July 13, 1961

To the Graduate Council:

I am submitting herewith a thesis written by Robert N. Terrell, entitled "Relationship of Beef Type and Breed to Offal Composition". 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.

J. R. Cole
Major Professor

We have read this thesis and recommend its acceptance:

C. V. Hobbs

John T. Smith

Accepted for the Council:

W. E. Spivey
Dean of the Graduate School

RELATIONSHIP OF BEEF TYPE AND BREED TO OFFAL COMPOSITION

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

---

by

Robert N. Terrell

August 1961

2a
33

ACKNOWLEDGEMENT

The author wishes to express his sincere appreciation and gratitude to the following persons:

To Professor J. W. Cole and Dr. C. B. Ramsey for their instruction and guidance throughout the graduate program and for their helpful suggestions in the revision of parts of this thesis.

To Dr. R. J. Cooper for his aid in compiling and interpreting the statistical analyses.

To Dr. John T. Smith for his cooperation and willingness to participate in the oral examination.

To Dr. C. S. Hobbs for his interest and direction throughout the graduate program.

To my fellow graduate students, undergraduate students, and all other persons who have aided in the collection of the data presented in this thesis.

488573

TABLE OF CONTENTS

CHAPTER		PAGE
I.	INTRODUCTION	1
II.	REVIEW OF LITERATURE	3
III.	PROCEDURE	7
IV.	RESULTS AND DISCUSSION	9
V.	SUMMARY AND CONCLUSIONS	25
LITERATURE CITED		27
APPENDIX		30

LIST OF TABLES

TABLE PAGE

I. Carcass Grade Distributions Within Breeds. 10

II. Average Pre-Slaughter, Carcass Grade, and Yield Information by Breed 11

III. Average Pre-Slaughter and Yield Information by Carcass Grade. 14

IV. Average Offal Component Percentages by Breed, Based on Kill Weight 16

V. Analysis of Variance of Average Offal Component Percentages, Based on Kill Weight. 17

VI. Relationship of Viscera Weight to Hot Carcass Weight by Breed. 19

VII. Relationship of Viscera Weight to Hot Carcass Weight by Carcass Grade. 22

APPENDIX TABLE

I. Average Percent of Full and Empty Gastrointestinal Components by Breed, Based on Kill Weight. 31

II. Average Percent of Full and Empty Gastrointestinal Components by Carcass Grade, Based on Kill Weight. 32

III. Average Percent of Visceral Components by Breed, Based on Kill Weight 33

IV. Average Percent of Visceral Components by Carcass Grade, Based on Kill Weight. 34

APPENDIX TABLE PAGE

V. Average Percent of Offal Components Other than Viscera by Breed, Based on Kill Weight 35

VI. Average Percent of Offal Components Other than Viscera by Carcass Grade, Based on Kill Weight 36

VII. Average Weights of Offal Components by Breed 37

VIII. Average Weights of Offal Components by Carcass Grade 40

CHAPTER I

INTRODUCTION

Extensive reports of detailed research concerning tissue and excretory shrinkage of beef animals from farm to market have been published. However, few investigations have been made which dealt with the weight losses that occur at the time of slaughter. These losses represent the components of the offal. Since more and more emphasis is being placed upon carcass evaluation and cut-out data as a guide to the selection of meat-type breeding stock, the need for a valid live weight figure becomes critical.

In the determination of dressing percentage and carcass cut-out data, the basis is either the live weight or the carcass weight. The data calculations are not as questionable when based on a carcass weight because only tissue shrinkage is involved and it is relatively minor. However, when these percentages are based on a live weight, the shrinkage due to excretion and offal components such as hide, viscera, and digestive tract can vary widely due to breed, pre-slaughter treatment, and the live weight figure used in making the calculations. The various live animal weights which may be used are: (1) off-feed weight taken at the farm or feed lot, (2) slaughter or kill weight taken just prior to slaughtering after the animals have received a prescribed pre-slaughter treatment, (3) slaughter or kill weight taken without a prescribed pre-slaughter treatment, and (4) adjusted live weight based on a standard viscera percentage. Because of the variations in these

weights, the question may arise, "What live weight should be used in determining dressing percentage and carcass cut-out values?"

Many adjustments have been proposed to account for shrinkage due to offal. For example, the National Barrow Show uses a digestive tract standard of 12.5 percent of empty body weight to obtain an adjusted live weight on which to base dressing percent. Recently, emphasis has been placed upon using standard viscera percentages in beef carcass contests. These standards are designed to adjust for the loss in weight due to components of the offal.

The variations in offal components and pre-slaughter treatment have a definite effect upon live weight. If live weight is to be used as a basis for the computation of various carcass improvement criteria, an investigation and report of the offal component percentages certainly is warranted.

The purpose of this study is to provide fundamental knowledge to the animal husbandman about the offal component percentages of beef animals and to elucidate some of the problems facing the establishment of valid offal standards.

CHAPTER II

REVIEW OF LITERATURE

Research relating specifically to offal composition is limited. The majority of the literature is concerned with growth and development of the digestive tract, physiology of ruminants, and the relationship of various organ weights to carcass and live animal data.

Wardrop (1960), studying the development of visceral organs of lambs fed different diets, found that the plane of nutrition can have a marked effect upon the growth and development of these organs. However, as far as the ruminant stomach was concerned, the type of nutrition was more important than the plane of nutrition in determining the rate of growth. Immediately after birth the four compartments altered rapidly in their relative proportions, but by about fifty-six days of age, they had reached approximately adult proportions. The same effect was true for the liver, heart and kidneys, relative to live weight.

In considering ruminant stomach development with respect to age, Kesler et al. (1951) worked with Holstein calves slaughtered periodically up to 32 days of age and found that the weights of rumen tissue and of the rumen contents increased slowly and steadily with advancing age.

Grossman (1949) reported that the abomasum of the newborn calf has about twice the capacity of the first three compartments combined, and that these stomachs reach their definitive relative capacities at about one and one-half years of age.

