FACTORS INFLUENCING YIELD OF SELECTED BY-PRODUCTS OF CATTLE SLAUGHTER WITH APPLICATION TO MARKETING BY CARCASS WEIGHT AND GRADE

by

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INTRODUCTION

General

In our present organized society of specialized production, agricultural products are seldom marketed directly to consumers. This is particularly true of meat and other products yielded from livestock slaughter. Livestock to be converted into meat are usually purchased and slaughtered by a commercial packer and pass through several transportation and service agencies before reaching final consumption. In this round-about system of production, consumer preferences for different products from livestock slaughter are reflected back from the retail meat market through the packer to the farmer by the pricing system. It is in response to this derived demand that farmers allocate their production resources. Thus, it is important that the method of marketing slaughter livestock accurately reflect back to the farmer consumer preferences for livestock products.

In this interest, consideration has been given to the system of marketing slaughter livestock by carcass weight and grade. Under this system of marketing, payments for livestock are made after slaughter and prices are based on the actual carcass weight and grade. In the present marketing system, prices are determined before slaughter and are based upon an estimated value of carcasses and by-products. Thus it is thought that the differences in value to the packer of different animals would be more accurately reflected back to farmers in the system of marketing by carcass weight and grade.

This marketing system is actually used in at least one packing plant in the United States and more extensively in other countries. The Shen-Valley Meat Packers, a cooperative meat packing plant in Virginia, has been buying all kinds of slaughter livestock by carcass weight and grade since 1949.[1] The system is used to market slaughter hogs in Sweden, Denmark, England, and Canada.[2] The National Advisory Beef Committee of Canada has recommended that beef cattle also be marketed by carcass weight and grade.[3] This is evidence at least that marketing by carcass weight and grade is adaptable to the marketing situation for some kinds of slaughter livestock in Sweden, Denmark, England, and Canada. However, it is recognized that marketing conditions in these countries are not entirely comparable to that found in the United States. Therefore, research work has been initiated to determine the desirability and practicability of marketing slaughter livestock by carcass weight and grade in this country.

In 1947, the North Central Livestock Marketing Research Committee in the United States set up the Cooperative Regional Research Project, "Marketing Slaughter Livestock by Carcass Weight and Grade." Ten state agriculture experiment stations

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1/"Cooperative Opens Modern Plant in Western Virginia" The National Provisioner, November 5, 1949, p. 15.

2/Shepherd, Geoffery, Livestock Marketing Methods in Denmark, Great Britian, and Canada (Iowa Agr. Expt. Sta. Bul. 353), January 1937, p. 160.

3/Report of the Sub-committee, The Practicability of Selling Cattle by Carcass Weight and Grade (Minister of Agriculture), March, 1942.

have been participating in this project, each studying the specie of livestock to which it is particularly adapted. At present, the marketing of slaughter cattle, hogs, veal calves, sheep and lambs by carcass weight and grade are each being studied by one or more state experiment stations.[1] The Kansas Station has been cooperating on the sub-project, "Marketing Slaughter Cattle by Carcass Weight and Grade."

The specific objectives of the Cooperative Regional Research Project as taken from the Project Outline are stated below.[2]

1. To determine how accurately the present method of marketing slaughter livestock in the United States reflects back to producers the differences in value to the packer of different animals.

2. To determine how accurately a system of sale by carcass weight and grade reflects these differences in value of slaughter livestock to producers.

3. To determine the economic and physical problems involved in marketing slaughter livestock by carcass weight and grade and possible solutions to these problems.

To achieve these objectives, consideration must be given to the reflection back to farmers of the value of by-products as well as carcasses. This is evident since both carcasses and by-products from livestock slaughter contribute to the value of animals to the packer. Tables 1 and 2 indicate the proportion of total income to packers attributed by meat and by-products.

1/Interim Report, Cooperative Regional Project NCM-3, February 1, 1950, pp. 1 and 2.

2/Project Outline, Cooperative Regional Research Project, (NCM-3), "Marketing Slaughter Livestock by Carcass Weight and Grade," North Central Regional Livestock Marketing Committee, 1947.

Table 1. Proportion of total income from by-products of different species of livestock in large packing plants.[1]

	Percentage income from meat	Percentage from all by-products including hide	Percentage income from hide or pelt
Sheep	81.4	18.6	14.5
Steer	87.3	12.7	8.6
Calf	92.8	7.2	Sold with carcass
Hog	96.6	3.4	Sold with carcass

1/Data from Readings on By-Products of the Packing Industry, University of Chicago (Chicago, Illinois, 1941), p. 10.

Table 2. Proportion of total income from by products of steers in a cooperating packing plant.[1]

	Percentage income from meat	Percentage income from hide	Percentage income from oleo fat	Percentage income from offal[2]
Steer	90.84	4.88	.77	3.51

1/Data calculated from individual slaughter test sheets of 140 steers in a cooperating packing plant.

2/Offal includes the credit given for all by-product items other than hide and oleo fat.

It will be noted from the tables that by-products are particularly important in the marketing of slaughter cattle. The value of by-products from slaughter cattle usually exceeds the cost of buying, slaughtering, processing, and selling of beef carcasses as well as by-products.[1] Consequently, before the

1/Dowell, Austin A., Gerald Engelman, Evan F. Ferrin, and Phillip A. Anderson. Marketing Slaughter Cattle by Carcass Weight and Grade (Minnesota Agr. Expt. Sta. Tech. Bul. 181), February, 1949, p. 39.

desirability and practicability of marketing slaughter cattle by carcass weight and grade can be determined, consideration should be given as to how the value of by-products are refelcted back to farmers under the carcass weight and grade system.

Research directed toward this end has been included in the Cooperative Regional Research Projects. This research will consist mostly of an analysis of all the data collected on selected by-products by cooperating states. Through this analysis, an attempt will be made to determine defferential by-product credits which should be allowed for carcasses of different classes, weights, and grades. The by-product study presented in this thesis is in cooperation with and a part of this larger regional study.

Review of Literature

Research on cattle slaughter by-products in connection with the regional carcass weight and grade project has been the principal source of literature which has particular application to this study. Three major studies on marketing slaughter cattle by carcass weight and grade have been published and each included limited research on by-products. These studies were: 1. "The Practicability of Selling Cattle by Carcass Grade and Weight" made by the Canadian National Advisory Beef Committee, 2. "Marketing Slaughter Cattle by Carcass Weight and Grade" published in 1949 at the Minnesota Agriculture Experiment Station in connection with the Cooperative Regional Research Project, 3. "Marketing Slaughter Steers by Carcass Weight and Grade", a master's

thesis written in 1949 at Kansas State College by Glen Allen.

Table 3 was taken from the report of the Canadian Study.[1] The weights of the various items were taken from the yield card made up by Swift and Company of Chicago. It was stated in the report, "In order to check on the Chicago standards, 22 animals were checked through the packing plant and the results agreed with these standards." The prices used in the table were the current prices received by packers in Vancouver during February, 1942. The following observation is quoted from the Canadian Report.[2]

> In this study with cattle selling at 9 to 10 cents per pound live weight the hide and fancy meat had a value of from 8.5 to 10 per cent of the value of the animal. The percentage value was slightly higher with small animals than with large animals, mainly because the hide of small animals is heavier in proportion to the body weight than is the hide of larger animals.

In the study made at Minnesota on marketing slaughter cattle by carcass weight and grade, physical data on hides were obtained.[3] The identity of each hide was maintained. The following paragraph describes the procedure used for analysis of hide data. The tentative results indicated in the latter portion of the quote has particular bearing upon this study.[4]

1/Report of Sub-Committee, op. cit., p. 9.

2/Ibid., p. 8

3/Dowell, A. A., Gerald Engelman, Evan F. Ferrin, and Phillip A. Anderson, op. cit., p. 40.

4/Ibid., p. 40.

Table 3. Hide and fancy meat values.[1]

Live weight of animals	Hide			Heart			Liver		
	Wt.	Value per lb.	Total value	Wt.	Value per lb.	Total value	Wt.	Value per lb.	Total value
		$	$		$	$		$	$
500-599	39	.095	3.70	2.2	.05	0.11	5.2	.12	0.62
600-699	46	.095	4.37	2.6	.05	0.13	6.2	.12	0.74
700-799	53	.095	5.03	3.0	.05	0.15	7.1	.12	0.85
800-899	58	.095	5.51	3.4	.05	0.17	8.1	.12	0.97
900-999	65	.095	6.17	3.8	.05	0.19	9.0	.12	1.08
1,000-1,099	69	.095	6.55	4.2	.05	0.21	10.0	.12	1.20
1,100-1,199	76	.095	7.22	4.6	.05	0.23	10.9	.12	1.31

1/Report of Sub-Committee, op. cit. p. 9.

Table 3. (concl.)

Live weight of animals	Tongue			Head meats			Total value
	Wt.	Value per lb.	Total value	Wt.	Value per lb.	Total value	
		$	$		$	$	$
500-599	2.1	.115	0.24	2.8	.075	0.21	4.88
600-699	2.5	.115	0.29	3.3	.075	0.25	5.78
700-799	2.9	.115	0.33	3.8	.075	0.28	6.64
800-899	3.3	.115	0.38	4.3	.075	0.32	7.35
900-999	3.7	.115	0.42	4.7	.075	0.35	8.21
1,000-1,099	4.1	.115	0.47	5.3	.075	0.40	8.83
1,100-1,199	4.5	.115	0.51	5.8	.075	0.43	9.70

> Scatter diagrams were prepared in which individual hide weights were plotted against individual live weights and individual carcass weights for steers, heifers, and cows combined, for each class separately, and for the different grades and breeds within each class. In all of the scatter diagrams there was a tendency for the weight of hides to increase with the increase in the weight of the animals. When steers, heifers, and cows were combined the positive relationship was pronounced but there was considerable scatter about the regression line. The scatter was reduced when the data were segregated on the basis of the sex, breed, and grade of the animals, but the number of individuals in many categories was too small to permit an accurate determination of the effect of each separate factor.

A scatter diagram of hide weights on live weight from 69 good grade Hereford steers was presented in the bulletin. The regression line was definitely positive which merely indicated that the hide weights increased with the weight of the animal. However, it was noted that even though the diagram included only steers of the Hereford breed that yielded carcasses in the good grade, hide weights at any particular live weight would be expected to fall within a range of 4.4 pounds above or below the regression line one-half of the time.[1] If nothing else, this indicated a high degree of variability among hide weights.

Glen Allen, in a thesis on "Marketing Slaughter Steers by Carcass Weight and Grade,"[2] made a preliminary study on the variability of hide and oleo fat yields from 140 steers which were analyzed in his study. He indicated the variability of hide

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1/Ibid., p. 41.

2/Allen, Glen, Marketing Slaughter Steers by Carcass Grade and Weight. (Master's Thesis, Kansas State College) 1949, pp. 52-53.

weights by making dot charts of hide weight on live weight for all grades containing 14 or more steers. He presented the following table to indicate the variability among oleo fat yields within one-third of carcass grades.

Table 4. The mean fat weight and standard deviation by carcass grade, 140 head of steers.[1]

Carcass grade	Number of head	Mean (pounds)	Standard deviation
AA 2	1	16.50	---
AA 3	1	28.75	---
A 1	14	23.71	8.92
A 2	16	21.95	4.89
A 3	40	18.77	4.29
B 1	21	17.75	5.12
B 2	20	16.24	4.79
B 3	1	12.25	---
C 3	4	8.19	---
D 1	21	7.42	1.84
E 1	1	5.75	---

1/Ibid., p. 53.

Allen's conclusions of his analysis of hide and oleo fat yields are quoted in the following paragraph.

