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ESTIMATION OF THE COMPOSITION OF LAMB CARCASSES AND CUTS
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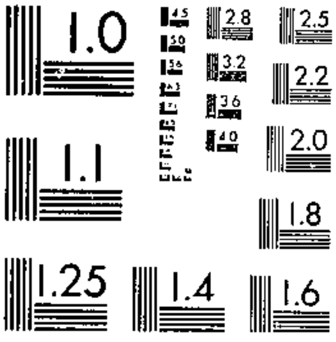

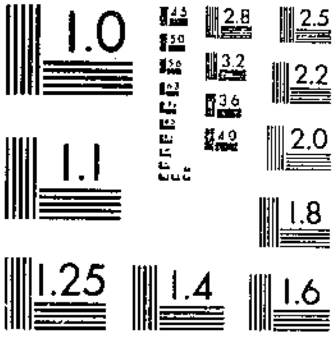

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Estimation of the Composition of Lamb Carcasses and Cuts[1]

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INTRODUCTION

Basically, research on the development of meat animals as influenced by the various production factors is concerned with changes that occur in certain body tissues including bone, muscle, and fat. The proportions of these tissues at any given stage of growth or fattening are of wide interest. In fact, they mean a great deal to the producer, packer, retailer, and especially the consumer, who in the final analysis is the person to be satisfied. As is well known, he wants a minimum of bone and in general a maximum of muscle (or lean meat), with only enough fat to give promise of satisfactory eating quality in the latter.

In the normal development of meat animals, skeletal growth ceases first, muscle growth next, and the final stage consists mainly of the deposition of fat. The fattening period is the most costly phase of animal feeding.

Chemical analysis of the entire animal body, excluding the contents of the digestive tract and bladder, will produce the most satisfactory data on composition. A similar analysis of the dressed carcass is re-

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[2] The author gives credit to R. L. Hiner, Paul E. Howe (on military leave), N. R. Ellis, W. R. Kauffman, and K. F. Warner of the Bureau of Animal Industry for analytical work, and to Edna V. Steely also of the Bureau for statistical work, in connection with the study.

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garded as the next best method. However, both procedures are time consuming and expensive. A short cut, therefore, is often necessary, and research workers have long been interested in simplified methods that will make possible the estimation of at least the major factors of composition with adequate accuracy.

REVIEW OF LITERATURE

The problem has interested other investigators as well as the present author. On the basis of data from five rams, two ewes, and one wether, varying widely in age, breeding, and fatness, Hammond[3] showed that the curve for increasing percentage of separable fat that most closely approximated the curve for the carcass as a whole was the one representing the shoulder. That for the leg came next. The latter, owing to the belief of this investigator that it could be cut with greater exactness, was selected in most cases in his work as the cut on which to base estimates of the amount of separable fat in the carcass.

Palsson[4] worked with 11 wether lambs and 5 wether yearlings of different breeds and crosses. The former were approximately 4.5 months of age and their dressed carcasses weighed about 40 pounds. The age of the yearlings was approximately 13 months and the weight of their dressed carcasses about 60 pounds. Correlation coefficients were reported for the relationships between the weights of separable bone, muscle, and fat of the leg and loin as well as these two cuts combined, on the one hand, and the corresponding components of the dressed carcass, on the other hand. Regression equations for estimating the components of the dressed carcass from those of the cuts were also presented. The conclusion was drawn that the weight of the skeleton could be estimated with a high degree of accuracy from the weight of bones in either one leg or the loin. These two cuts combined, however, appeared to provide a still better estimate. The weight of muscle in one leg or in the loin and leg was an excellent index of the weight of muscle in the entire dressed carcass. The weight of separable fat in one leg, loin, or the two cuts combined provided a good index of the total weight of fat in the carcass. The results indicated that in this respect also the combination of the two cuts provided the most precise measure.

The comparative increases in the separable-fat content of the rib, loin, breast, neck, shoulder, and leg cuts of lamb as that component of the dressed carcass increased from approximately 5 to 37 percent, have been shown by Hankins and Titus.[5] The data were obtained on 42 lambs. At low levels of fatness of the carcass, there were only small differences between the cuts and between any given cut and the carcass. However, the fat content of the cuts soon began to diverge, the rib, loin, and breast tending to group themselves at a relatively high level of fatness, above the carcass, and the neck, shoulder, and leg cuts at

[3] HAMMOND, JOHN. GROWTH AND THE DEVELOPMENT OF MUTTON QUALITIES IN SHEEP. 597 pp., illus. Edinburgh and London. 1932.