Various observations were made by Warner et al. (1956) on the development of the ruminant stomach with respect to age and type of diet. Calves receiving dry feed had a noticeable increase in volume and tissue deposition of the rumen and reticulum with age, as well as a more extensive papillary development of the rumen wall. These initial changes were evident at four weeks of age and increased steadily. Calves fed milk alone showed little change. It was postulated from this study that chemical entities, probably end products of microbial digestion of feed, rather than coarse materials, stimulate the development of the rumen and reticulum tissue.

In a more specific analysis of offal composition, Zeigler (1958) found that the offal fat averaged about 3 percent of a beef animal's live weight, ranging from 1 percent in cattle of the U.S. Good grade to 6.5 percent for U.S. Prime cattle. The liver averaged about 1 percent of the live weight, the heart 0.35 percent, the tongue 0.25 percent and the liquid blood 3.5 percent of the live weight. Hide weight varied with the breed of cattle. Slaughter records of purebred steers killed and dressed in the Pennsylvania State University Laboratory showed that hides of Herefords averaged 8.5 percent; Angus, 7.5 percent; and Shorthorns, 6.5 percent of the live weights of the animals, with an overall average of approximately 7.0 percent.

Data submitted by Walton et al. (1934) concerning yield of blood from beef animals slaughtered on farms and ranches in 1932, revealed that for an average live weight of 754 pounds, the yield of blood was 25.65 pounds, or 3.4 percent of the live weight.

Swift and Company (1936) found that on the average only 54.3 percent of a live steer is considered consumable beef. Of the remaining 45.7 percent of the live weight, 10.1 percent has little value and 19.5 percent is lost when the digestive tract is emptied at the time of slaughter, leaving only 16.1 percent of the offal components which may be converted into finished by-products.

In an experiment designed to study the effects of fatness and age on the proportion of carcass and offal, Moulton et al. (1922) reported that, except for the caul and ruffle fat, the percentage of each visceral organ comprising the empty body decreased with an increase in age and fatness.

In comparing a purebred dairy cow with a purebred beef cow, Sweet et al. (1928) reported that the weights of intestines, intestine contents, stomach and stomach contents were much greater for the Jersey cow than for the highly finished Angus cow.

Kraybill et al. (1954) analyzed data from Hereford steers, Shorthorn steers and nineteen pairs of identical twins of different breeds. When the ranges in age, fatness and weight were limited, the close association between lean body mass and organ weights of spleen, liver, heart, kidney and pancreas was lowered.

Offal items were weighed by Butler et al. (1956) in an effort to account for the two to three percent advantage in dressing percentage of crossbred Brahman steers over Hereford steers. Most of this difference was found to be in the paunch. The empty digestive tract was 6.02 percent of the slaughter weight for the Herefords and 5.34 percent for

the crossbreds. Other "dress-off" items exerted little influence on the two to three percent average yield difference noted constantly over a four-year period.

In a study pertaining to beef production and quality as influenced by crossing Brahman bulls with Hereford and Shorthorn cows, Black et al. (1934) reported that no statistically significant differences existed in hide thickness, intestine length, or in weights of hearts, lungs, spleen, thymus gland, brain, shanks and caul, ruffle and paunch fat. However, there was a significant difference existing in paunch weights which was primarily in capacity rather than the amount of tissue present.

CHAPTER III

PROCEDURE

The animals used in this project were purchased when four to five months of age and were fed at the University of Tennessee Blount Farm. The following breeds and numbers of each were represented: Jersey (19), Guernsey (2), Holstein (24), Hereford (27), Angus (23), Brahman (16), Santa Gertrudis (12), and Brahman X British breeds (10).

In order to keep environmental effects at a minimum, all animals within years were raised under the same feeding and management practices. During the first year, all animals were individually fed ad libitum. However, during the second, third, and fourth years the animals were group fed ad libitum.

During the first three to four months of the feeding period, the ration consisted of 25 percent ground hay, 43 percent shelled corn, 20 percent calf starter, 8 percent cottonseed meal, 3 percent molasses, 0.5 percent dicalcium phosphate and 0.5 percent salt. However, at the end of this initial feeding period the 20 percent calf starter was replaced by 20 percent corn.

The animals were slaughtered at a weight of 900 pounds or at twenty months of age, whichever was reached first. All animals received the same pre-slaughter treatment. Off-feed weights were taken twenty-four hours previous to slaughter and kill weights were recorded just prior to slaughter. Thus, each animal was given an equal twenty-four hour shrinkage without feed or water.

During the first year of this study, both Guernsey and Jersey breeds were used. However, during the second and following years, only Jerseys were used. Hereafter in this thesis where reference is made to Jerseys, both Guernsey and Jersey breeds will be included.

The University of Tennessee Meats Laboratory facilities were used for slaughtering and processing. The methods and procedures used were those outlined by Deans (1951) in the Report of Proceedings, Fourth Annual Reciprocal Meat Conference, with the following exceptions: (1) the hyoid bones were not unjointed from the skull, (2) the brain and pituitary gland were not removed from the head, (3) the hide was not trimmed, (4) the stomachs and intestines were emptied of their contents, washed thoroughly and allowed to drip dry for approximately three hours before weighing, (5) the spinous processes of the thoracic vertebrae were not scribed.

The carcasses were shrouded, chilled in a 34-36° F. cooler for a minimum of twenty-four hours, and were then weighed to obtain a chilled carcass weight. The carcasses were graded to the nearest one third of a grade by a federal grader. The left side was held for detailed physical separation and chemical analyses. The right side was used for organoleptic studies in cooperation with the University of Tennessee Home Economics Department.