> As a result of these preliminary studies, it is the writer's opinion that any variability studies of this type should be done in accordance to grade, sex, live weight and the season of the year before any conclusions are reached.

The whole tenor of literature making reference to by-products in connection with marketing by carcass weight and grade

is summed up in the following quote from Engelman.[1]

> Another broad area of investigation is an analysis of the by-products from the slaughter process. Of these the most important are the hide in cattle and calves and the pelt in lambs. The composite value of these and other by-products generally exceeds the cost of slaughtering and thus provides an incremental value above that of the carcass alone . . . Since the value contribution of these by-products, particularly the internal fats and edible organs, might vary considerably by grade, weight and sex of the animal, there would be considerable merit, therefore, in determining the approximate yields of the various by-products in order that differential credits by grade, and possibly by sex, can be calculated.

Definition of Terms

Live Weight System of Marketing. A system in which prices are based on the live weight and a given price per hundred-weight; the method now practiced in the United States.

Carcass Weight and Grade System of Marketing. A system in which price is based on the actual carcass weight and grade. Grading is done by an unbiased grader. Each packer sets up his own price differentials for the various grades. Also referred to as "rail grade and weight" and "dead weight and grade".

Carcass Weight. The weight of the carcass after cooling for a 24 hour period. For this study, it is the weight of the hot carcass immediately preceding shrouding, arbitrarily shrunk 2.13 percent. The percentage was furnished by the cooperating packer.

1/Engelman, Gerald, Carcass Grade and Weight Studies in Marketing Livestock. (Journal of Farm Economics) 29 (II) p. 426. November, 1947.

Carcass Grade. Referred to as "grade" throughout the thesis.

(1) Official - the grade of the cold carcass as determined by a grader employed by the Production and Marketing Administration, U. S. Department of Agriculture. Grading was done according to standards determined by that authority.[1] U. S. grade is referred to in this study as a "full grade".

U. S. grade name	Symbols used	
	Full grade	1/3 grade
Choice	AA	AA 1 AA 2 AA 3
Good	A	A 1 A 2 A 3
Commercial	B	B 1 B 2 B 3
Utility	C	C 1 C 2 C 3
Cutter	D	D 1 D 2 D 3
Canner	E	E 1 E 2 E 3

1/"Amendment No. 1 To Service and Regulatory Announcements No. 99, Official United States Standards for Grade of Carcass Beef," Agricultural Marketing Service, U. S. Dept. of Agr., July, 1939.

OBJECTIVES OF STUDY

The necessity of considering the value of by-products as well as carcasses in achieving the objectives of the Cooperative Regional Research Project has been previously emphasized. Therefore, the objectives of by-product research in connection with the regional project should be these same objectives except with reference only to by-products. These objectives for by-product research would then read: 1. To determine how accurately the present method of marketing reflects back to farmers the differences in value to the packer of by-products from different animals. 2. To determine how accurately a system of sale by carcass weight and grade reflects these differences in value of by-products to farmers. 3. To determine the economic and physical problems of by-products involved in marketing by carcass weight and grade and possible solutions to these problems. Such information is in part what will be needed to determine the desirability and practicability of marketing slaughter livestock by carcass weight and grade.

However, it has been observed that research on by-products need not necessarily be seriously concerned with all three of these objectives. Since by-product credits are used under the present system of marketing, no new problem due to such credits should arise under marketing by carcass weight and grade.[1] Consequently, without any further research on by-products, the reflection back to farmers of the value of by-products should be

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1/Dowell, Austin A., Gerald Engelman, Evan F. Ferrin, and Phillip A. Anderson op. cit. p. 53.

at least as accurate under the carcass method as such reflections are now under the live weight method. Therefore, research on by-products in connection with marketing by carcass weight and grade has generally been directed toward obtaining accurate by-product credits to be used under the carcass method. This has resulted from the general belief that the only practical way under any system of marketing of reflecting back to farmers the value of by-products to packers is through credits in prices offered to farmers.

Thus, the research on by-products in the Cooperative Regional Research Project has been planned to consist mostly of an analysis of all the data collected on selected by-products by the cooperating states. Through this analysis, an attempt will be made to determine differential by-product credits which should be allowed for carcasses of different classes, weights and grades. In line with this specific objective of the Regional Project, the general purpose of the present study was to serve as a guide to this regional analysis of by-product data--to indicate methods and procedures to be used and trends of results.

In lieu of these purposes and resources of data available for this study, the following objectives were chosen:

1. To study by-product credits under live weight and carcass weight and grade marketing systems.

2. To determine methods of analyzing by-product data which achieve results most applicable to marketing by carcass weight and grade.

3. To determine factors which significantly influence yields of hide and oleo fat from cattle slaughter.

4. To express estimated hide and oleo fat yields in the most applicable form for determining the value contribution of these two items per hundred pounds carcass weight.

LIMITATIONS

As noted from the objectives in the previous section, the statistical part of this study was limited to only hide and oleo fat by-products from cattle slaughter. This limitation is not as serious as might be expected since these two items generally amount to more than 60 percent of the total value of by-products from cattle slaughter.[1] Also, it is questionable whether it is practicable to obtain weights of any other individual by-product items for research purposes, since the variability of such items from different carcasses is probably economically insignificant. It is only when the value of these numerous by-product items other than hide and oleo are totaled that they become economically significant.

Likewise, as noted from the objectives, this study does not attempt to determine the actual monetary value of hides and oleo fat which should be credited to carcasses of different weight and grade. Such monetary determinations are not necessary or

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1/Table 2.

practical in research of this kind except perhaps for illustrative purposes. For by-product research to be applicable to marketing by carcass weight and grade, it is only necessary to express estimated yields of by-products in such a form so that current prices can be conveniently applied to determine the value of the by-product per hundred pounds carcass weight.

More serious limitations to this study occur because of the quantity and distribution of hide and oleo fat data available. For this reason, the analysis of hide and oleo fat yields was limited to steers and heifers of the Hereford breed. Data from lower grades were lacking so that analysis of hide and oleo fat yields from utility, cutter, and canner grades could not be considered. The quantity of data from extreme weights of carcasses was also lacking.

Thus, tests to determine factors which significantly influence hide and oleo fat yields were weakened in some cases because of the limitation of the data available. This was particularly true in testing the influence of breed on hide and oleo fat yields. More specific limitations and weaknesses of analysis will be mentioned in connection with the particular analysis concerned.

METHOD OF PROCEDURE

Referring to the first objective only general information was available in published materials for the study of by-product credits under the live weight and carcass system. Through correspondence with some of the major packers, an attempt was made to

obtain more detailed information on how by-product credits are determined and reflected back to farmers under the present system. Considerable information on this subject was also obtained from direct contact with a cooperating packer. Through further correspondence, information was obtained on how by-product credits were handled wherever marketing slaughter cattle by carcass weight and grade is or has been practiced. Some general information was available in published materials on how by-product credits for slaughter cattle would be reflected under the carcass system of marketing.

Source of Hide and Oleo Fat Data

The hide and oleo fat weights used in the statistical portion of this study were collected by the Kansas Agricultural Experiment Station in connection with the research project, "Marketing Slaughter Cattle by Carcass Weight and Grade." This research project began in 1948 with a study conducted by Glen Allen on marketing slaughter steers by carcass weight and grade.[1] The following year John Dotson collected data for the project on slaughter heifers. The writer attempted to collect similar data on slaughter steers, heifers and cows. The data used in this study were accumulated from these several years' work on the carcass weight and grade project at the Kansas Station. Hide and oleo fat weights were obtained from the same animals used in

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1/Allen, Glen op. cit.

this carcass marketing project so that the hide weight, oleo fat weight, live weight, carcass weight, carcass grade, and other information was recorded for each animal.

The collection of such data was made possible through the cooperation of a commercial meat packer. Each animal was followed through the buying, slaughtering, and grading process at the plant. Numbers on metal ear tags were used to identify the live animal through to the skinning operation of the killing floor unless the animals were already numbered by branding. This metal tag or brand number was then used to identify the hide after skinning. After skinning, a water proofed manila tag containing the same number as the metal ear tag was attached to the carcass by a metal clip. Another manila tag was placed in the offal cart. In this way the identity of each desired item was maintained.

Any disease condemnations of carcasses or internal organs, and weight of trim for bruises were recorded while on the killing floor. Men working in the hide cellar and offal room recorded weights of individual hides and oleo fat weights from each animal. The hot carcass weight was likewise obtained. The hot carcass weight was shrunk 2.13 per cent to arrive at the weight of the carcass after cooling.

These data were either originally recorded on or transferred to 4 by 6 inch cards. The information form on these cards used to record the above data is shown in Appendix A.

To facilitate analysis, desired information on each animal was transferred to a summary card, Form VI, Appendix A.

Procedure and Method of Analyzing By-Product Data

It was generally evident in all of the by-product research cited previously that hide and oleo fat yields are extremely variable. Yields of hide and oleo fat from cattle producing carcasses of the same weight and grade were shown to vary considerably. Allen concluded from his study that other factors such as breed, sex, and season of the year may cause part of this variability.[1] Consequently, one of the objectives of this study was to determine if these factors in addition to grade and weight do have an effect on hide and oleo fat yields. The first step in this analysis was to classify the cattle from which hide, oleo, and carcass weights were obtained into groups according to breed, sex, season of the year slaughtered and grade of carcass yielded. By comparing hide and oleo yields from cattle in two classified groups which differed only with respect to one factor, the effect of this one factor on hide and oleo yields might be estimated. For example, hide weights from Hereford steers slaughtered in the winter which yielded carcasses grading good were compared with hide weights from other Hereford steers slaughtered in the winter which yielded carcasses grading commercial. If the difference between the means of the hide weights from each group was found to be statistically significant, then it was concluded that the difference in hide weights was associated with good and commercial

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1/Allen, Glen, Loc. cit., p. 53.

carcass grades. The same procedure was used to test the effect of other factors; e.g., breed, sex and season of slaughter on hide weights as well as oleo fat weights.

It was recognized that differences in hide and oleo fat weights between two such classified groups might be caused in part or completely by differences in the weights of cattle within each group. Upon recognizing this, a problem arose as to how this possible influence could be eliminated or held constant when testing the effect of factors other than weight of the animal. Since one of the objectives of this thesis was to study methods of analyzing by-product yields, two methods of analysis were developed in this study. Each provides a procedure for determining what factors significantly affect hide and oleo yields.

One of these methods involved further classification of the test cattle into groups according to arbitrarily set carcass weight intervals. Carcass weights were used instead of live weights in order to be more applicable to marketing by carcass weight and grade. Table 5 illustrates how the test cattle used in this study were classified when using this method.

From this classification of test cattle, hide and oleo fat weights were recorded into fairly homogeneous groups with respect to the factors considered in this study. Such grouping allowed tests to be made of the influence of each factor upon hide or oleo yields. For example, (Table 5), it was possible to compare hide and oleo yields from cattle groups A, B, C, D, E, F, G, H, etc. and study the relationship of these by-products yields to carcass weight. The t-test was used when testing for significant

Table 5. Classification of data when analyzing effect of factors on hide or oleo yields by carcass weight intervals.