[4] PALSSON, H. MEAT QUALITIES IN THE SHEEP WITH SPECIAL REFERENCE TO SCOTTISH BREEDS AND CROSSES. Pt. I. Jour. Agr. Sci. 24 (4): 544–626, illus. 1939.

[5] HANKINS, O. G., and TITUS, HARRY W. GROWTH, FATTENING, AND MEAT PRODUCTION. U. S. Dept. Agr. Yearbook (Food and Life) 1939: 450–468, illus.

a relatively low level, below the carcass. When the separable-fat content of the carcass became about 22 percent, that of the leg began to fall below all other parts. After the fat content of the carcass attained a level of about 28 percent, the rib tended to be fatter than all other cuts. At the extreme of 37 percent in separable-fat content of carcass there was a difference of nearly 30 percent between the rib, the fattest cut, and the leg, which contained the least fat. The results of this study are so presented that, with a given percentage of separable fat of any of the six primary cuts of a lamb carcass, one can obtain the corresponding approximate values for all other cuts as well as for the carcass as a whole.

Three categories of lamb carcasses including fat, intermediate, and thin were recognized in a report by Hankins and Howe.[6] Those containing 35 percent or more of ether extract in the edible portion of the dressed carcass were placed in the first-mentioned group. The limits of the second group were 20 to 34 percent, inclusive, and the thin lambs contained less than 20 percent. The corresponding numbers of individuals were 10, 19, and 13. Mean values for separable fat, lean meat, and bone content of the dressed carcasses and of the six primary cuts, including leg, rib, three-rib shoulder, loin, neck, and breast, were given. For the edible portion of the carcass, leg, rib, and shoulder of each of the three groups of carcasses, mean chemical composition values, including ether extract, protein, water, and ash, were reported.

In a similar study, by Hankins and Foster,[7] 51 lambs were involved, representing the six official market grades recognized by the Department—Prime, Choice, Good, Commercial, Utility, and Cull. The mean percentages of separable fat, lean meat, total edible portion, and bone for each primary cut and the entire dressed carcass of each grade were presented. The relationships between the values for the various cuts and those for the carcass, as well as among the cuts themselves, are indicated in the report mentioned and also in the findings of Hankins and Howe.[8]

OBJECTIVES OF THE STUDY

Objectives of the work reported in this bulletin were to determine the relationships between (1) the proportions of separable fat, muscle, and bone[9] in the different primary cuts of lamb and those in the dressed carcass as a whole; (2) the different cuts themselves with respect to these composition factors; and (3) the major chemical components of the edible portion of the rib, leg, and shoulder cuts and the corresponding components of the dressed carcass. A further objective was to develop methods for estimating (1) the percentages of fat, muscle, and

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[6] HANKINS, O. G., and HOWE, PAUL E. THE APPROXIMATE COMPOSITION OF CUTS FROM LAMB CARCASSES OF DIFFERENT DEGREES OF FATNESS. 2 pp. U. S. Bur. Anim. Indus. May 1942. (Processed.)

[7] HANKINS, O. G., and FOSTER, M. T. APPROXIMATE PHYSICAL COMPOSITION OF THE PRIMARY CUTS FROM LAMB CARCASSES OF DIFFERENT MARKET GRADES. 3 pp. U. S. Bur. Anim. Indus. and U. S. Agr. Market. Serv., Dec. 1940. (Processed.)

[8] See footnote 6.

[9] In the interest of brevity, throughout the remainder of the paper separable fat, separable muscle, and separable bone are referred to simply as fat, muscle, and bone.

bone in the lamb carcass and cuts from the percentages of fat, muscle, and bone in one of the primary cuts and (2) the major chemical components of the carcass from the chemical components of certain cuts.

EXPERIMENTAL MATERIAL USED

During a period of several years carcasses were selected from animals used in certain cooperative and independent investigations not connected with the present study. The cooperative experiments were conducted with the agricultural experiment stations of Maryland University and Purdue University (Indiana). In the former case the lambs were fed at the Union Stock Yards, Baltimore, Md., and in the latter instance at La Fayette, Ind. The animal-production phase of the independent experiments was conducted by the Bureau of Animal Industry at the Agricultural Research Center of the Department, located at Beltsville, Md.; the United States Morgan Horse Farm, Middlebury, Vt.; and the United States Sheep Experiment Station, Dubois, Idaho. All lambs were slaughtered and all analytical work on the meat was done at Beltsville.