CHAPTER IV

RESULTS AND DISCUSSION

A partial description of the steers used in this project is given in Tables I and II. Table I shows the carcass grade distribution within breeds, which are more or less representative of the cattle marketed in the southeastern area of the United States. The grades and total numbers of each are: Prime (2), Choice (24), Good (47), Standard (52) and Utility (8). The pre-slaughter, carcass grade, and yield information by breed is presented in Table II. The average off-feed weights ranged from 782 to 899 pounds, with a mean of 859 pounds. The Holsteins which had the highest rate of gain and usually were slaughtered first, had an average off-feed weight of 897 pounds, only to be exceeded slightly by the Santa Gertrudis with an average off-feed weight of 899 pounds. The slow gaining, late maturing Jerseys had the smallest off-feed weight and usually were fed to twenty months of age.

The kill weights for all breeds averaged 51 pounds less than the off-feed weights.

The average twenty-four hour pre-slaughter shrink loss ranged from 4.9 to 6.8 percent with a mean for all breeds of 5.9 percent. The Holsteins, which had one of the heavier off-feed weights, had the highest pre-slaughter shrink loss of 6.8 percent, while the Jerseys, which had the smallest off-feed weight, followed closely with 6.0 percent. The higher percentages for these dairy breeds becomes quite obvious when reference is made to Appendix Table I which contains the percentages of

TABLE I

CARCASS GRADE DISTRIBUTIONS WITHIN BREEDS

Carcass grade	Breed							Carcass grade totals
	Hereford	Angus	Brahman	Brahman X	Santa Gertrudis	Holstein	Jersey	
Prime		2						2
Choice	10	13			1			24
Good	16	8	4	6	8	2	3	47
Standard	1		11	4	3	19	14	52
Utility			1			3	4	8
Breed totals	27	23	16	10	12	24	21	

TABLE II

AVERAGE PRE-SLAUGHTER, CARCASS GRADE, AND YIELD INFORMATION BY BREED

Breed	Off-feed wt.	Kill wt.	24 hr. pre-slaughter shrink	Hot carcass wt.	Chilled carcass wt.	Cooler shrink	Carcass grade	Dressing percentage[a] off-feed	Dressing percentage[a] kill wt.	Kidney[a] knob
	lbs.	lbs.	%	lbs.	lbs.	%		%	%	%
Hereford	882	832	5.6	525	518	1.4	H Gd+	58.7	62.2	4.0
Angus	857	803	6.2	514	508	1.3	L Ch-	59.3	63.2	4.8
Brahman	819	779	4.9	492	484	1.6	A Std+	59.1	62.1	3.5
Brahman X	881	835	5.3	521	513	1.6	H Std+	58.2	61.4	3.6
Santa Gert.	899	848	5.7	544	537	1.3	A Gd-	59.7	63.3	4.4
Holstein	897	836	6.8	505	497	1.5	A Std	55.4	59.5	4.3
Jersey	782	735	6.0	429	422	1.6	A Std-	53.9	57.4	6.2
Overall averages for all animals	859	808	5.9	502	494	1.4	L Gd	57.6	61.2	4.5

[a]Chilled carcass weight was used in determining percent kidney knob and dressing percentage.

the digestive tract components. The average pre-slaughter shrink losses for Brahman, Brahman crosses, and Santa Gertrudis, were 4.9, 5.3, and 5.7 percent, respectively. These data would indicate that, as the amount of Brahman blood increases, the percent pre-slaughter shrink loss decreases. An agreement with the work of Butler et al. (1956) is found when a comparison of the pre-slaughter shrink losses of Brahman crosses and Herefords are considered. The Brahman crosses have a lower percent of pre-slaughter shrink loss. The British breeds of Hereford and Angus had intermediate values for the percent pre-slaughter shrink loss.

The ranges in hot and chilled carcass weights varied widely while the ranges in percent cooler shrinkage were relatively small.

Carcass grades ranged from average Standard minus to low Choice minus, with a mean for all breeds of low Good. The dairy breeds of Holstein and Jersey, with their long, angular, thin-fleshed carcasses, had an average carcass grade in the lower one half of Standard, while the Brahmans and Brahman crosses had an average carcass grade in the upper one half of Standard. The higher grading beef breeds were those containing British blood. The Angus with the highest average carcass grade of low Choice minus, slightly out graded the Herefords which had an average carcass grade of high Good plus. The Santa Gertrudis had an average carcass grade of average Good minus, which was slightly above the mean for all breeds.

The dressing percentages, based on an off-feed weight, ranged from 53.9 to 59.7 percent, with an all breed mean of 57.6 percent. The Santa Gertrudis had the highest off-feed dressing percentage with 59.7

percent. The Holsteins and Jerseys had the lowest off-feed dressing percentages with 55.4 and 53.9 percent, respectively. The low dressing percentages for these dairy breeds are due to a larger percent of their live weight being "tied up" in visceral components, as may be observed in Appendix Table III. As expected, the dressing percentages based on kill weights for all breeds were higher than the off-feed dressing percentages.

The average percent of kidney knob ranged from 3.5 to 6.2 with a mean of 4.5 percent for all breeds. The Jerseys had the highest percent kidney knob and the lowest dressing percentage. Had the kidney knob been removed from the carcasses at the time of slaughter, the yield figures would be comparatively much lower.

The pre-slaughter and yield information presented in Table III shows some very distinct trends with respect to carcass grade. With an exception of the Choice and the Good grades, there was a general increase in off-feed weight with an increase in carcass grade. The same among grade effects were observed for kill weights.

The Utility and Standard grades had the largest percentages of pre-slaughter shrink loss, with 6.6 and 6.2 percent, respectively. The Good grade had a slightly lower average percent pre-slaughter shrink loss than Choice and Prime.

Although there was a wide range in hot and chilled carcass weights, the percent cooler shrink loss varied only 0.3 percent. It was greater in the lower grading carcasses than in the higher grading carcasses.