Carcass grade 6/	Hereford 1/															
	Steer 2/								Heifer							
	Winter 3/				Summer				Winter				Summer			
	Carcass weight intervals 4/				Carcass weight intervals				Carcass weight intervals				Carcass weight intervals			
	300-399	400-499	500-599	600-699	300-399	400-499	500-599	600-699	300-399	400-499	500-599	600-699	300-399	400-499	500-599	600-699
Choice																
Good	A5/	B	C	D	E	F	G	H								
Commercial	I	J	K	L	M	N	O	P								
Utility	Q	S			U											
Cutter	R	T			V											
Canner																

1/Each breed would be classified in the groups shown by the table.
2/A division for cows would be made if such data were available.
3/In this study, November through April was classed as winter and the other months as summer.
4/These carcass weight intervals should be made as small as quantity and distribution of data will allow.
5/These capital letters are for explanatory purposes only.
6/One-third carcass grades should be considered if the quantity of data is sufficient to make practical this further classification.

differences between means of two groups of hide or oleo weights.[1] The analysis of variance was used when means of more than two groups were being compared.[2] If differences between the means of data from carcasses in different weight intervals but alike as to other factors were found to be non-significant, then it was concluded that carcass weight had little influence on hide or oleo fat weights. The carcass weight intervals could then be eliminated from the classification. If differences between the means were found to be significant, the weight intervals were retained in order to make valid tests of the influence of other factors on hide and oleo fat weight. Carcass weight intervals were needed in order to hold relatively constant the influence of weight of the animal when testing the effect of other factors on hide or oleo yields.

In this way, by comparing hide and oleo yields from similar animals which yielded carcasses in the same weight interval but in different grades, the effect of grade was tested. For example, tests for significance were made of the differences between the means of hide and oleo weights from groups of cattle A, I, Q, and R; B, J, S, and T;[3] etc. in each season for each sex to the extent that data were available. If these differences were significant, it was concluded that grade was a significant factor affecting

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1/Snedecor, George W. Statistical Methods (Iowa State College Press, Ames, Iowa,) pp. 53-57. 1948.

2/Ibid. pp. 214-252.

3/See Table 5 p. 20.

hide or oleo yields.

The effect of season of slaughter was analyzed by testing differences of hide and oleo yields from groups of cattle A and E, I and M, Q and U,[1] and so forth in the other weight intervals within each sex. By a similar procedure, the effect of sex was analyzed, and the effect of breed could have been analyzed if data were available. If any factor was found consistently to have a nonsignificant effect on hide and oleo yields, it was eliminated from the classification, and consequently, from further tests for significance of other factors.

The other method of analysis used in this study to test the effect of different factors on hide and oleo fat yields was the covariance analysis. This is a statistical method used to reduce data from experiments involving two or more variants measured in several groups.[2] In this study, the weight of the by-products and carcass weights were the two variants measured. The classification of the test cattle into groups according to breed, sex, season, and grade as illustrated in Table 6. provided the several groups in which the measured variates were recorded and correlated.

A prerequisite to the use of the covariance method was that a significant correlation exist between the two variates--carcass weight and the by-product weight. If a significant relationship

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1/See Table 5, p. 20.

2/Snedecor, George W., op. cit. p. 318-29.

Table 6. Classification of data when analyzing effect of factors on hide and oleo yields by covariance method.

Grade		Hereford			
		Steer		Heifer	
		Winter	Summer	Winter	Summer
Choice	AA 1				
	AA 2				
	AA 3				
Good	A 1	A	B	C	D
	A 2	E			
	A 3				
Commercial	B 1				
	B 2				
	B 3				
Utility	C 1				
	C 2				
	C 3				
Cutter	D 1				
	D 2				
	D 3				
Canner	E 1				
	E 2				
	E 3				

did not exist between the two variants, then the regular analysis of variance could be used on the data. Physical by-product weights and percentages which these weights were of the respective carcass weights were plotted on carcass weights. For example, referring to Table 6, physical by-product weights and percentage weights, from the groups of cattle A, B, C, D, E, and so forth were plotted on respective carcass weights. From these dot charts it was

determined what kind of relationships, if any, existed between the by-product weights and carcass weights. If physical weights tended to fit a straight line, then the percentages should tend to fit a concave line. The variant, either physical weights or percentages, which had the most significant correlation with carcass weight was used in the analysis.

This significant correlation answered the question as to the influence on hide or oleo yields of the weight of the animal as indicated by carcass weight. In the covariance analysis, this influence was mostly eliminated by testing the significance of differences between hide and oleo weights which were linearly adjusted to a common carcass weight.[1]

The covariance analysis used in this study on hide yields from Hereford steers slaughtered in the winter is presented in Appendix B.

The writer considers the covariance analysis to be advantageous over the weight interval analysis discussed earlier. In the covariance analysis, the data need not be divided into carcass weight groups, thus tests can be made between groups of larger size or more extensively classified groups. Differences in the average carcass weights of groups within the same carcass weight interval may tend to distort the conclusions drawn from the weight interval analysis. Differences in relationships between the by-product weights and carcass weights at different levels of carcass

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1/Snedecor, George W., on. cit. p. 322-3.

weights will not be directly shown by the carcass weight interval analysis and, consequently, the results may appear erratic and inconclusive. However, the weight interval analysis is simplier and is convenient to use in an exploratory analysis of by-product data.

BY-PRODUCT CREDITS UNDER LIVE WEIGHT AND CARCASS SYSTEMS

With the present utilization of by-products from cattle slaughter, the value of by-products to the packer usually exceeds their costs of buying, slaughtering, processing, and selling.[1] This means that packers usually can pay more for live cattle than they receive from the carcasses yielded from cattle when slaughtered. The amount of this by-product credit depends upon the ability of the packer to utilize by-products, the cost of plant operations, and the value of by-products obtained from the live animals concerned. This of course would probably be true under the carcass system as well as the live weight system. The question concerned with in this discussion is how are credits for cattle slaughter by-products determined and reflected back to farmers under the present system of marketing and how would by-product credits probably be determined and reflected under the carcass system of marketing. Such information is a prerequisite to any decision as to the desirability and practicability of the adoption of marketing slaughter cattle by carcass weight and grade in the United States.

1/Dowell, Austin A., Gerald Engelman, Evan F. Ferrin, and Phillip Anderson. op. cit. p. 39.

Under the usual live weight system of marketing slaughter cattle, the value of by-products are reflected back to farmers in the prices offered per hundred pounds live weight. The determination of credits for slaughter cattle products is usually done in the following way. Buyers receive regular test reports of the slaughter record of lots of cattle previously bought by them.[1] These reports include the total amount paid for the cattle, labor charge for slaughtering, value of by-products, carcass weights and grades, and the value of the carcasses to the packer. Losses due to condemnations, bruises, and grubs are usually on these test reports.

The total value of by-products shown on these test reports is usually summarized into three items--hide, oleo, and offal. In the calculation of these three items, the actual weights and grades of hides yielded by lots of cattle bought by buyers are obtained. These weights are multiplied by the current hide prices for each hide grade to determine the total worth to the packer of the hide yielded from lots of cattle purchased. The total weight of oleo fat by lots of cattle purchased are obtained and this weight is multiplied by the current price per pound of oleo. The third by-product item on the test reports is offal credit. This item is the credit given to lots of cattle bought for the value of all by-product items other than oleo and hide. To determine this credit, the packer usually makes a schedule

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1/Dowell, Austin A., Gerald Engelman, Evan F. Ferrin, and Phillip Anderson op. cit. p. 8.

of such credits per hundred pounds live weight or carcass weight. This schedule is determined from tests made from time to time on the yield of these by-product items included in the offal credit from different weights and classes of cattle. Thus, from information on the test reports of previously purchased cattle, packer buyers estimate current differential by-product credits for different kinds and types of cattle. These credits are then taken into consideration in prices offered per hundred pounds live weight.

The above described procedure is at least the general method used by packers to estimate the value of by-products yielded from lots of cattle purchased. Various methods, depending on the size of the packer, are used to instruct the buyer of these by-product credits.

If cattle were marketed by carcass weight and grade, differential by-product credits probably would be reflected in the prices offered per hundred pounds carcass weight.[1] This could be done in the same manner as described above under the live weight system. In fact, the Shen-Valley Meat Packers Incorporated, a packer in the United States that buys cattle by carcass weight and grade, uses this system.[2] The prices offered for different grades of carcasses are adjusted to include the differential value of by-products from animals yielding different weights of

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1/Dowell, Austin A., Gerald Engleman, Evan F. Ferrin, and Phillip Anderson. op. cit. p. 40.

2/Received through correspondence.

carcasses. Average yields of by-products from carcasses of different weights are used to determine the differential value of by-products by weight of carcass.

Thus, it appears that research to increase the accuracy of the determination and reflection of differential by-product credits is important to both systems of marketing. Such research would be in order as part of the effort to increase the accuracy of reflections back to farmers of the differences in value to the packer of different slaughter cattle.

Even one step further than the determination of accurate differential by-product credits might be taken in the interest of accurate payments to farmers for slaughter cattle. At best, these differential by-product credits would be an accurate average. In the long run, farmers would tend to receive accurate reflections for the by-products yielded by their slaughter cattle. However, some inaccurate reflections would still exist on individual lots sold. Thus, it becomes apparent that the only way exact reflections could be made would be to weigh the by-products from each animal or lot of animals purchased. This, of course, would probably be impractical for most by-product items. That is, the cost of weighing, identification, etc. of each by-product item probably would more than exceed the benefits from increased accuracy of reflections made to farmers for the value of by-products. However, the writer is of the opinion that this would not necessarily be true for some of the major by-product items such as hide and oleo fat. Hide weight is obtained per head and oleo fat weight per lot of cattle purchased under the present system for the

purpose of the test reports previously mentioned. Therefore, the cost of making payments for hide and oleo according to actual amounts yielded under the carcass system of marketing would probably not be much more than the present method of reflecting the value of these by-products to farmers.

It should be noted, however, that difficulties of pricing would occur if such a system were used to make payments to farmers for hides and oleo fats under the carcass system. Prices quoted per hundred pounds carcass weight for different carcass grades would not be adjusted for the value of hide and oleo fat. Since special payments would be made on these items, packers would have to quote oleo and hide prices to farmers in addition to carcass prices. This would greatly complicate the decision of farmers in chosing which packer to sell to and also would complicate the reporting of market prices.

Under either system of reflecting the value of by-products, more attention would be given to the value of by-products if slaughter cattle were marketed by carcass weight and grade. Farmers would be able to compare wholesale meat prices with the price they received per hundred pounds carcass weight. Thus farmers would realize more readily the importance of by-products and be more inclined to exert efforts to produce disease and grub free cattle. Packers would be able to identify very accurately the farmers who produced cattle which yielded large quantities of high quality products and offer premium prices to them accordingly.

FACTORS AFFECTING HIDE YIELDS

The variants used in this covariance analysis of factors which significantly affect hide yields were the carcass weight and the percentages which the hide weights were of the carcass weights. These percentages will hereafter be referred to as hide percent or percentages. The number of animals in each group within which these two variants were measured and correlated for this covariance analysis is shown in Table 7. No attempt was made to test for factors which significantly affected the hide yields from the non-Hereford test cattle. The groups of hide weights from the Hereford cattle on which tests were made to determine the influence of certain factors on hide yields will be indicated in the following discussion of each factor.

Carcass Weight

Significant correlations of hide percentages on carcass weights from animals which were identical as to breed, sex, season of slaughter, and grade of carcass yielded indicated that hide yields were associated with the weight of carcass. Table 8 shows the correlation coefficients for all of the tests made within one-third and full carcass grades. The hide percentages tended to decrease as carcass weight increased. The rate of this decrease in hide percentages from certain classified groups of cattle may be noted on Figs. 1 and 2. With this significant correlation and inverse relationship between carcass weights and hide percentages, it was necessary through the method of covariance to

Table 7. Distribution of 418 cattle among classified groups for covariance analysis on factors affecting hide yields.