Physical-composition data were accumulated on the carcasses and 6 primary cuts of 64 selected lambs of the following breeding: Columbia, 2; Corriedale, 3; Shropshire, 18; Southdale, 6; Southdown, 15; Hampshire×Corriedale, 3; Hampshire×Rambouillet, 6; Southdown×Corriedale, 1; Corriedale×Southdown, 2; Suffolk×Corriedale, 2; Tasmanian Merino, 1; and unknown breeding 5. Of these lambs 12 were ewes, 22 were rams, and 30 were wethers. The variations in age at slaughter, live weight of the unshorn lambs at slaughter, chilled-carcass weight, and the proportions of fat, muscle, and bone with ligament in the dressed carcass are shown in table 1. The 64 lambs constituted a group that was regarded as very satisfactory for the purposes of the study.

Data on chemical composition of the carcasses and of the rib, leg, and 3-rib shoulder cuts of 42 lambs were likewise accumulated during a period of several years. Thirty-five of these animals were included in the larger group previously described. Of the seven additional lambs, one was experimentally fed by the Maryland University station at the Union Stock Yards, Baltimore, Md.; three by the Purdue University station at La Fayette, Ind.; and three by the Bureau at Middlebury, Vt. All slaughtering and subsequent work was done by the Bureau at Beltsville, Md.

The 42 lambs were distributed as follows with respect to breeding: Columbia, 2; Corriedale, 3; Rambouillet, 1; Shropshire, 15; Southdale, 1; Tasmanian Merino, 2; Hampshire × Corriedale, 2; Hampshire × Rambouillet, 7; Southdown × Corriedale, 1; Corriedale × Southdown, 2; Southdown × Rambouillet, 1; and unknown breeding, 5. There were 14 ewe lambs, 7 ram lambs, and 21 wether lambs. Table 2 shows the variations among the animals in age at slaughter, live weight of the unshorn lambs at slaughter, weight of chilled carcass, and the percentages of ether extract, protein, water, and ash in the edible meat of the dressed carcass. Like the group of 64 lambs, these 42 animals constituted a representative group and were considered to be very satisfactory for the purposes of the study.

TABLE 1.—*Variations with respect to age, weights, and physical components of carcasses among the 64 lambs used in the physical-composition studies*

Age		Live weight at slaughter		Chilled-carcass weight		Components of chilled carcass					
Months	Number of lambs	Pounds	Number of lambs	Pounds	Number of lambs	Fat	Number of lambs	Muscle	Number of lambs	Bone with ligament	Number of lambs
						Percent		*Percent*		*Percent*	
4	1	36-45	1	12.6-17.5	4	2.51- 7.50	3	42.51-47.50	9	7.51-12.50	1
5	12	46-55	6	17.6-22.5	7	7.51-12.50	2	47.51-52.50	18	12.51-17.50	16
6	16	56-65	9	22.6-27.5	1	12.51-17.50	7	52.51-57.50	27	17.51-22.50	21
7	1	66-75	8	27.6-32.5	11	17.51-22.50	9	57.51-62.50	9	22-51-27.50	11
8	3	76-85	9	32.6-37.5	8	22.51-27.50	12	62.51-67.50	1	27.51-32.50	11
9	11	86-95	12	37.6-42.5	8	27.51-32.50	19			32.51-37.50	2
10	7	96-105	5	42.6-47.5	9	32.51-37.50	11			37.51-42.50	2
11	4	106-115	4	47.6-52.5	8	37.51-42.50	1				
12	2	116-125	2	52.6-57.5	3						
13	0	126-135	2	57.6-62.5	3						
14	2	136-145	1	62.6-67.5	0						
(1)	5	(2)	5	67.6-72.5	2						

[1] Unknown.
[2] Not obtained.