TABLE III

AVERAGE PRE-SLAUGHTER AND YIELD INFORMATION BY CARCASS GRADE

Carcass grade	Off-feed wt.	Kill wt.	24 hr. pre-slght. shrink loss	Hot carcass wt.	Chilled carcass wt.	Cooler shrink loss	Dressing percentage		Kidney[a] knob
							off-feed	kill wt.	
	lbs.	lbs.	%	lbs.	lbs.	%	%	%	%
Prime	906	854	5.8	567	559	1.3	61.7	65.5	5.5
Choice	876	825	5.8	529	522	1.3	59.6	63.3	4.8
Good	881	831	5.6	526	518	1.4	58.8	62.3	4.4
Standard	844	792	6.2	479	471	1.6	55.8	59.5	4.4
Utility	757	707	6.6	413	407	1.4	53.8	57.6	3.9

[a]Chilled carcass weight was used in determining percent kidney knob and dressing percentage.

Dressing percentage, when based on either off-feed or kill weight, showed a very distinct increase with increases in carcass grade. This is largely a function of the heavier live weights of the upper grades, along with their additional covering of fat, as compared to the lower grades.

Although the Prime grade had the highest percent kidney knob, these among grade differences are not as great as the differences among breeds. This is probably confounded by the fact that the lower grading dairy breeds usually have a higher percentage of kidney knob than the higher grading beef breeds.

The offal component percentages presented in Table IV are the most important factors influencing the weight losses which occur at the time of slaughter.

The Holstein and Jersey breeds had the highest percentages for all the variables presented in Table IV, with the exception of percent ruffle and caul fat and hide. This largely accounts for their low dressing percentages. The breeds containing Brahman blood had the lower values for omasum and abomasum, ruffle and caul fat, total digestive tract and viscera. However, as the percent of Brahman breeding increased, the percent of hide increased, which agrees with the work of Carpenter et al. (1961). The Herefords and Angus represented intermediate percentages for the variables presented in Table IV.

In analyzing the data presented in Table V on a grade within breed basis, there were no significant differences observed in percent omasum and abomasum, small and large intestines, liver, and total

TABLE IV

AVERAGE OFFAL COMPONENT PERCENTAGES BY BREED,
BASED ON KILL WEIGHT

Breed	Rumen, reticulum and esophagus	Omasum and abomasum	Small and large intestines	Ruffle and caul fat	Total G.I. tract with ruffle and caul fat	Hide	Liver	Viscera
Hereford	6.9	1.9	2.9	3.8	15.6	9.1	1.0	18.7
Angus	7.2	2.0	3.0	3.9	16.1	7.4	1.1	19.5
Brahman	7.1	1.7	3.4	3.3	15.0	9.8	1.4	17.2
Brahman X	7.3	1.8	3.0	2.7	14.9	9.4	1.0	18.1
Santa Gert.	7.2	1.9	2.7	3.4	15.2	8.3	1.1	18.5
Holstein	8.6	2.4	3.5	3.8	18.5	7.2	1.3	22.2
Jersey	9.0	2.8	3.9	5.4	21.7	7.0	1.3	24.7
Overall averages for all animals	7.6	2.1	3.2	3.9	16.9	7.0	1.2	20.1

TABLE V

ANALYSIS OF VARIANCE OF AVERAGE OFFAL COMPONENT PERCENTAGES BASED ON KILL WEIGHT

Source of variation	DF	Rumen, reticulum and esophagus	Omasum and abomasum	Small and large intestines	Ruffle and caul fat	Total G.I. tract with ruffle and caul fat	Hide	Liver[a]	Viscera
Breed	6	15.85**	3.02**	3.27**	11.73**	103.33**	24.44**	.59	141.42**
Grade/Breed	13	9.14**	.15	.59	2.79*	3.45	1.28*	1.05	8.74**
Animals/Grade and Breed	113	1.67	.10	.60	1.32	4.93	.62	.41	2.68

[a]There were only 112 degrees of freedom for percent liver.

**Significant at $P < (.01)$.

*Significant at $P < (.05)$.

gastrointestinal tract. These results may be due to the fact that the beef breeds largely were graded in the upper three grades while the dairy breeds were representative of the lower grades.

All of these variables were highly significant at the $P < (0.01)$ level for among breed differences, with the exception of percent liver (Table V). These differences may be attributed to the type and specific purpose for which these various breeds are used. Detailed information concerning the data presented in Tables IV and V may be found in Appendix Tables I, III and V.

Table VI gives the relationship of viscera weight to hot carcass weight by breed. This table was prepared in an attempt to more critically examine the possible use of a standard viscera percentage in evaluating beef carcasses. The observed viscera weight, as it will be referred to, was obtained after all animals had received a twenty-four hour pre-slaughter shrinkage without feed or water.

The average viscera weights ranged from 134.4 to 185.7 pounds, with a mean of 162.6 pounds. Holsteins and Jerseys had the heaviest viscera weights with 185.7 and 191.6 pounds, respectively, which materially exceeds the mean for all breeds. The Brahmans had the lowest average viscera weight with 134.4 pounds while the Brahman crosses had an average viscera weight of 151.2 pounds, and the Santa Gertrudis had an average viscera weight of 156.8 pounds. Hereford and Angus average viscera weights were almost identical.

It is assumed that the pre-slaughter shrink loss is due primarily to an excretory loss and not an actual tissue shrinkage since the animals

TABLE VI

RELATIONSHIP OF VISCERA WEIGHT TO HOT CARCASS WEIGHT BY BREED

Breed	Hot carcass wt.	Viscera wt.	24 hr. pre-slght. shrink loss	Viscera + 24 hr. pre-slght. shrink loss	Viscera wt. / Hot** carcass wt.	Viscera + 24 hr. pre-slght. shrink loss / Hot** carcass wt.
	lbs.	lbs.	lbs.	lbs.	%	%
Hereford	525	156.0	49.8	206.0	29.7	39.2
Angus	514	156.9	53.3	210.9	30.5	40.9
Brahman	492	134.4	40.0	174.4	27.3	35.4
Brahman X	521	151.2	46.7	197.2	29.0	38.0
Santa Gert.	544	156.8	51.5	207.8	28.8	38.3
Holstein	505	185.7	61.2	246.7	36.8	48.9
Jersey	429	181.6	47.2	218.6	42.4	53.4
Overall averages for all animals	502	162.6	51.0	213.4	32.4	42.5

**Differences among breeds are significant at $P < (0.01)$.

were not exposed to a prolonged treatment without feed or water. Saffle et al. (1960) found no significant tissue shrinkage in swine during a fast of 72 hours.