Grade		Hereford[1]				Non-Hereford			
		Steer		Heifer		Steer		Heifer	
		Winter[2]	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Choice	AA1				3				
	AA2	1	1		3				
	AA3	2	5		5				
Full Grade		3	6	0	11				
Good	A1	11	11		21	1	2	1	
	A2	14	17	3	6	1		1	
	A3	23	35	29	2		2	4	
Full Grade		48	63	32	29	2	4	6	0
Commercial	B1	22	19	23			3	8	
	B2	7	15	39		2	2	9	
	B3			9		3		12	
Full Grade		29	34	71	0	5	5	29	0
Utility	C1			4		1			
	C2					5		3	
	C3					1	4		
Full Grade				4		7	4	3	0
Cutter	D1						20		
	D2								
	D3		1				1		
Full Grade			1				21		
Canner	E1						1		
	E2								
	E3								
Full Grade							1		
Total		80	104	107	40	14	35	38	0

1/"Hereford", as used here, does not denote purebreds but animals in which Hereford breeding tended to predominate.

2/Cattle slaughtered in May through October were recorded in summer season. The other months of the year were included in the winter season.

Table 8. Correlation coefficients of hide percentages on carcass weight in each classified group.

Grade	Hereford							
	Steer				Heifer			
	D/F[1]	Winter	D/F	Summer	D/F	Winter	D/F	Summer
Choice								-.32
A1	9	-.61*	9	-.63*			19	-.51*
Good A2	12	-.45	15	-.16			4	-.31
A3	21	-.83**	33	-.74**	27	-.61**		
B1	20	-.41	17	-.94**	21	-.70**		
Com- B2	5	-.58	13	-.84**	37	-.42**		
mercial B3					7	-.13		

* Significant at 5 percent level of probability.
** Significant at 1 percent level of probability.

1/D/F=Degrees of Freedom.

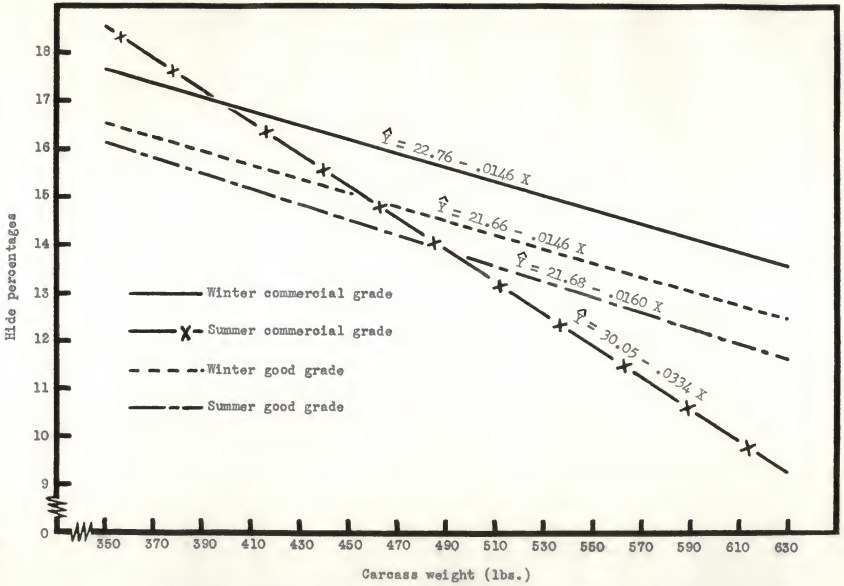

Fig. 1. Hereford steer hide percentages related to carcass weights and classified by season of slaughter and carcass grade.

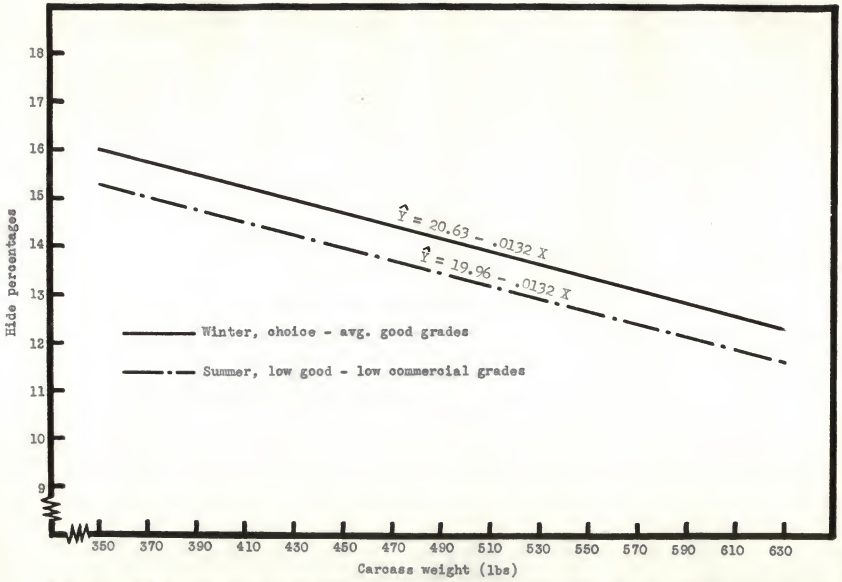

Fig. 2. Hereford heifer hide percentages related to carcass weights and classified by season of slaughter and carcass grade.

adjust for differences in carcass weights between groups of data when testing the influence of other factors.

It may be helpful to express the relationship found between carcass weight and hide yield in physical terms instead of hide percentages. This can be done by merely multiplying the hide percentage by its respective carcass weight. By making these multiplications for several different carcass weights for each grade and season shown in the Figs. 1 and 2, similar figures showing the estimated physical hide weights on carcass weights can be made. Figure 3 is such a figure calculated from the hide percentages shown in Fig. 1.

It will be noted in Fig. 3 that the differences in hide weights from the four groups tended to increase as carcass weight increased. The similar relationship of hide weights to carcass weight of three groups and the irregularity of the sample of hide weights from summer steers grading commercial will also be noted in Fig. 3. Hide weights from these three similar groups tended to increase approximately 7 to 11 pounds per hundred pounds increase in carcass weight. Hide weights from this particular sample of summer steers grading commercial tended to decrease as carcass weight increased in the heavier steers. Because of the nonsignificant differences between the positive regression coefficients of three groups and the significantly different negative regression of hide weights from commercial summer steers, this latter sample is considered by the writer not to be typical of hide weights from commercial steers slaughtered in the summer; e.i., a caprice of sampling.

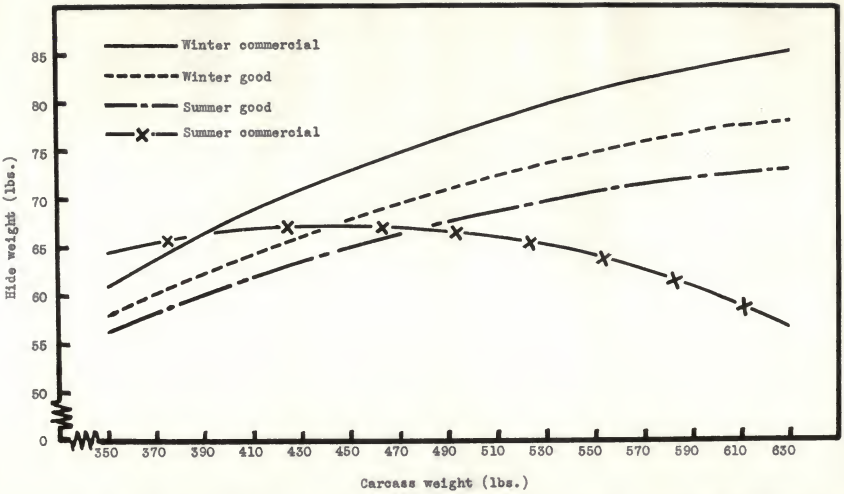

Fig. 3. Steer hide weights related to carcass weights and classified by season of slaughter and carcass grade.

Figure 3 is not presented as accurate estimates of hide yields from respective Hereford steers, but it is only the result of the analysis on hide yields available for this study. It is presented to give a more clear impression of the differences in weights of hides from Hereford steers in different grades and slaughtered in different seasons as found in this study.

Carcass Grade

In this study, one-third grades within a full carcass grade were found not to significantly affect hide yields. These hide percentages were, of course, adjusted for differences in carcass weight. However, significant differences were found in hide percentages after adjusting to a common carcass weight from full grades good and commercial of steers slaughtered in the winter and summer.

The differences in the relationships or regression coefficients of one-third or full grades of steers slaughtered in the winter were not found to be significant. Therefore an average regression calculated from the pooled sum of squares and products was used as the best estimate of the relationship between hide percentages and carcass weights from Hereford steers slaughtered in the winter.[1] Thus the slope of the regression lines for good and commercial grades from steers slaughtered in the winter were the same. These regression lines are shown in Fig. 1. The

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1/See Appendix B, Table 18.

regression coefficients of hide percentages on carcass weights from steers slaughtered in the summer were found to be significantly different. Thus, the regression lines of these two grades have different slopes as shown in Fig. 1.

In physical terms, hide weights from winter steers grading commercial were found to be on the average about 5 pounds heavier than hide weights from steers grading good. In the summer season, a different relationship of hide weights on carcass weights existed between weights of hides from steers grading good and commercial. (Fig. 3) Up to a carcass weight of about 480 pounds the hide weights from commercial grade steers tended to be heavier than hides from the good grade steers. At heavier carcass weights, the hide weights from the good grade steers tended to be heavier.

Tests of the influence of carcass grade on hide yields from heifers were limited. This can be noted from the classification of heifers shown in Table 7 from which hide yields were collected for this study. Differences in hide yields from winter heifers grading low good, top, average, and low commercial were not significant. Likewise, hide yields from summer heifers in different grades available were not significantly different. Also, the regression coefficients for heifers in all of the different grades available within and between seasons were not significant.

The writer believes that it should not be concluded from these results that carcass grades significantly influence hide yields from Hereford steers but not Hereford heifers. If hide weights were available from heifers grading over a wider range

of grades, significant differences between these hide yields might have occurred.

It was concluded from the previous analysis of the available data that hide yields from Hereford steers grading in different full carcass grades probably are significantly different. It is suggested by the writer that the same may occur in hide weights from Hereford heifers, but data were not available to test this hypothesis.

Season of the Year

The summer season in this study was considered to be May through the month of October, and the other months of the year were included in the winter season. As noted in Table 7, hide weights were collected from 139 Hereford steers which were slaughtered in the summer. Of the 139 steers, 109 were slaughtered in June and 30 were slaughtered in July. Half of the 40 summer heifers were slaughtered in June and half in July. Of the steers slaughtered in the winter, 30 were slaughtered in November, 5 in December, 39 in February, and 20 in March. The 145 heifers classified as being slaughtered in the winter were well distributed among the winter months. Thirty-five head were slaughtered in November, 42 in December, 30 in January, and 38 in February.

From Table 7, it will be seen that tests of the effect of season on the hide yields were limited to Hereford steers. Hide weights from heifers in the same grade in each season were not available. Therefore, differences in the available hide yields

from heifers in each season could be attributed to differences in grade, season or both. However, the regression coefficients of hide percentages on carcass weights from summer and winter heifers were not significantly different. Figure 2 illustrates the regression lines of hide percentages on carcass weights from winter and summer heifers. It must be kept in mind that the differences between these two regressions are not necessarily due to season, but may be due to carcass grade as explained above.

Tests of significance of the effect of season on hide weights from Hereford steers were made between hide percentages of good and commercial grades of each season. The adjusted hide percentages between seasons within these grades were significantly different in both good and commercial grades. However only the regression coefficient of the commercial grade summer steers was significantly different from the other coefficients in both grades of each season. Thus, the regression lines in Fig. 1 illustrate the best estimate that can be made from the available data of hide weights from Hereford steers grading good and commercial.