TABLE 2.—*Variations with respect to age, weights, and chemical components of the edible meat of the carcasses among the 42 lambs used in the chemical-composition studies*

Age		Live weight at slaughter		Chilled-carcass weight		Components of edible meat of chilled carcass							
Months	Number of lambs	Pounds	Number of lambs	Pounds	Number of lambs	Ether extract	Number of lambs	Protein	Number of lambs	Water	Number of lambs	Ash	Number of lambs
						Percent		*Percent*		*Percent*		*Percent*	
4	1	36-45	2	12.6-17.5	5	2.6- 7.5	1	10	1	37.6-42.5	2	0.60	2
5	12	46-55	5	17.6-22.5	8	7.6-12.5	4	11	0	42.6-47.5	3	.65	2
6	7	56-65	7	22.6-27.5	2	12.6-17.5	1	12	2	47.6-52.5	11	.70	6
7	0	66-75	3	27.6-32.5	5	17.6-22.5	10	13	4	52.6-57.5	6	.75	6
8	3	76-85	6	32.6-37.5	3	22.6-27.5	7	14	5	57.6-62.5	10	.80	7
9	11	86-95	7	37.6-42.5	10	27.6-32.5	5	15	7	62.6-67.5	5	.85	8
10	1	96-105	0	42.6-47.5	4	32.6-37.5	7	16	7	67.6-72.5	4	.90	7
11	0	106-115	1	47.6-52.5	2	37.6-42.5	5	17	8	72.6-77.5	1	.95	2
12	2	([1])	11	52.6-57.5	0	42.6-47.5	2	18	8			1.00	0
([2])	5			57.6-62.5	1							1.05	1
				62.6-67.5	0							1.10	1
				67.6-72.5	2								

[1] Not obtained.
[2] Unknown.

PROCEDURE

In slaughtering the lambs, the forefeet were taken off at the "break joint" and the skin (pelt) was removed in the customary manner. The head was separated from the neck at the atlas joint, which is the union of the occipital bone and the first cervical vertebra. The abdominal and thoracic viscera were then removed, leaving the kidney and kidney fat intact. The carcasses were retained in one piece, that is, they were not separated into the two sides by splitting down the backbone. The weight of the warm dressed carcasses was generally obtained about 30 minutes after slaughter. Chilling was done at approximately 34° F. and continued for 48 to 72 hours, after which the carcass weight was taken to an accuracy of 0.25 pound.

Every effort was made to cut the carcasses in a strictly uniform manner. Starting in the flank, a straight-line cut was made, which touched the end of the thirteenth rib and continued on to cross the humerus bone at the middle. This cut removed the breast including the foreleg from the underside of the carcass. The corresponding cut was removed from the other side of the carcass in the same manner. Next a cut was made between the third and fourth ribs, which resulted in a piece consisting of a three-rib shoulder and the neck. These two parts were separated by cutting on a line flush with the top of the shoulder. A cut was then made between the twelfth and thirteenth ribs, thus removing a rib cut that included nine ribs. The loin was separated from the legs at the "small of the back," or the external angle of the ilium, the cut being made parallel to that between the twelfth and thirteenth ribs. The double shoulder, rib, loin, and leg cuts were then cut into the left- and right-side cuts of each. The legs were trimmed by removing the sacral vertebrae with the attached fat and lean, rounding the flank corner and trimming off the loose fat from the inside face, and removing the lower part of the leg at the hock joint. The leg was then Frenched by cutting off the muscle and tendon for 1.5 inches above the hock joint in a piece of average size but with a slight variation in this distance, depending on the size of the leg. As a final step in the preparation of the cuts for analysis, the kidney and kidney fat were removed from the loin.

The next step was the separation of each cut into fat, muscle, and bone or bone with ligament, as the case might be. In most cases the cuts from both sides of the carcass were used. These physical analyses were made with great care by experienced personnel, and the different components were weighed to an accuracy of 0.01 pound. To represent the fat content of the dressed carcass as a whole, the sum of all fat separated from the various cuts, including the leg trimmings and the kidney fat, was obtained. The total weight of muscle included all separated lean tissue and the kidney. Likewise, for total bone the sum of the weights of all separated bone, or bone and ligament, was obtained.

Making a chemical analysis of the edible meat of the cuts from the two sides of the carcass was uniformly followed. In the case of the rib cut two samples were taken—the eye muscle and the remaining edible portion. In the leg and shoulder a composite sample of the fat and muscle was used in each instance. A fifth sample for chemical analysis consisted of a combination of the edible meat (fat and muscle) from the loin, neck, breast, trimmings, and kidney fat. The ether extract, protein, water, and ash contents of each of these five samples were determined. Thus the composition of the edible meat of the leg and shoulder cuts was determined and, through further calculation and the requisite combinations of data, that of the rib cut and carcass was also obtained.