In order to arrive at an "off-feed" viscera weight, assuming the animals had received no twenty-four hour pre-slaughter shrinkage, the pounds of pre-slaughter shrink loss have been added to the observed viscera weight to give a viscera plus twenty-four hour shrink loss figure. This "off-feed" viscera weight divided by hot carcass weight will be used to evaluate the standard viscera percentage employed at the 1960 Waterloo Meat Animal Show. The standard viscera percentage used at this particular show was 42.9 percent of the hot carcass weight.

The average viscera weight divided by the hot carcass weight ranged from 42.4 to 27.3 percent with a mean of 32.4 percent (Table VI). The Herefords and Angus had values of 29.7 and 30.5 percent, respectively. These values were slightly higher than those of the Brahmans, Brahman crosses, and Santa Gertrudis, which had percentages of 27.3, 29.0 and 28.8 percent, respectively.

In analyzing the viscera weight divided by the hot carcass weight, it becomes quite obvious that the only breeds which approach the viscera standard of 42.9 percent are the Holsteins and Jerseys with 36.8 and 42.4 percent, respectively. Since these are dairy breeds, it would be rather impractical to exhibit them in a beef carcass contest. These data indicate that any attempt to standardize viscera percentages may introduce serious error, particularly if the animals are kept away from feed and water twenty-four hours previous to slaughter.

When the twenty-four hour pre-slaughter shrink loss is added to the observed viscera weight and this total divided by the hot carcass weight, the range is 53.4 to 35.8 percent with a mean of 42.5 percent. This average percent of viscera plus twenty-four hour shrink loss for all breeds, is 0.4 percent below the Waterloo viscera standard. Furthermore, it was obtained after adding the pre-slaughter shrink loss to the observed viscera weight and treating the value as if the animals had received no pre-slaughter shrinkage. The Holsteins and Jerseys were considerably above the mean for all breeds in average percent of viscera plus twenty-four hour shrink loss with 48.9 and 53.4 percent, respectively. The Angus with 40.9 and the Herefords with 39.2 percent more closely approached the mean for all breeds, but were still approximately two percent below it. The Brahman, Brahman crosses, and Santa Gertrudis had values of 35.4, 38.0 and 38.3 percent, respectively, which were considerably below the mean for all breeds.

If only the breeds of Angus and Hereford are considered, the standard viscera percentage is still 2.9 percent too high, even when the pre-slaughter shrink loss is added to the observed viscera weight. If the large viscera weights and pre-slaughter shrink losses of Holsteins and Jerseys were removed from Table VI, the all breed average for viscera plus twenty-four hour shrink loss divided by hot carcass weight, would be 38.4 percent.

The data in Table VII shows the relationship of viscera weight to hot carcass weight by grade. The average viscera weights ranged from 156.4 to 169.6 pounds. Utility had the highest average percent viscera

TABLE VII

RELATIONSHIP OF VISCERA WEIGHT TO HOT CARCASS WEIGHT BY CARCASS GRADE

Carcass grade	Hot carcass wt.	Viscera wt.	24 hr. pre-slght. shrink loss	Viscera + 24 hr. pre-slght. shrink loss	Viscera wt. / Hot** carcass wt.	Viscera + 24 hr. pre-slght shrink loss / Hot** carcass wt.
	lbs.	lbs.	lbs.	lbs.	%	%
Prime	567	158.7	52.5	211.2	28.0	37.3
Choice	529	158.0	50.8	208.8	30.0	39.5
Good	526	156.4	49.4	205.8	30.0	39.1
Standard	479	169.6	52.1	221.7	35.4	46.3
Utility	413	169.1	50.1	219.3	41.0	53.1

**Differences among grades are significant at $P < (0.01)$.

based on hot carcass weight with 41.0 percent while the Prime grade had the lowest value of 28.0 percent. Again, these percentages are below the standard viscera percentage used at Waterloo.

A range of 37.3 percent for Prime to 53.1 percent for Utility was observed when the hot carcass weight was divided into the combined viscera plus twenty-four hour pre-slaughter shrink loss weight.

As shown in Tables VI and VII, there are highly significant differences among breeds and among grades for the percent of viscera and viscera plus twenty-four hour shrink loss divided by hot carcass weight.

One of the main objections to the adjustment of live weight by using a standard viscera percentage is the fact that, more often than not, the live weight would be increased. If this adjusted live weight is used to determine dressing percentage, it becomes apparent that "true" dressing percentage will be lowered. Therefore, adjustment for a live weight would depress dressing percentage and consequently carcass value would be lowered.

From the data presented in Tables VI and VII, and from the previous discussion, it appears that there is no need to adjust for live weight when the animals are given the same pre-slaughter treatment. Also, the establishment of a standard viscera percentage seems rather invalid because of the biological variability of animals. However, if a viscera percentage is to be used in adjusting for a live weight, it would be more valid to use a value determined from data concerning breed and grade within breed differences than it would be to apply a standard

viscera percentage figure to all animals regardless of breed or carcass grade.

CHAPTER V

SUMMARY AND CONCLUSIONS

Detailed offal information was obtained from 133 steers representing six breeds and five U.S.D.A. carcass grades. The animals were raised under the same environmental conditions from approximately four months of age and full fed a high concentrate ration to twenty months of age or 900 pounds, whichever was reached first. All animals received a twenty-four hour pre-slaughter shrinkage without feed or water. Detailed percentages and actual weights of offal components are presented in the Appendix Tables.