As would be expected, hides from cattle slaughtered in the winter tended to be heavier than hides from summer slaughter. From steers grading good, this difference in hide weight tended to be about 3.5 pounds. Figure 3 presents a clearer picture of the differences in hide weights between winter and summer seasons than an average difference. Hide weights from heifers slaughtered in the winter tended to be approximately 3 pounds heavier than hide weights from heifers slaughtered in the summer. However, as

explained before the heifers of the two seasons were of different grades so that this difference of 3 pounds may or may not have been associated with season of the year.

Sex

Again it may be noted from Table 7 what tests were available to determine the influence of sex on the hide yields collected for this study. Hide yields from the 27 heifers slaughtered in the summer grading top and average good were compared with hide yields from the 28 steers of the same season and grade. Hide yields from 29 winter heifers which graded low good were compared with hide yields from 23 steers of the same season and grade. Hide yields from 62 winter heifers grading top and average commercial and 29 winter steers of the same grade were used as another test of the influence of sex on hide yields. In all three tests the hide yields from steers were significantly heavier than the hide yields from the heifers.

In the first two tests mentioned above, the hide weights yielded from steers were on the average about 2.3 pounds heavier than hides from heifers. In the latter test, the steer hides were approximately 6.5 pounds heavier than the heifer hides. These differences, if not accurate estimates, are at least indicative of the significant influence of sex on hide yields.

Breed

Data were not available in this study to compare hide yields

from the different breeds. It was only possible to make limited tests on the significant differences of hide yields from Herefords and what hide yields were collected from other breeds pooled as one group. "Hereford" as used here, does not denote purebreds, but animals in which Hereford breeding tends to predominate. The only covariance test made of this kind was between hide yields from 29 non-Hereford winter heifers grading commercial and 71 Hereford heifers of the same grade and season. In this test the hides from Herefords were found to be significantly heavier. It was also observed that the variance of hide percentages increased when other than Hereford data were included in the correlation. This further indicates that the hide yields from different breeds of the test cattle were different.

FACTORS AFFECTING OLEO FAT YIELDS

Physical oleo weights appeared to have a linear relationship with carcass weights while oleo weights as a percentage of carcass weights tended to have a non-linear relationship with carcass weights. Therefore, physical oleo weights and carcass weights were used as the variants in this covariance analysis to determine the factors which significantly affect the oleo yields collected.

Season of the year did not significantly affect oleo yields so that the cattle from which oleo fat data were collected were reclassified without consideration of season of the year as shown in Table 9. This reclassification was done in order to increase the number of cattle in classified groups used in testing the

Table 9. Distribution of 408 cattle among classified groups for covariance analysis on factors affecting oleo yields.

Grade		Hereford[1]		Non-Hereford	
		Steer	Heifer	Steer	Heifer
Choice	AA1		3		
	AA2	2	3		
	AA3	7	5		
Full Grade		9	11		
Good	A1	21	21	3	1
	A2	30	9	1	1
	A3	57	31	2	4
Full Grade		108	61	8	6
Commercial	B1	41	22	3	7
	B2	20	37	4	9
	B3		9	3	12
Full Grade		61	68	10	28
Utility	C1		4	1	3
	C2			5	
	C3			5	
Full Grade			4	11	3
Cutter	D1			20	
	D2				
	D3				
Full Grade				20	
Canner	E1				
	E2				
	E3				
Total		178	144	49	37

1/"Hereford", as used here, does not denote purebreds but animals in which Hereford breeding tended to predominate.

influence of factors other than season on oleo yields. The total number of test cattle in this oleo fat analysis was less than the number of cattle from which hide weights were collected. This was a result of viscera condemnation of some of the test cattle

which caused oleo fat weights not to be collected from such cattle.

Carcass Weight

Oleo yields from similar Hereford cattle with respect to grade and sex but yielding carcasses of different weight were found to vary considerably. In other words, oleo yields analyzed in this study were associated with carcass weight, otherwise the covariance analysis would not have been used on oleo fat yields. This association is evidenced by the significant correlation coefficients of oleo fat on carcass weight as shown in Table 10.

Table 10. Correlation coefficients of oleo weights on carcass weights in each classified group.

Carcass grade		Hereford			
		D/F[1]	Steer	D/F	Heifer
Choice		7	.61	9	.40
Good	A1	19	.75**	19	.45*
	A2	28	.57**	7	.51
	A3	55	.67**	29	.62**
Commercial	B1	39	.71**	20	.62**
	B2	18	.58**	35	.77**
	B3			7	.10

1/Degrees of freedom
* Significant at 5 percent level of probability.
** Significant at 1 percent level of probability.

Figure 4 illustrates the rate of increase in oleo fat yields which was found to be associated with increases in carcass weight.

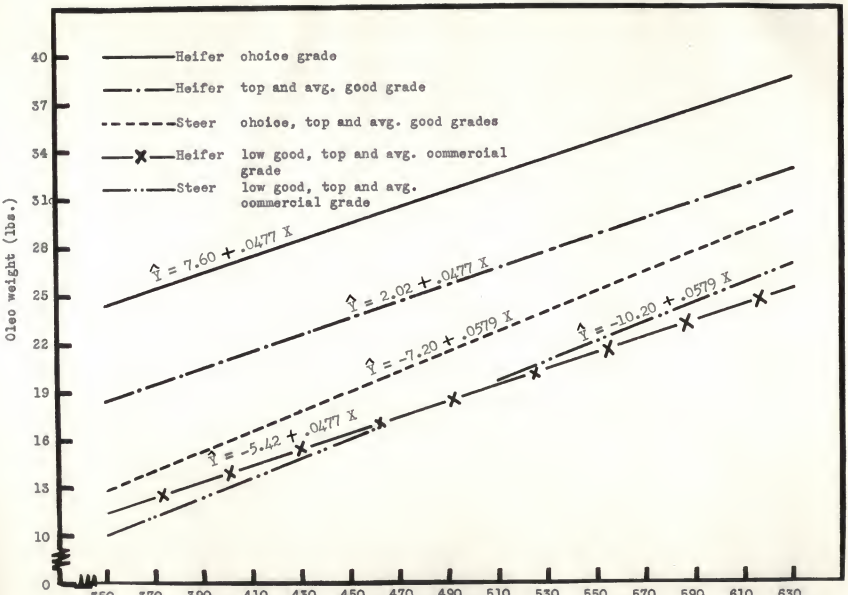

Fig. 4. Oleo fat yields on carcass weight by sex and grade.

Oleo fat yields from Hereford steers were found to increase about 5.79 pounds per hundred pounds increase in carcass weight. From Hereford heifers this rate of increase was found to be about 4.77 pounds. Thus it was noted that the relationships of oleo fat yields on carcass weight was not seriously affected by sex or grade (Fig. 4.).

Sex and Carcass Grade

An unusual situation was found to exist among the oleo weights in this study with respect to carcass grade. Oleo weights from top and average good steer carcasses and from top and average good heifer carcasses formed two homogeneous groups. In the steers, oleo weights from the choice grade were not significantly different from weights from the top and average good grade groups. Oleo weights from choice heifers, however, were found to be significantly different from the top and average good groups. Oleo weights from both Hereford steers and heifers of the low good through low commercial grades were a homogeneous group. Each of these five sex and grade groups: 1. Choice, top good, and average good steers; 2. Low good, top and average commercial steers; 3. Choice heifers; 4. Top and average good heifers; and 5. Low good, top and average commercial heifers were significantly different from each other with respect to oleo weights. Table 11 shows the grade and sex means of oleo fat yields by grade and sex and illustrates points of significant differences between the means as described above. Carcass grade was definitely a factor influencing oleo yields from the test cattle used in this study.

Table 11. Mean oleo weights adjusted for differences in carcass weights and classified by carcass grade and sex.[1]

Carcass grade	Hereford	
	Adjusted mean oleo yields of steers	Adjusted mean oleo yields of heifers
	Pounds	Pounds
Choice	21.78	30.13
Top good	22.11	25.00 [2]
Average good	22.90	23.48
Low good	20.41 [2]	17.90 [2]
Top commercial	18.83	18.16
Average commercial	18.20	15.89
Low commercial		16.80

1/Method of adjustment explained in Snedecor, op. cit. p. 321-2.

2/Significant differences between means.

The regression lines of oleo weights on carcass weights of the significant groupings of sex and grade as found in this study are shown in Fig. 4. It will be noted from this Figure that while sex and grade significantly affected oleo fat yields, the relationship between oleo fat and carcass weight was not seriously affected by these two factors. It will also be noted in Fig. 4 that oleo fat yields from Hereford steers whose carcasses graded choice, top and average good averaged about three pounds heavier than oleo fat yields from low good, top and average commercial steers. Oleo fat weights from choice heifer carcasses were estimated to be 6 pounds heavier than oleo fat weights from top

and average good grade heifer carcasses. Oleo fat weights from carcasses of these latter grades were on the average seven pounds heavier than fat weights from heifer carcasses grading low good to low commercial. This suggests that carcass grades of further range would be associated with further differences in oleo fat yields.

Within these same grade groups as described above, differences in oleo fat yields due to sex were noted. Oleo yields from heifers, especially at lighter carcass weights, tended to be heavier than oleo yields from steer carcasses. This tendency was noted when comparing oleo weights from steer carcasses grading choice, top and average good and heifer carcasses grading top and average good. At a carcass weight of 350 pounds the heifer oleo yields of these grades tended to be six pounds heavier than the steer oleo yields. However, at a carcass weight of 600 pounds, the heifer yields were on the average only three pounds heavier. In the low grading group, heifer yields tended to be about 1.5 pounds heavier than the steer yields from carcass of 350 pounds. But, from 600 pound carcasses, the steer yields tended to be about 1.2 pounds heavier than heifer oleo fat yields.

Breed

It was not possible in this study to test significant differences between oleo yields from particular breeds. The data were mostly from the Hereford breed. Even by pooling oleo weights from all other breeds collected, only a few tests of significance could be made of oleo yields from Herefords and non-Herefords. Referring to Table 9, oleo yields from the 28 non-Hereford heifers grading commercial were compared with oleo yields from the 68 Hereford heifers of the same grade. It was found from this test that the adjusted oleo yields from the 68 Hereford heifers were significantly heavier than the oleo yields from the non-Herefords. However, the relationship between oleo weights and carcass weights from the Hereford and non-Hereford heifers was not seriously different.

APPLICATION TO MARKETING BY CARCASS WEIGHT AND GRADE

Application of estimated by-product yields would depend on how the value of by-products would be handled when slaughter cattle were marketed by carcass weight and grade. It seems apparent that the packer must either reflect the value of by-products through carcass prices offered or by-products must be bought separately from carcasses. Some of the major by-products such as hide, oleo fat, and perhaps fancy meats might be of enough value to consider marketing on a weight and grade basis. However, if this were done, prices for each of these items besides carcass prices would be offered by the packer when bidding for slaughter

cattle. So many prices would certainly complicate bargaining decisions and market price reporting. Consequently, at the present time, this method of marketing by-products probably would be considered impractical. Thus it is likely that if slaughter cattle were marketed by carcass weight and grade, the value of by-products would be reflected through the carcass prices bid by packers.

The question then arises as to how packers could accurately reflect the value of by-products back to farmers through prices per hundred pounds carcass weight. It is probable that the same procedure used to reflect the value of by-products through live weight prices in the present system of marketing could just as effectively be used to make this reflection through carcass prices in marketing by carcass weight and grade. However in the interest of finding the most accurate way to reflect the value of by-products back to farmers, consideration should be given to the possibility of estimating by-product yields on a differential basis rather than on an average basis.

