
48	17	28.7	1.74	217	201	7.37	76.77	69.55
72	18	28.7	1.68	220	203	7.73	76.36	69.45
96	18	29.0	1.69	215	197	8.37	75.78	68.78

[a]Dressing percent based on off feed weight.

[b]Shipper Style - carcass with head, leaf fat and ham facing left on.

[c]Packer Style - carcass with head, leaf fat and ham facing removed.

TABLE II

ANALYSIS OF VARIANCE OF DRESSING PERCENTAGE
WITH TIME OFF OF FEED IN RELATION TO
LENGTH OF HAULS

Entries	Degrees of Freedom			Mean Square		
	Total	Litter	Error	Time[a]	Litter	Error
Short Haul	34	6	24	2.53	5.58*	1.86
Long Haul	15	12	9	2.91	1.49	2.12
Short and Long Haul	51	3	36	3.15	5.79*	2.36

* Denotes significance at the five percent level.

[a] Degrees of freedom for time in all cases was three.

however, were sired by the same Yorkshire boar. Therefore, hogs in this group were closely related no matter which litter they comprised. This explains why the variation in dressing percentage was small between litters of the long haul group.

Because of the significant variation in dressing percentage between most of the litters, correlation of the average dressing percentage downward trend with time off feed was determined (Table X). A negative correlation of .293 was observed which was significant at the five percent level. The values used in this correlation were the dressing percentage mean of each of the fasting intervals. From this negative correlation it would appear that some tissue shrinkage might be taking place. However, as stated in the preceding paragraph, the analysis of variance did not show this difference which might be due to the great variation between litters.

Brody (1945) reported that for a 220.5 pound hog it would require 2,654 Calories for a male and for a female 2,316 Calories to fullfill the energy requirements for a twenty-four hour period of fasting. It might be logically reasoned that the hogs used in this thesis could have obtained enough energy for the first twenty-four hours from the loss in liver weight, empty gastro-intestional tract and from the undigested feed in the intestional tract. Approximately one-half of the hogs used in this thesis were males and one-half were females. By taking an average of the Calories necessary for a male (2,654) and female (2,316), it would be assumed that 2,485 Calories were necessary to take care of the energy requirement for a twenty-four hour period, or 7,455 Calories

for seventy-two hours. Pomeroy (1941) reported that fat was the first tissue used as a source of energy when hogs were placed on a submaintenance diet. Since fat has nine Calories of energy per gram, it was estimated that 1.83 pounds of fat tissue would be necessary to supply the energy requirements for seventy-two hours. This would only be 0.82 percent tissue loss for a 220.5 pound hog. As was shown in Table I, there was 1.30 percent lower yield, based on a shipper style carcass, for hogs fasted ninety-six hours as compared to those killed immediately off of feed. This was fairly close to the above calculated shrinkage. If some muscle tissues or carbohydrates were used as energy the calculated value would be even closer to that shown in Table I.

Table III shows percentages of the various portions of offal that affect dressing percentage materially. It is clearly shown that over one-half of the loss in weight of viscera occurred in the first twenty-four hours and eighty-seven percent had taken place by the end of the forty-eighth hour. These figures were almost identical to those of the total shrinkage. The full stomach and the full small intestine decreased most in weight in the first twenty-four hours. The full large intestine lost most of its weight during the second twenty-four hours of fasting. The weight of liver decreased as hours off feed increased. No trend was evident for the caul or ruffle fat. A very interesting observation of this table was the steady decrease in percentage of empty stomach, empty small intestine and large intestine with time off feed.

Analysis of variance technique was used to statistically evaluate the various offal data including the gastro-intestional tract with con-

TABLE III

OFFAL DATA IN PERCENT[a]

Hours Off Feed	Liver	Caul Fat	Ruffle Fat	Viscera	Gastro-Intestional Tract		Stomach		Small Intestine		Large Intestine	
					Full	Empty	Full	Empty	Full	Empty	Full	Empty
0	1.56	0.32	1.44	14.8	11.4	4.97	3.09	0.68	2.81	1.32	3.93	1.48
24	1.48	0.36	1.39	11.3	7.9	4.63	1.14	0.66	1.78	1.14	3.55	1.48
48	1.30	0.33	1.35	9.5	6.4	4.17	0.83	0.66	1.46	1.04	2.40	1.27
72	1.28	0.34	1.41	9.0	5.6	4.22	0.74	0.63	1.27	0.91	2.18	1.29
96	1.15	0.35	1.43	8.7	5.4	4.07	0.69	0.61	1.17	0.82	1.87	1.22

[a]Based on off feed weight.

tents as compared with hours of fasting. These values are listed in Table IV. It was observed that a highly significant difference at the one percent level occurred between time off feed and the percentage of the following: viscera, gastro-intestional tract, stomach, small intestine and large intestine. This was probably due to feed and other material passing through the gastro-intestional tract as hours of fasting increased. No significant difference was found for ruffle or caul fat in relationship to hours of fasting.