In analyzing breed differences in full offal components, highly significant differences were found in percentages of rumen, reticulum and esophagus, omasum and abomasum, small and large intestines, ruffle and caul fat, total gastrointestinal tract, hide and viscera. The grade within breed differences for omasum and abomasum, small and large intestines, total gastrointestinal tract and liver, were not statistically significant.

Definite trends in percentages of offal components were observed for the types and breeds studied. As the percentage of Brahman breeding increased, the percentage of hide increased while the percentages of total viscera and pre-slaughter shrinkage decreased. The Holstein and Jersey dairy breeds, with few exceptions, exhibited higher offal component percentages than the beef breeds.

The percentages of pre-slaughter shrink and cooler shrink are

generally larger for the lower grading breeds than the higher grading breeds.

Highly significant differences were observed among breeds and among carcass grades when hot carcass weight was divided into the average viscera and viscera plus twenty-four hour pre-slaughter shrink weight. Also, the among breed percentages for these two variables had a wider range than the among grade percentages. When breed differences are considered the adjustment for live weight, by using a standard viscera percentage, is subject to error.

The data presented in this thesis indicate that there are large and significant breed differences existing in percentages of offal components.

CRANES CREST

LITERATURE CITED

LITERATURE CITED

Black, W. H., A. T. Semple and J. L. Lush. 1934. Beef production and quality as influenced by crossing Brahman with Hereford and Shorthorn cattle. U.S.D.A. Tech. Bul. 417.

Butler, O. D., R. L. Reddish, G. T. King and R. L. Simms. 1956. Factors contributing to the difference in dressing percentage between Hereford and Brahman X Hereford steers. J. Animal Sci. 15:523.

Carpenter, J. W., A. Z. Palmer, W. G. Kirk, F. M. Peacock and M. Koger. 1961. Slaughter and carcass characteristics of Brahman and Brahman-Shorthorn crossbred steers. J. Animal Sci. 20:336.

Deans, R. J. 1951. A recommended procedure for slaughtering experimental cattle. Report of Proceedings Fourth Annual Reciprocal Meat Conference.

Grossman, J. D., DVM. 1949. Form, development and topography of the stomach of the ox. J. Amer. Vet. Med. Assoc. 114:416.

Kesler, E. M., Magnar Ronning and C. B. Knodt. 1951. Some physical characteristics of the tissue and contents of the rumen, abomasum and intestines in male Holstein calves of various ages. J. Animal Sci. 10:969.

Kraybill, H. F., R. L. Hiner and V. M. Farnworth. 1954. The relationship of organ weights to lean body mass and empty body weights in cattle. J. Animal Sci. 13:548.

Moulton, C. R., P. F. Trowbridge and L. D. Haigh. 1922. Changes in proportions of carcass and offal on different planes of nutrition. Missouri Agr. Exp. Stat. Bul. 54.

Saffle, R. L. and J. W. Cole. 1960. Fasting effects on dressed yields, shrinkage, and pH of contractile tissue in swine. J. Animal Sci. 19:242.

Snedecor, George W. 1956. Statistical Methods. Fifth edition. The Iowa State College Press, Ames, Iowa.

Sweet, W. W., R. R. Graves, and F. W. Miller. 1928. Comparison of conformation, anatomy and skeletal structure of a highly specialized dairy cow and a highly specialized beef cow. J. Agr. Research. 37:685.

Swift and Company. 1936. Cattle by-products. Agr. Research Bul. 6.

Walton, G. P. and R. F. Gardiner. 1934. Conservation of waste from the small scale slaughter of meat animals. U.S.D.A. Circ. 63.

Wardrop, I. D. 1960. The post-natal growth of the visceral organs of the lamb. J. Agr. Sci. 55:127.

Warner, R. G., W. P. Flatt and J. K. Loosli. 1956. Dietary factors influencing the development of the ruminant stomach. J. Agr. and Food Chem. 4:788.

Ziegler, P. T. 1958. The Meat We Eat. Fifth edition. The Interstate Printers and Publishers, Danville, Illinois.

APPENDIX

APPENDIX TABLE I

AVERAGE PERCENT OF FULL AND EMPTY GASTROINTESTINAL COMPONENTS BY BREED, BASED ON KILL WEIGHT

Breed	No. of animals	Kill wt.	Rumen, reticulum and esophagus		Omasum		Abomasum		Small intestine		Large intestine		Ruffle fat and pancreas	Caul Fat	Total G.I. tract with fat and pancreas	
			F	E	F	E	F	E	F	E	F	E			F	E
Hereford	27	832	6.9	1.6	1.4	.62	.52	.32	1.6	1.1	1.3	1.0	1.6	2.2	15.6	4.3
Angus	23	803	7.2	1.7	1.4	.64	.55	.35	1.7	1.2	1.3	0.9	1.7	2.2	16.1	4.5
Brahman	16	779	7.1	1.6	1.1	.44	.60	.32	1.7	1.0	1.6	1.2	1.7	1.5	15.0	4.1
Brahman X	10	835	7.3	1.7	1.1	.56	.72	.36	1.7	1.2	1.3	1.0	1.2	1.5	14.9	4.8
Santa Gert.	12	848	7.2	1.6	1.2	.52	.65	.31	1.6	1.0	1.1	0.9	1.2	2.1	15.2	4.1
Holstein	24	836	8.6	1.8	1.7	.72	.68	.39	2.1	1.3	1.4	1.0	1.6	2.1	18.5	5.2
Jersey	21	735	9.0	1.9	1.9	.76	.88	.47	2.3	1.5	1.6	1.1	2.4	3.0	21.7	4.9
Overall averages for all animals		808	7.6	1.7	1.4	.63	.64	.36	1.8	1.2	1.4	1.0	1.7	2.2	16.9	4.6