Engelman has suggested that current values of by-products per hundred pounds carcass weight can easily be calculated from estimated by-product yields which are expressed as a percentage weight of the carcass.[1] He explained that by merely multiplying the current price per pound by the by-product percentage yield of carcass weight by one hundred, the value of the by-product

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1/Engelman's suggestion and explanation was received through correspondence.

per hundred pounds carcass weight could be obtained. For example, if the estimated hide percentage of cattle yielding carcasses weighing 400 pounds was 15 percent and the current hide price was 20 cents per pound, the value of the hide per hundred pounds carcass weight would be $3.00 (15 x $ .20 x 100 = $3.00). A mathematical justification of this calculation is presented in Appendix C.

Hide and oleo fat percentage yields by carcass weights were calculated in the covariance analysis of factors which affect yields of these by-products. Therefore, if the results of this study were to be used as explained above, hide and oleo fat percentages for different grades and weights of carcasses from Hereford steers and heifers could be read from Figures 1 and 2. However, it would probably be more convenient to have these schedules of hide and oleo percentages and carcass weights in a table form. Such a table of the estimated hide percentages would appear as in Table 12. A schedule of the estimated oleo percentages shown in Fig. 4 would appear as in Table 13.

It usually would be desirable to calculate an estimate of the value of by-products per hundred pounds carcass weight for carcasses weighing within a certain hundred pound weight range. In this case, the hide and oleo percentages which were associated with the carcass weight falling in the middle of the weight range desired would be used in the calculation. For example, the by-product percentage associated with the carcass weight of 450 pounds would be used in calculating the value of by-products for carcasses weighing between 400 and 500 pounds.

Table 12. A schedule of hide percentages in significant sex, season and grade groupings by carcass weight.[1]

Carcass weight (lbs.)	Steers				Heifers	
	Winter		Summer		Winter	Summer
	Good Percent	Commercial Percent	Good Percent	Commercial Percent	Percent	Percent
400	15.82	16.92	15.28	16.69	15.35	14.68
450	15.09	16.19	14.48	15.02	14.69	14.02
500	14.36	15.46	13.68	13.35	14.03	13.36
550	13.63	14.73	12.88	11.68	13.37	12.70
600	12.90	14.00	12.08	10.01	12.71	12.04

1/Data are from Figs. 1 and 2.

Table 13. A schedule of oleo fat percentages in significant grade and sex groupings by carcass weight.[1]

Carcass weight (lbs.)	Steers		Heifers		
	Choice, Top. & Ave. Good Percent	Low Good, Top. & Ave. Com. Percent	Choice Percent	Top. & Ave. Good Percent	Low Good, Top & Ave. Com. %
400	4.0	3.2	6.8	5.2	3.5
450	4.2	3.6	6.6	5.2	3.7
500	4.4	3.8	6.4	5.2	3.8
550	4.5	4.0	6.3	5.2	3.9
600	4.7	4.2	6.2	5.2	4.0

1/Data calculated from estimated physical yields presented in Fig. 4.

With Tables 12 and 13 and current prices of hide and oleo, an estimated value of these two items per hundred pounds carcass weight could easily be calculated as previously explained. Of course, hide and oleo are only two of the many by-products of cattle slaughter. Further research might result in estimated percentage yields of all or some of the other by-product items.

However, all by-products could be considered if credits for offal were available by carcass weight. Some packers under the present live weight system of marketing currently estimate the value of offal by carcass weight. Thus, if Tables 12 and 13 were complete and accurate and offal credits were available by carcass weight, an estimate of the value of all by-products per hundred pounds carcass weight could be calculated for cattle of different classes, breeds, sexes, grades and slaughtered in different seasons of the year.

Actual application by the packer of these estimated by-product values in determining carcass weight prices to be bid, might possibly be made in the following way. As previously stated, the value of by-products from cattle slaughter usually exceeds all slaughtering and selling costs of the packer. This means that when marketing by carcass weight and grade, the carcass price bid by packers for some carcasses would be more than the wholesale price of such carcasses. Thus, in determining carcass prices to bid, the packer might begin with the wholesale price quotations on carcasses. These prices usually would be classified by hundred pound weight groups, carcass grades, and into classes of steers and heifers, cows, bulls, and veal calves. Through the use of estimated hide and oleo percentage yields and offal credits by carcass weight, the value of by-products per hundred pound carcass weight can be calculated for each grade and weight classification of the wholesale price quotations. By subtracting slaughtering and selling costs per hundred pounds

carcass grade and weight group of the wholesale price quotations. Then the wholesale prices in each grade and weight group could be adjusted according to the relationship of slaughtering and selling costs to the value of by-products to determine the carcass price to be bid for specified carcasses.

It was indicated in this study that differences in the yield of by-products are associated not only with carcass grade and weight but also with other factors such as breed, sex, and season of the year. If these differences in the yield of by-products associated with factors other than carcass weight and grade were of enough value to be of economic importance, the packer would certainly consider such factors when determining prices to offer for carcasses. For instance, according to this study, packers could afford to bid more per hundred pounds carcass weight for Hereford steer carcasses grading commercial and weighing 500 to 600 pounds than for carcasses of the same weight and grade yielded by Hereford heifers. Both the hide and oleo yields tended to be heavier from Hereford steers than from Hereford heifers at this weight and grade. Further research on estimated by-product yields probably would reveal other such instances and determine what factors other than carcass grade and weight that would need to be considered by the packer. However, since estimated by-product percentage yields determined in such research would be classified into these factors, the packer could determine what carcass prices to bid for any such specified carcasses as previously explained in the above paragraph.

If it were found necessary to determine separate carcass prices to be bid for cattle of different breed and sex, the buyer could be informed of these prices and bid accordingly. In other words, the buyer might offer a different bid for carcasses of the same weight and grade when buying two lots of cattle of different breed or sex. In buying lots of cattle that included both sexes or more than one breed, the packer buyer could offer a separate schedule of carcass prices for each homogeneous group of cattle in the lot. This could be done since in marketing by carcass weight and grade, the identity of animals are maintained through the slaughtering process. Of course, the packer buyer could also estimate average carcass prices that should be bid for all the animals in a mixed lot instead of a separate price for each group. This would have to be done in the case of cattle that were crossbred, since the buyer would probably not be given carcass prices to be bid for such cattle.

Factors that affect the quality of by-products to the packer which may be observed in the live animal would also have to be taken into consideration by the packer buyer. The branding of cattle and grub infestation of cattle affect the value of hides considerably. It is common for a spread of as much as six cents per pound to exist between branded and native hide prices. The spread between grubby and grub free hides is usually smaller.

It might be possible for the packer through the use of estimated hide percentage yields to inform the packer buyer to make discounts of a certain amount for grubby or branded hides.

For example, assume that branded steer hides were worth six cents less per pound than native steer hides and the hide percentage yield associated with steer carcasses weighing 300-400 and grading good was 18 percent. The discount for such carcasses would be $1.08 per hundred pounds carcass weight. (18 x .06 x 100 = $1.08) Discounts for other reasons might be handled this same way if the cause of such discounts were evident in the live animal.

An attempt was made in this section to discuss how estimated by-product yields, particularly hide and oleo fat yields, might possibly be applied if slaughter cattle were marketed by carcass weight and grade. It was not intended to conclusively decide the desirability and practicability of this use of estimated by-product yields. It seems that this question would depend mostly upon the variability of by-product yields which existed among similar cattle that yielded carcasses of the same weight and grade. The degree of such variability is probably the major limiting factor to the degree of accuracy in payments to farmers for by-products which may be obtained through the use of estimated by-product yields. For it is apparent that due to such variability some inequities in the payment for by-products would occur even if estimated by-product yields could be practically applied to individual animals. Thus extensive research is needed to estimate by-product yields with a probable error as small as possible. Additional costs of applying such estimates would then need to be weighed against possible gains in accuracy before the desirability

of using estimated by-product yields as described could be determined.

SUMMARY AND CONCLUSIONS

This study consists of two phases: (1) Analysis of factors affecting hide and oleo yields, (2) application of this analysis to the marketing of slaughter cattle by carcass weight and grade. The first phase included a study of methods of analysis from which it was concluded that the appropriate procedure was to apply the covariance method in the determination of factors affecting hide and oleo fat yields. Involved in the second phase was a discussion of practical methods of handling the value of by-products in the live weight and carcass weight and grade systems of marketing.

Carcass weight, grade, season of slaughter, sex and breed were found to be associated with differences in hide yields which were significant from a statistical point of view. No attempt was made to determine the economic significance of these differences. Carcass weight was the most important factor associated with hide yields. As carcass weight increased, hide yields increased but at a decreasing rate. For example, hide yields from Hereford steers slaughtered in the winter and having a carcass grade of good or commercial tended to increase 10.9 pounds as carcass weight increased from 350 to 450 pounds, but hide yields increased only 6.7 pounds as carcass weight increased from 500 to 600 pounds.

Some of the variability of hide yields from carcasses of the

same weight was explained by the influence of other factors. Adjusted hide weights from winter steers grading commercial were found to average about five pounds heavier than hide weights from steers grading good. The effect of carcass grade on hide yields varied in different seasons of slaughter and with the sex of the animal. In this study, no significant differences among hide weights from heifers were found to be associated with carcass grade. However, it is probable that this was due to the small spread of grades from which hide weights were collected. Hides from Herefords slaughtered in the winter tended to be heavier than hides from summer slaughter. With steers grading good, this difference tended to be about 3.5 pounds. Steer hides were on the average consistently heavier than heifer hides. Of the three tests possible in this study within the good and commercial grades of the Hereford breed, steer hides averaged 2 to 6 pounds heavier than heifer hides. From the limited testing in this study, it was concluded that breed would cause part of the variability of hide yields from carcasses of the same weight. For this reason, only hide weights from one breed, cattle showing predominate Hereford breeding, were used when studying the influence of other factors.

Carcass weight, grade, sex and breed were found to be associated with significant differences in oleo fat yields. Oleo fat yields from Hereford steers tended to increase about 5.79 pounds per hundred pounds increase in carcass weight. The increase in oleo fat yields from Hereford heifers per hundred pounds carcass weight

was 4.77 pounds. The relationship of oleo weights to carcass weight was not affected greatly by carcass grade or sex, but these factors along with breed were found to cause some of the variability of oleo fat yields from carcasses of the same weight. Oleo fat weights from Hereford steer carcasses grading choice, top and average good and from carcasses grading low good to low commercial formed two homogeneous groups. The adjusted oleo fat weights of the higher grading groups of steers averaged three pounds heavier per head than fat weights from the lower grading steers. With heifers, oleo fat weights from choice carcasses, top and average good, and low good through average commercial grade carcasses formed three homogeneous groups which were significantly different from each other. Fat weights from choice heifer carcasses were estimated to be six pounds heavier than fat weights from top and average good grade heifer carcasses. Oleo fat weights from carcasses grading top and average good were on the average seven pounds heavier than fat weights from carcasses grading low good to low commercial. This indicates that carcass grades of even wider range might have quite an effect on oleo fat yields--the higher the grade, the larger the yield of oleo fat.

Oleo yields from heifer carcasses weighing 350 pounds and grading above low good tended to be six pounds heavier than from similar steer carcasses. At a carcass weight of 600 pounds, the heifer yields were about three pounds heavier than steer yields. The lower grading group reflected this same trend to a

lesser degree--1.5 and 1.2 pounds heavier, respectively. This tendency of relatively heavier oleo fat yields from heifers at lighter carcass weights may be explained by the fact that heifers finish at lighter weights than steers.

Only limited analysis was possible in this study with respect to breed as a factor affecting oleo fat yields. Some of the variability of oleo fat yields was reduced when only one breed was considered. Tests showed a significant difference between oleo yields from cattle of predominate Hereford breeding and from cattle of other than Hereford breeding.