In this same table, highly significant differences between litters were noted for the small intestine, large intestine, ruffle fat and caul fat. Significant differences between litters were also noted for viscera, gastro-intestional tract and liver. These observations may be partially due to amount of feed eaten before weighing at the farm or perhaps the difference in percentage of gastro-intestional tract of different types of hogs as was found by Cole et al. (1953).

All previous work done on shrinkage has compared hogs which were in transit over a period of time to hogs which were raised near the particular packing company. These studies did not take into consideration the type of hog, chuffy, intermediate or rangy which was involved, how they were fed and handled before transit or the degree of finish. Because of the significant differences noted between litters in this thesis, misleading results could easily be secured if non-descript breeds of hogs fed and managed under variable conditions were compared.

A highly significant difference at the one percent level was

TABLE IV

ANALYSIS OF VARIANCE OF OFFAL DATA PERCENTAGES
WITH TIME OFF OF FEED

Entries	Total Degrees[a] of Freedom	MEAN SQUARES Time	Litter	Error
Viscera (with contents)	51	17.68**	1.76*	0.83
Gastro-Intestional Tract (with contents)	51	17.20**	1.84*	0.70
Stomach (with contents)	51	0.513**	0.134	0.69
Small Intestine (with contents)	51	0.94**	0.10**	0.03
Large Intestine (with contents)	51	7.03**	0.87**	0.22
Liver	51	0.2400**	0.0475*	0.0197
Ruffle Fat	51	0.04	0.17**	0.02
Caul Fat	51	0.0033	0.0141**	0.0030

* Denotes significance at the five percent level.

** Denotes significance at the one percent level.

[a] Degrees of freedom was 3 for time, 12 for litter and 36 for error in all cases.

noted for the percentages of liver as effected with time off feed. Wilcox et al. (1953) showed that the liver was the store house of glycogen in the body. Ingraham (1948), Rose and Peterson (1951), Callow (1938, 1939), and Bate-Smith (1937-1949) stated that glycogen was first used as a source of energy when animals were exercised or fasted. The liver was the only organ of economic value which appeared to have a significant amount of tissue shrinkage. Approximately 0.9 of a pound of liver was lost in those hogs fasted ninety-six hours. This was probably due to the loss in glycogen which is a readily available source of energy for the hogs.

Statistical values of the empty offal items in relation to time without feed are listed in Table V. It is interesting to note that there is a highly significant difference at the one percent level between the time off feed and the empty gastro-intestional tract, empty small intestine and the empty large intestine. An F value of 2.78 was obtained between the empty stomach and time off feed whereas a value of 2.86 is necessary for a significance at the five percent level. It is difficult to fully understand how this shrinkage took place. The hogs had free access to water and considerable liquid was found in the gastro-intestional tract, therefore, it was not believed that this difference was due to dehydration. A possibility might be that considerable nutrients were present in the intestional wall and these nutrients were used as a source of energy and not replaced because of fasting. Again observing Table III, it was found that 0.9 of one percent, based on off feed weight, of shrinkage had taken place from zero to the end

TABLE V

ANALYSIS OF VARIANCE OF GASTRO-INTESTIONAL TRACT
WITH TIME OFF OF FEED

Entries	Total Degrees[a] of Freedom	Mean Squares		
		Time	Litter	Error
Gastro-Intestional Tract	51	.7966**	.2750**	.0966
Stomach	51	.0100	.0133**	.0036
Small Intestine	51	.2633**	.0458**	.0108
Large Intestine	51	.1633**	.042*	.0206

* Denotes significance at the five percent level.

** Denotes significance at the one percent level.

[a] Degrees of freedom was 3 for time, 12 for litter and 36 for error in all cases.

of the ninety-sixth hour of fasting for the empty gastro-intestional tract. On a two hundred pound live hog this would constitute 1.8 pounds of the total shrinkage. No previous work was found on this subject.

The various cutting percentages were recorded in Table VI. No trend was observed for any of the items listed. An analysis of variance of the data revealed that no significant differences occurred in these various items in relation to time. However, highly significant differences were found for all cuts listed between litters (Table VII). This again shows the great difference existing between hogs of different type and emphasizes the advisability of making comparisons between litter mates.

Ingraham (1948) reported considerable ham spoilage if the pH of muscle tissue was high. It is a well established fact that the pH of hams will be high if animals were exercised before slaughter. In Table VIII the average pH values of hams for all fasting periods are listed. No definite trend was found between pH and time off feed. No significant difference was observed between pH and time off feed (Table IX). Nearly all of the previous work done with pH of muscle has been with its relationship to fatigue and not necessairly with time fasted. The hogs used for this thesis which were transported a long distance might have been somewhat fatigued, however, they were permitted to rest approximately eighteen hours before the first ones were slaughtered.