APPENDIX TABLE II

AVERAGE PERCENT OF FULL AND EMPTY GASTROINTESTINAL COMPONENTS BY CARCASS GRADE, BASED ON KILL WEIGHT

Carcass grade	No. of animals	Kill wt.	Rumen, reticulum and esophagus		Omasum		Abomasum		Small intestine		Large intestine		Ruffle fat and pancreas	Caul fat	Total G.I. tract with fat and pancreas	
			F	E	F	E	F	E	F	E	F	E			F	E
Prime	2	854	6.6	1.6	1.3	.76	.36	.24	1.3	1.0	1.3	0.9	2.0	2.4	15.3	4.5
Choice	24	825	6.9	1.7	1.4	.62	.52	.34	1.6	1.1	1.3	1.0	1.7	2.4	15.8	4.2
Good	47	831	7.1	1.6	1.4	.60	.58	.33	1.7	1.1	1.3	0.9	1.5	2.1	15.6	4.3
Standard	52	792	8.3	1.8	1.5	.64	.74	.39	2.0	1.3	1.5	1.1	1.9	2.1	18.3	4.8
Utility	8	707	9.6	1.9	1.8	.77	.91	.47	2.3	1.5	1.5	1.1	1.7	1.9	20.0	5.8

APPENDIX TABLE III

AVERAGE PERCENT OF VISCERAL COMPONENTS BY BREED, BASED ON KILL WEIGHT

Breed	No. of animals	Kill wt.	Total G.I. tract with fat and pancreas: 24 hr. shrink G.I. % F	24 hr. shrink G.I. % E	Total G.I. tract with fat and pancreas: off-feed[a] G.I. % F	Heart	Liver	Lungs, trachea and pericardium	Viscera total
Hereford	27	832	15.6	4.3	21.5	.36	1.0	1.4	18.7
Angus	23	803	16.1	4.5	22.7	.37	1.1	1.6	19.5
Brahman	16	779	15.0	4.1	20.1	.29	1.4	1.5	17.2
Brahman X	10	835	14.9	4.8	20.5	.34	1.0	1.4	18.1
Santa Gert.	12	848	15.2	4.1	21.2	.35	1.1	1.3	18.5
Holstein	24	836	18.5	5.2	25.8	.38	1.3	1.6	22.2
Jersey	21	735	21.7	4.9	28.1	.41	1.3	1.6	24.7
Overall averages for all animals		808	16.9	4.6	23.2	.36	1.2	1.5	20.1

[a]Off-feed G.I. percent was derived by adding the difference in off-feed weight minus the kill weight to the twenty-four hour shrink G.I. weight.

APPENDIX TABLE IV

AVERAGE PERCENT OF VISCERAL COMPONENTS BY CARCASS GRADE, BASED ON KILL WEIGHT

Carcass grade	No. of animals	Kill wt.	Total G.I. tract with fat and pancreas: 24 hr. shrink G.I. % F	24 hr. shrink G.I. % E	off-feed[a] G.I. % F	Heart	Liver	Lungs, trachea and pericardium	Viscera total
Prime	2	854	15.3	4.5	21.5	.37	1.0	1.4	18.6
Choice	24	825	15.8	4.2	22.0	.37	1.0	1.5	19.1
Good	47	831	15.7	4.3	22.0	.36	1.1	1.5	18.8
Standard	52	792	18.2	4.8	24.8	.36	1.3	1.5	21.4
Utility	8	707	20.1	5.8	27.2	.41	1.2	1.6	23.9

[a]Off-feed G.I. percent was derived by adding the difference in off-feed weight minus the kill weight to the twenty-four hour shrink G.I. weight.

APPENDIX TABLE V

AVERAGE PERCENT OF OFFAL COMPONENTS OTHER THAN VISCERA BY BREED, BASED ON KILL WEIGHT

Breed	No. of animals	Kill wt.	Blood	Hide	Head				Feet		Tail
					untrimmed	trimmed	tongue	head meat	fore	hind	
Hereford	27	832	3.2	9.1	3.1	2.3	.30	.46	.88	.88	.19
Angus	23	803	3.1	7.4	3.2	2.5	.26	.43	.78	.80	.15
Brahman	16	779	3.1	9.8	3.1	2.6	.24	.25	.92	.94	.24
Brahman X	10	835	3.2	9.4	3.1	2.4	.28	.42	.92	.95	.24
Santa Gert.	12	848	3.3	8.3	3.0	2.3	.29	.33	.89	.92	.21
Holstein	24	836	3.8	7.2	3.4	2.6	.29	.41	.94	.98	.18
Jersey	21	735	3.5	7.0	3.4	2.6	.29	.46	.87	.88	.22
Overall averages for all animals		808	3.3	7.0	3.2	2.5	.28	.41	.88	.90	.20

APPENDIX TABLE VI

AVERAGE PERCENT OF OFFAL COMPONENTS OTHER THAN VISCERA
BY CARCASS GRADE, BASED ON KILL WEIGHT

Carcass grade	No. of animals	Kill wt.	Blood	Hide	Head				Feet		Tail
					untrimmed	trimmed	tongue	head meat	fore	hind	
Prime	2	854	2.8	6.8	2.8	2.3	.18	.31	.68	.72	.14
Choice	24	825	3.1	7.9	3.1	2.4	.29	.47	.82	.83	.16
Good	47	831	3.2	8.6	3.1	2.4	.28	.37	.87	.89	.19
Standard	52	792	3.5	8.1	3.3	2.6	.28	.40	.92	.95	.21
Utility	8	707	3.7	7.9	3.6	2.8	.30	.46	.98	1.00	.23

APPENDIX TABLE VII

AVERAGE WEIGHTS OF OFFAL COMPONENTS BY BREED[a]