In the second part of this study, an attempt was made to determine how estimated differential by-product yields such as found in this study might be applied to the carcass weight and grade system of marketing slaughter cattle. It was shown that estimated differential by-product yields expressed as percentages of carcass weight could easily be converted to current values per hundred pounds carcass weight. This was done by multiplying the by-product percentage times the current by-product price per pound times one hundred. By this method the packer could use estimated by-product yields to determine differential by-product credits for different cattle. Using these differential by-product credits, estimated killing and selling costs per hundred pounds carcass weight and wholesale carcass prices, the packer could determine prices to bid for carcasses of different weight and grade. If by-product credits were differentiated according to factors as found in this study, the packer would probably

determine separate prices to be bid for carcasses of different weight, grade, sex and breed. Season of year might also be considered. With these prices, the buyer could determine what prices to offer by considering the sex and predominate breeding of the cattle being bought. Other factors which could be observed in the live animal and which affect the value of by-products such as grubs and branding, would need to be considered by the packer buyer. Discounts per hundred pounds carcass weight for such factors could be calculated by multiplying the loss in value of the by-product times the estimated by-product percentage yield of the carcass weight. More responsibility would be placed upon the packer buyer in determining what carcass prices to bid for lots of cattle which contained animals of both sexes and mixed breeding.

It was suggested that the above described use of estimated by-product yields might be a possible method of reflecting back to farmers a differential by-product credit when slaughter cattle were marketed by carcass weight and grade. There are undoubtedly many complications to such a method which the writer has failed to discuss. However, it was concluded that the desirability and practicability of this method would depend mainly upon the variability of by-product yields from similar cattle. For, the accuracy of this method depends directly upon the variability of the value of by-products from cattle yielding the same weight and grade of carcass and of the same sex and breed. It is evident that some inequities in the payment for by-products would occur

in this method of reflecting the value of by-products due to the variability of by-product yields. Further research will be required to determine the degree of this variability. The only way that exact payments could be made would be to determine by-product credits according to the by-product yield of each individual animal or lot as determined after slaughter. Consideration should at least be given to the possibility of using this method on the major by-product items.

It is probable that more attention would be given to the value of by-products by both packer and farmers under the carcass weight and grade system of marketing. The effect of the value of by-products on the worth of the animal to the packer and thus to the farmer would probably be more evident. However, since by-product credits are involved in any system of slaughter cattle marketing, no new problem would necessarily arise with respect to by-products in shifting from a live weight to a carcass weight and grade system of marketing. It is probable that the same method used to consider the value of by-products in the present system of marketing could just as effectively be used to reflect the value of by-products in carcass prices under marketing by carcass weight and grade. Further research will be required to be able to weigh additional costs against possible gains in accuracy of the different methods of reflecting the value of by-products under marketing by carcass weight and grade.

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May all the officials and employees of John Morrell and Company, the cooperating packer of the research on marketing by carcass weight and grade at Kansas Agricultural Experiment Station, be recognized for the courteous, non-pecuniary and vital contribution to this study.

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APPENDIX

APPENDIX A

Form II.
Marketing Slaughter Cattle by Carcass Grade and Weight
Killing Floor: Individual Animal

Lot No._____. Tag No. _____. Date _____

Hour Slaughtered_____.

Condemnations:

	Disease	Other (Specify)
Carcass		
Head		
Heart		
Liver		
Lungs		
Other		

Weight of Trim for Bruises, etc._____

Carcass Weight (Hot)_____.

Form III.
Marketing Slaughter Cattle by Carcass Grade and Weight
Hide Cellar: Individual Animal

Lot No. _____. Tag No. _____. Date _____

Weight_____. Trim_____lbs.

Class	Sub-class	Grade 1	Grade 2
Steer or Heifer	Native		
	Texas (side branded)		
	Colorado (side branded)		
	Butt-branded		
Cow	Native		
	Branded		

Why downgraded:

Grubby_____. Tag No. _____. Dockage for dirt_____.

Form VI.

Marketing Slaughter Cattle by Carcass Grade and Weight
Individual Animal: Summary

Date_____

Lot No._____ Tag No.__

Estimated Carcass Grade
Choice 1__2__3__
Good 1__2__3__
Commercial 1__2__3__
Utility 1__2__3__
Cutter 1__2__3__
Canner 1__2__3__

Hour Weighed_____

Live Weight_____

Estimated Yield_____
Cold_____%

Carcass Weight:
Hot_____
Cold_____

Breed:_____ Sex_____

Weight Group_____

Buying Price $_____

Actual Carcass Grade
Choice 1__2__3__
Good 1__2__3__
Commercial 1__2__3__
Utility 1__2__3__
Cutter 1__2__3__
Canner 1__2__3__

Actual Yield
Cold_____

Error of
Estimated Yield_____%

Carcass Price:
Chicago $_____
Morrell $_____

Total Carcass Value $_____

Hide: Weight_____lbs.
Class_____
Grade 1__2__
Value per lb.___
Total Value

Carcass Value per
100 lbs. live weight $_____

Grade Error by 1/3:

Over_____ Under_____

Caul Fat_____lbs._____oz.
Ruffle Fat_____lbs._____oz.
Total Fat _____lbs._____oz.

Bruises_____

Hour Slaughtered_____

Condemnations_____

Offal Credit $_____

_____

Table 14. Carcass weight (X) and hide percentage weight of the carcass (Y) of 77 Hereford winter steers in five carcass grade groups.

	CARCASS GRADE									
	Good grade						Commercial grade			
	Top good		Average good		Low good		Top commercial		Average commercial	
n:	X	Y	X	Y	X	Y	X	Y	X	Y
1	438	15.52	351	15.67	375	18.67	393	18.07	451	16.63
2	450	15.33	441	16.10	435	16.17	458	15.28	465	17.20
3	458	15.72	498	14.66	438	15.30	456	16.23	497	16.30
4	477	14.05	499	12.62	463	15.55	477	15.72	560	10.71
5	479	13.57	504	13.29	490	13.38	503	15.51	564	14.72
6	494	13.76	506	16.80	490	16.73	505	14.46	583	14.06
7	506	13.24	520	10.77	514	13.82	509	15.13	595	15.80
8	511	13.11	546	11.90	519	14.84	514	14.00		
9	526	11.03	550	15.82	520	13.65	525	12.38		
10	580	14.48	564	15.42	524	14.69	529	15.50		
11	589	12.22	573	13.44	563	12.66	535	13.08		
12			587	14.31	563	13.85	543	12.89		
13			607	11.70	576	13.72	545	16.88		
14			612	12.25	578	13.67	563	15.37		
15					585	14.36	577	15.77		
16					587	12.10	584	11.99		
17					591	13.03	604	13.58		
18					593	14.16	604	14.40		
19					607	12.36	612	13.54		
20					623	13.80	621	14.17		
21					640	13.12	661	14.22		
22					651	12.29	665	14.59		
23					656	10.67				
Sums	5608	152.03	7358	194.75	12571	321.89	11973	325.56	3715	105.42
Means	500.73	13.82	525.57	13.91	546.57	14.00	544.23	14.80	530.71	15.06
SX^2	2782268		3929742		6991473		6613311		1992245	
SY^2		2121.71		2755.82		4565.33		4864.12		1616.79
SXY	75691.75		101592.96		173698.80		176298.14		55496.89	

Good grade totals: SX = 25437 SY = 668.67 n = 48 SXY = 350983.51 SX^2 = 13703483 SY^2 = 9442.86

Commercial grade totals: SX = 15688 SY_2 = 430.98 n = 29 SXY = 231795.03 SX_2 = 8605556 SY^2 = 6480.91

Grand totals: SX = 41125 SY = 1099.65 n = 77 SXY = 582778.54 SX^2 = 22309039 SY^2 = 15923.77

Table 14 presents the carcass weight and hide percentage weight data on 77 winter Hereford steers which were collected for this study and the basic calculations necessary for the covariance analysis. This table corresponds to Table 12.1 on page 318 of Snedecor's book, Statistical Methods. The next step in the analysis was to test the significance of the adjusted means of the 5 third grade groups. This test is explained on pages 319 and 320 of Snedecor's book. The F ratio was significant at the five percent level which indicates that the means of the hide percentages of the 5 groups did not come from the same statistical population. The conclusion was that the carcass weight does not explain the differences among the hide percentage weights, the group means of the hide percentages were still significant after the carcass weights were adjusted to a common weight basis. Evidently carcass grade influenced the hide percentage yield.

The next step was to determine if third of a carcass grade significantly influenced hide yields within a full grade. These tests are shown in Tables 15 and 16. The adjusted means of the third grade groups within either the good or commercial were not significant, but Table 17 shows that the means of the hide percentages adjusted to a common carcass weight of the good and commercial carcass grades taken as two groups were significantly different. Thus the conclusion is that full carcass grades were a factor associated with significant differences in hide yields of the 77 Hereford steers slaughtered in the winter that were used in this study.

Table 15. Analysis of covariance and test of significance of adjusted group means in good grade.[1]

Source of variation	D/F[2]	Sum of squares and products			Errors of estimate		
		Sx^2	Sxy	Sy^2	Sum of squares	D/F	Mean Square
Total of good grade	47	223463	-3369.80	127.87	77.05	46	
Third grade group means	2	16012	62.18	0.23			
Within grade groups	45	207451	-3430.98	127.64	70.90	44	1.61
For test of significance of adjusted group means					6.15	2	3.08

$$F = \frac{3.08}{1.61} = 1.91 \text{ not significant}$$

[1] Snedecor, op. cit., pp. 319-20.

[2] Degrees of freedom.

Table 16. Analysis of covariance and test of significance of adjusted group means in commercial grade

Source of variation	D/F	Sum of squares and products			Errors of estimate		
		S_x^2	S_{xy}	S_y^2	Sum of squares	D/F	Mean square
Total of com. grade	28	118889	-1350.29	75.95	20.61	27	
Third grade group means	1	970	- 18.79	.36			
Within grade groups	27	117919	-1331.50	75.59	60.56	26	2.33
For test of significance of adjusted group means					.05	1	.05

$$F = \frac{0.05}{2.33} = .02 \quad \text{not significant}$$

Table 17. Test of significance of adjusted commercial and good grade means.

Source of variation	D/F	Sum of squares and products			Errors of estimate		
		Sx^2	Sxy	Sy^2	Sum of squares	D/F	Mean Square
Total	76	344550	-4534.53	219.48	159.80	75	
Grade means	1	2198	185.56	15.66			
Within grades	75	342352	-4720.09	203.82	138.74	74	1.87
For test of significance of adjusted grade means					21.06	1	21.06

$$F = \frac{21.06}{1.87} = 11.26$$ significant at 1% level

Table 18 shows the regression and correlation data of the 5 third grade groups. Significant correlation coefficients were evidence that carcass weight influences hide yields. Table 19 shows the test made of the significance of the regression coefficients of the 5 groups. The F ratio was not significant which indicates that carcass grade did not affect the relationship of hide percentage yield to carcass weight. The regression coefficient calculated from the pooled sums of squares and products in Table 18 would be a better coefficient to use in the regression equation than the individual group regression coefficients. Thus, the regressions of the good and commercial grade winter steers shown in Fig. 1 are the same. These same tests of significance of adjusted group means and regressions, Tables 17 and 19, were employed in determining whether season of the year, sex, or breed were factors affecting hide yields.