Table X shows the correlation of the various body measurements with dressing percentage. A highly significant positive correlation of .495 was found between dressing percentage and back fat thickness. This

TABLE VI

CUTTING DATA IN PERCENT

Hours Off Feed	Primal Cuts	Ham	Loin	Shoulder	Belly	Fat Trim	Leaf Fat
0	44.9	13.9	9.5	11.0	11.0	17.1	2.76
24	46.1	13.9	9.8	11.4	10.8	15.5	2.82
48	45.9	14.1	9.8	11.3	10.8	15.1	2.97
72	45.8	14.2	9.9	11.0	10.7	15.1	2.72
96	45.0	13.9	9.7	11.2	10.4	15.2	2.85

TABLE VII

ANALYSIS OF VARIANCE OF CUTTING DATA IN RELATION TO TIME OFF OF FEED

Entries	Total Degrees[a] of Freedom	Mean Squares		
		Time	Litter	Error
Primal Cuts	51	2.98	15.21**	1.54
Ham	51	.29	3.21**	.31
Loin	51	.15	4.70**	.21
Shoulder	51	.453	1.199**	.403
Belly	51	.3830	2.17**	.1822
Leaf Fat	51	.14	.39*	.16
Fat Trim	51	.4033	27.30**	1.87

* Denotes significance of the five percent level.

** Denotes significance of the one percent level.

[a] Degrees of freedom was 3 for time, 12 for litter and 36 for error in all cases.

TABLE VIII

AVERAGE pH VALUES OF PORK CONTRACTILE TISSUE

Hours Off Feed	pH Fresh	pH Cured & Smoked
0	5.4	5.4
24	5.4	5.4
48	5.3	5.5
72	5.4	5.4
96	5.3	5.5

TABLE IX

ANALYSIS OF VARIANCE OF pH. OF FRESH AND SMOKED HAM
WITH TIME OFF OF FEED

Entries	Degrees of Freedom				Mean Squares		
	Total	Time	Litter	Error	Time	Litter	Error
pH Fresh	51	3	12	36	.0033	.0342**	.0087
pH Smoked	35	3	8	24	.0067	.0300**	.0108

* Denotes significance of the five percent level.

** Denotes significance of the one percent level.

TABLE X

CORRELATIONS OF VARIOUS CARCASS MEASUREMENTS

Entries	Correlation	P 0.01[a]	P 0.05[b]
1. Dressing Percentage Trend - Time	.293	.354	.273
2. Dressing Percentage - Average Fat Back	.495	.325	.250
3. Dressing Percentage - Length of Chest	.207	.325	.250
4. Dressing Percentage - Chest Depth	.109	.325	.250
5. Dressing Percentage - Chest Width	.160	.325	.250
6. Dressing Percentage - Length x Width x Depth of Chest	.081	.325	.250
7. Chest Depth - Gastro-Intestional Tract Full	.206	.325	.250

[a] Values necessary to be significant at the one percent level.

[b] Values necessary to be significant at the five percent level.

was in keeping with the results of Bowman (1954), Zobrisky et al. (1953), and Aunnan and Winters (1949). No significant correlations were found between dressing percentage and the following: length of chest, depth of chest, or length x width x depth of chest.

CHAPTER V

SUMMARY AND CONCLUSIONS

In analyzing the data presented in this thesis the following summary and observations can be made.

When hogs were fasted ninety-six hours nearly one-half of the total shrinkage occurred during the first twenty-four hours and eighty-eight percent by the end of the forty-eighth hour.

No significant difference was found between dressing percentage and shrinkage time. However, a significant correlation was noted between the average dressing percent trend and time off feed.

The percentage loss in weight of the viscera was almost identical to the percentage of total shrinkage.

Highly significant differences were noted between shrinkage time and full viscera, full gastro-intestional tract, full stomach, full small intestine and full large intestine.

A highly significant difference was noted between fasting time and empty gastro-intestional tract, small intestine and large intestine. The empty stomach was very close to significance at the five percent level.

No statistical significance was found between primal cuts, ham, loin, belly, shoulder, cutting fat, leaf fat, ruffle fat or caul fat with time off feed.

No statistical difference was found between pH of muscle tissue and time off feed.

A positive highly significant correlation of 0.495 between dressing percentage and fat back thickness was found.

No significant correlation was found between the various chest measurements and dressing percentage.

The liver was the only organ of economic value which showed a significant amount of tissue shrinkage.

From the data presented in this thesis, it is believed that tissue shrinkage has been over estimated and over emphasized. This belief is supported by work of Henning and Stout (1932) and the calculated value of Brody (1945).

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