Breed	No. of animals	Rumen, reticulum, and esophagus		Omasum		Abomasum		Small intestine		Large intestine		Ruffle fat and pancreas	Caul fat
		F	E	F	E	F	E	F	E	F	E		
Hereford	27	57.7	13.3	11.5	5.2	4.3	2.3	13.4	9.3	10.7	8.2	13.1	18.4
Angus	23	57.6	13.9	11.4	5.2	4.4	2.3	13.4	9.6	10.3	7.4	14.2	17.6
Brahman	16	55.2	12.6	8.3	3.4	4.6	2.5	13.0	8.0	12.4	9.1	13.2	11.5
Brahman X	10	60.7	14.3	9.2	4.7	6.0	3.0	14.4	10.1	10.9	8.2	10.2	12.7
Santa Gert.	12	61.1	13.8	10.3	4.4	5.5	2.6	14.0	8.7	9.2	7.4	10.4	18.1
Holstein	24	71.9	15.4	14.3	6.0	5.7	3.3	17.8	11.2	11.7	8.6	13.9	17.8
Jersey	21	66.2	13.6	13.9	5.6	6.4	3.5	16.9	11.0	11.5	8.5	17.9	22.1
Overall averages for all animals		61.8	13.9	11.7	5.1	5.2	2.9	14.8	9.8	11.0	8.2	13.7	17.5

APPENDIX TABLE VII (continued)

Breed	Small and large intestines with fat	Total G.I. tract without fat and pancreas		Stomach four compts.	Heart	Liver	Lungs, trachea and pericardium	Spleen
		F	E					
Hereford	36.7	98.1	36.0	73.5	3.0	8.3	11.6	1.5
Angus	37.6	97.2	36.4	73.4	3.0	8.8	12.5	1.2
Brahman	31.2	92.2	31.8	68.1	2.3	10.5	11.4	1.7
Brahman X	35.7	101.3	40.2	75.9	2.9	8.6	11.5	1.8
Santa Gert.	39.5	100.1	34.6	76.9	3.0	9.5	11.4	1.7
Holstein	43.5	122.7	43.4	87.4	3.2	10.8	13.8	1.8
Jersey	46.4	119.4	35.8	82.1	3.0	9.6	11.8	1.6
Overall averages for all animals	38.5	105.4	37.0	77.2	2.9	9.4	12.1	1.6

APPENDIX TABLE VII (continued)

Breed	Blood	Viscera	Hide	Head				Feet		Penis	Tail
				untrimmed	trimmed	tongue	head meat	fore	hind		
Hereford	26.9	156.0	76.6	25.8	19.4	2.6	3.8	7.3	7.4	.8	1.6
Angus	24.6	156.9	59.2	25.6	20.0	2.1	3.5	6.3	6.5	.6	1.2
Brahman	24.5	134.4	76.0	24.0	20.0	1.9	2.0	7.2	7.3	.6	1.8
Brahman X	26.9	151.2	78.8	26.0	20.1	2.3	3.5	7.7	8.0	.7	2.0
Santa Gert.	28.2	156.8	70.4	25.2	19.8	2.4	2.8	7.5	7.8	.8	1.8
Holstein	31.6	185.7	60.6	28.2	22.1	2.5	3.4	7.9	8.2	.6	1.5
Jersey	25.8	181.6	51.7	25.1	19.4	2.1	3.4	6.4	6.5	.6	1.6
Overall averages for all animals	27.0	162.6	66.3	25.8	20.2	2.3	3.3	7.1	7.3	.7	1.6

[a]All weights are in pounds.

APPENDIX TABLE VIII

AVERAGE WEIGHTS OF OFFAL COMPONENTS BY CARCASS GRADE[a]

Carcass grade	No. of animals	Rumen, reticulum and esophagus		Omasum		Abomasum		Small intestine		Large intestine		Ruffle fat and pancreas	Caul fat
		F	E	F	E	F	E	F	E	F	E		
Prime	2	56.7	13.2	11.0	6.5	3.0	2.0	11.4	8.5	10.7	8.0	17.4	20.8
Choice	24	57.1	13.7	11.3	5.1	4.3	2.8	13.4	9.5	10.4	8.1	14.0	19.7
Good	47	58.9	13.5	11.3	5.0	4.8	2.8	13.9	9.3	10.6	7.9	12.6	17.5
Standard	52	65.9	14.4	12.1	5.0	5.8	3.1	16.2	10.4	11.8	8.7	14.7	16.8
Utility	8	68.1	13.7	13.0	5.4	6.5	3.3	16.3	10.7	10.4	7.8	11.8	13.8

APPENDIX TABLE VIII (continued)

Carcass grade	Small and large intestines with fat	Total G.I. tract without fat and pancreas		Stomach four compts.	Heart	Liver	Lungs, trachea and pericardium	Spleen
		F	E					
Prime	39.0	92.9	38.3	70.8	3.1	8.9	12.3	1.0
Choice	37.2	96.6	34.5	72.7	3.1	8.7	12.0	1.3
Good	37.0	100.2	36.2	75.0	3.0	9.0	12.5	1.6
Standard	40.6	112.6	38.3	80.0	2.8	10.4	12.0	1.7
Utility	38.4	116.6	41.0	87.6	2.9	8.8	11.3	1.6

APPENDIX TABLE VIII (continued)

Carcass grade	Blood	Viscera	Hide	Head				Feet		Penis	Tail
				untrimmed	trimmed	tongue	head meat	fore	hind		
Prime	23.6	158.7	57.7	24.2	19.7	1.5	2.6	5.8	6.1	.6	1.2
Choice	25.3	158.0	65.2	25.7	19.4	2.4	3.9	6.7	6.8	.7	1.3
Good	27.0	156.4	71.6	25.7	20.2	2.4	3.1	7.2	7.4	.7	1.6
Standard	28.1	169.6	64.0	26.1	20.5	2.2	3.2	7.3	7.5	.7	1.7
Utility	26.0	169.1	55.7	25.4	20.0	2.1	3.3	6.9	7.1	.7	1.6

[a]All weights are in pounds.