Table 18. Regression and correlation data in third grade groups of Hereford winter steers.[1]

Third grade groups	D/F	Sums of squares and products: S_x^2	S_{xy}	S_y^2	Correlation coefficient	Regression coefficient	Errors of estimate: Sum of Squares	D/F
Top good	10	24262	-435.82	20.52	-.6148*	-.0179	12.76	9
Avg. good	13	62587	-762.08	46.71	-.4457	-.0122	37.41	12
Low good	22	120602	-2235.08	60.41	-.8280**	-.0185	18.99	21
Top commercial	21	97278	-880.49	46.42	-.4071	-.00905	38.45	20
Avg. commercial	6	20641	-451.01	29.17	-.5813	-.0218	19.32	5
	72	325370	4762.48	203.23			126.93	67

[1] Snedecor, op. cit., p. 325.

Table 19. Analysis of errors of estimate from average regression within third grade groups.[1]

Source of variation	D/F	Errors of estimate: Sum of squares	Mean square
Deviation from average regression within groups	71	133.52	
Deviation from individual group regressions, Table 16	67	126.93	1.89
Differences among lot regressions	4	6.59	1.65

$$F = \frac{1.65}{1.89} = .873 \text{ not significant}$$

[1] Snedecor, op. cit., p. 327.

APPENDIX C

It was proposed to prove that the value of hides per hundred pounds carcass weight can be calculated by multiplying the current hide price per pound by the hide percentage yield of the carcass weight times one hundred. The following symbols were used to express the given and unknown factors:

Given: Hide price per pound - P
Carcass Weight - C
Hide percentage yield of carcass weight - H

Unknown: Value of hide per hundred pound carcass weight - X

It follows that H x C would equal the total weight of the hide yielded. P(H x C) would equal the total value of the hide. Then the total value of the hide P(H x C) divided by the carcass weight C would equal the value of the hide per pound of carcass weight. By multiplying this value by 100 the value of X or the hide per hundred pounds carcass weight would be obtained. Thus it follows that:

$$\frac{P(H \times C)}{C} \times 100 = X$$

The value of C may be cancelled out without changing the value of the fraction $\frac{P(H \times C)}{C}$. Thus, P x H x 100 = X or in other words the hide price multiplied by the hide percentage times 100 would equal the value of the hide per hundred pounds carcass weight.

FACTORS INFLUENCING YIELD OF SELECTED BY-PRODUCTS OF CATTLE SLAUGHTER WITH APPLICATION TO MARKETING BY CARCASS WEIGHT AND GRADE

by

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AN ABSTRACT

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In recent years, economists in the field of livestock marketing in the United States have expressed an interest in the system of marketing slaughter livestock by carcass weight and grade. This system of marketing was first used in other countries and has apparently been successful in the marketing of slaughter hogs in Sweden, Denmark, England, and Canada. In this marketing system payment is made after livestock are slaughtered and on the basis of the actual carcass weight and grade. This would eliminate the procedure in our present live weight system of marketing in which the packer buyer estimates the value of live animals based on the anticipated value of carcasses and by-products. Thus, some economists have thought that the differences in value to the packer of different animals would tend to be more accurately reflected back to farmers in the system of marketing by carcass weight and grade than in the live weight system. Partially because of this possibility, the North Central Livestock Marketing Research Committee established a regional project to study the desirability and practicability of marketing slaughter livestock by carcass weight and grade. Such a study necessarily involves at least some consideration of the handling of by-products as well as the carcasses. Thus, one aspect of the regional project will be an analysis of the by-product data collected by the cooperating states for the purpose of determining differential by-product credits which should be allowed for carcasses of different classes, weights, and grades. The general purpose of the by-product study presented here was to contribute to and cooperate with this by-product analysis of the

Cooperative Regional Research Project.

In lieu of this general purpose and resources of data available, two major objectives may be listed for this study: (1) To determine factors affecting hide and oleo fat yields from cattle slaughter, (2) To apply the results of this analysis to the marketing of slaughter cattle by carcass weight and grade. Included with the first objective was a consideration of methods of analyzing by-product data. Involved in the second objective was a discussion of methods of handling the value of by-products in the live weight and carcass weight and grade system of marketing.

The covariance method of analysis was found to be most applicable in the determination of factors affecting hide and oleo fat yields. The data used in this analysis were collected by the Kansas Agricultural Experiment Station through the cooperation of a commercial meat packer and in connection with the research project, "Marketing Slaughter Cattle by Carcass Weight and Grade." These data consisted of a record of the hide weights, carcass weights, carcass grades, dates of slaughter, and the breed of 233 steers and 185 heifers.

The first step in the covariance analysis was to classify carcass weights and corresponding hide and oleo fat weights into homogeneous groups according to the factors being tested--carcass grade, season of slaughter, sex, and breed. With the data so classified, one test of the effect of these factors on hide or oleo fat yields involved the testing for significance of the differences of by-product yields from animals which were homogeneous with respect to all the above factors except the one being con-

sidered. For example, if hide weights from cattle of the same breed, sex, and season of slaughter which yielded carcasses of the good grade were significantly different from the hide weights of similar cattle which yielded commercial grade carcasses, it would be concluded that carcass grade was a factor associated with differences in hide yields. In such testing, the effect on hide or oleo fat yields of the differences in carcass weights between the classified groups was eliminated by the adjusting of mean of hide and oleo fat yields to a common mean carcass weight. This is part of the procedure of the covariance analysis and was made possible through the use of regression equations of the hide and oleo fat yields on carcass weight. A significant correlation was considered evidence of the association of carcass weight with differences in hide and oleo fat yields. The testing of significance between regressions of the classified groups of hide and oleo fat weights on carcass weights provided another test of the effect on hide and oleo fat yields of carcass grade, season of slaughter, sex, and breed. The quantity and distribution of the data available limited the analysis to the choice, good, and commercial grades and to cattle of predominate Hereford breeding. Some testing was possible between cattle of predominant Hereford breeding and cattle of other breeds.

In the analysis of factors affecting hide yields, all of the factors considered were found to be associated with differences in hide yields which were significant from a statistical point of view. No attempt was made to determine the economic signi-

ficance of these differences. It was found that hide yields tended to increase at a decreasing rate as carcass weight increased. For example, hide yields from Hereford steers slaughtered in the winter and having a carcass grade of good or commercial tended to increase 10.9 pounds as carcass weight increased from 350 to 450 pounds, but hide yields increased only 6.7 pounds as carcass weight increased from 500 to 600 pounds. Hide yields from commercial grade steer carcasses tended to be five pounds heavier than hide yields from similar carcasses grading good. However, this relationship of hide yields from good and commercial carcasses varied from cattle of different sex and season of slaughter. No significant differences of hide yields from heifers were found to be associated with carcass grade. This may have been due to the small spread of grades of heifer carcasses on which tests were possible--low good to low commercial. Hides from cattle slaughtered in the winter tended to be heavier than hides from summer slaughter. With Hereford steers grading good, this difference was about 3.5 pounds. Steer hides were on the average consistently heavier than heifer hides. Of the three tests possible in this study within the good and commercial grades of the Hereford breed, steer hides averaged 2 to 6 pounds heavier than heifer hides. The limited testing possible concerning breed indicated that differences in breed caused an increase in the variability of hide yields and that probably significant differences of hide yields were associated with differences in breed. In any case, only data from the Hereford breed were used in the analysis of the effect of other factors on hide yields.

In the analysis of factors affecting oleo fat yields, all of the factors considered except season of slaughter were found to be associated with significant differences in oleo fat yields. Oleo fat yields from Hereford steers tended to increase about 5.79 pounds per hundred pounds increase in carcass weight. The increase in oleo fat yields from Hereford heifers per hundred pounds carcass weight was 4.77 pounds. Oleo fat yields from steers grading choice to average good were about three pounds heavier than yields from steer carcasses grading low good to low commercial. Oleo fat yields from heifer carcasses grading choice were estimated to be six pounds heavier than oleo fat yields from top and average good grade heifer carcasses. Oleo fat yields from these latter grade carcasses averaged about seven pounds heavier than oleo fat yields from low good to low commercial heifer carcasses. Thus, a direct relationship was found between carcass grade and oleo fat yields--the higher the grade, the larger the yield of oleo fat. Also it was interesting to note that a significant difference occurred between oleo fat yields associated with the average good grade and the low good grade of both the steer and heifer carcasses. Oleo fat yields from heifers tended to be heavier than oleo fat yields from steers, especially at lighter carcass weights. For example, oleo yields from heifer carcasses weighing 350 pounds and grading above low good tended to be six pounds heavier than from similar steer carcasses. At a carcass weight of 600, the heifer yields were about three pounds heavier than steer yields. The low good to low commercial grade group reflected the same trend to a lesser degree--1.5 and 1.2 pounds heavier respectively. The tests

possible in this study indicated that breed influences oleo fat yield. At least some of the variability of oleo fat yields was reduced when only the cattle of predominate Hereford breeding were considered.

In the consideration of methods of handling the value of by-products in the live weight and carcass weight and grade systems of marketing several conclusions were reached. It was concluded that probably the only practical method of handling the value of by-products in either system of marketing is to reflect this value in the prices bid for cattle. This necessitates an estimation of by-product values in both systems of marketing since prices bid in both systems are offered before cattle are slaughtered. It was considered that payments for by-products on the basis of actual by-product yields as determined after slaughter would at best only be practical for some of the major by-product items. Furthermore, it was concluded that the method used in the present marketing system of estimating and reflecting the value of by-products in prices bid per hundred pounds live weight probably is as accurate as is practically possible at the present time. This method of the live weight system could probably be used just as effectively in reflecting the value of by-products in prices bid per hundred pounds carcass weight in the carcass grade and weight system of marketing. Thus, it was concluded that no new problems would necessarily arise with respect to by-products in shifting from a live weight to a carcass weight and grade system of marketing. It is probable, however, that the effect of the value of by-products on

the worth of the animal would be more evident and receive more consideration by both packer and farmers under a system of marketing by carcass weight and grade.

Further consideration of the handling of by-products in marketing by carcass weight and grade was concerned with the desirability and practicability of using estimated differential by-product yields to determine and reflect by-product credits. The following speculation was made as to how estimated differential by-product yields such as found in this study could be used by the packer in buying slaughter cattle by carcass weight and grade. It was shown that estimated differential by-product yields expressed as percentages of the carcass weight could very easily be converted to current values per hundred pound carcass weight. This was done by multiplying the by-product percentage times the current by-product price per pound times one hundred. By this method the packer could use estimated by-product yields to determine differential by-product credits for different cattle. Using these differential by-product credits, estimated killing and selling costs per hundred pounds carcass weight and wholesale carcass prices, the packer could determine prices to bid for carcasses of different weight and grade. If by-product credits were differentiated according to factors as found in this study, the packer probably would determine separate prices to be bid for carcasses of different weight, grade, sex, and breed. Season of year would also be considered. With these prices, the buyer could determine what prices to offer by considering the sex and predominate breeding of the cattle being bought. Other

factors which could be observed in the live animal and which affect the value of by-products, such as grubs and branding, would need to be considered by the packer buyer. Discounts per hundred pounds carcass weight for such factors could be calculated by multiplying the loss in value of the by-product times the estimated by-product percentage yield of the carcass weight. More responsibility would be placed upon the packer buyer in determining what carcass prices to bid for lots of cattle which contain animals of both sexes and mixed breeding.

It was concluded that the accuracy of payments to farmers in the above method of reflecting the value of by-products would depend mainly upon the variability of by-product yields within classified groups of cattle. The degree of this variability would be a major factor in determining the extent to which cattle should be classified and the economic significance of differences of by-product yields between classified groups of cattle. It should be noted that some inequities of payments will occur in any system of reflecting by-product credits. Further research will be required to determine the extent of these inequities and to weigh additional costs against possible gains in accuracy of the different methods of reflecting the value of by-products under marketing by carcass weight and grade.