In preparing the material for analysis and in carrying out the chemical determinations, the same methods were employed as in work previously reported by the Bureau.[10] Likewise, the statistical formulae used in the analysis of the data were the same as those given in that report. All relationships were treated as linear.

RESULTS

Relations Between Physical Components of Carcass and Cuts

In comparing the physical components of the dressed lamb carcass with those of the various primary cuts, the study was made on the group that contained 64 individuals (table 1). Table 3 gives the ranges, means, and standard deviations of the percentages of fat, muscle, and bone or bone and ligament in the dressed carcasses and primary cuts. Attention is called especially to the wide variations in components shown in the table. These are viewed as further evidence that the group of 64 lambs was very satisfactory for the purposes of the study.

Table 3.—*Ranges, means, and standard deviations of physical-composition data on the dressed carcasses and primary cuts of 64 lambs*

Sample analyzed and components	Range	Mean	Standard deviation
	Percent	*Percent*	*Percent*
Dressed carcass:			
Fat	5.66–38.70	25.25	8.16
Muscle	43.50–64.43	53.00	4.44
Bone and ligament	12.11–38.09	21.75	6.41
Breast:			
Fat	4.17–41.97	28.41	9.32
Muscle	33.33–56.06	43.59	5.54
Bone	15.30–50.00	28.00	8.21
Leg:			
Fat	2.61–25.62	16.08	5.70
Muscle	57.72–75.60	66.98	3.60
Bone	9.73–31.42	16.94	4.89
Loin:			
Fat	2.13–44.71	28.49	10.39
Muscle	44.66–73.40	56.54	6.07
Bone	4.42–33.33	14.97	6.03
Neck:			
Fat	0.00–35.00	17.77	8.67
Muscle	32.00–70.16	50.06	8.21
Bone and ligament	17.44–53.76	32.17	8.43
Rib:			
Fat	2.18–44.65	28.80	11.38
Muscle	32.95–61.25	48.44	6.22
Bone and ligament	11.86–48.09	22.70	7.93
Shoulder:			
Fat	6.76–31.88	21.60	6.15
Muscle	44.27–74.15	58.53	5.08
Bone and ligament	10.23–31.68	19.87	6.10

[10] Hankins, O. G., and Howe, Paul E. estimation of the composition of beef carcasses and cuts. U. S. Dept. Agr. Tech. Bul. 926, 20 pp., illus. 1946.

The coefficients of correlation, with their probable errors, representing the relationships between physical-composition factors of the dressed carcasses and those of the primary cuts are shown in table 4. With respect to fat content, the relation between the carcass and the rib cut was closer than between the former and any other cut. Moreover, the correlation coefficient (r) was very high. This close relationship is further brought out in figure 1, in which the narrow scatter about the regression line is of special interest. The regression equation for estimating the fat content of the carcass from that of the rib

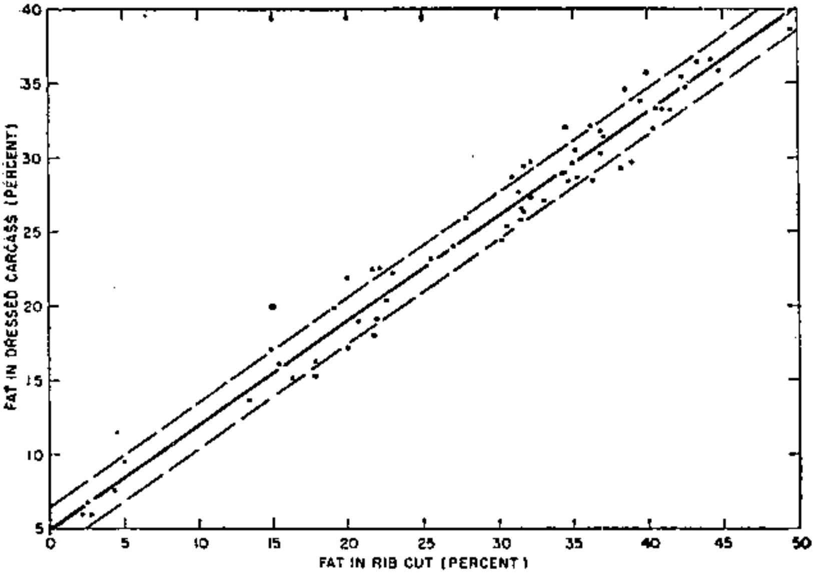

Figure 1.—Relation between fat content of rib cut and of dressed lamb carcass.

is as follows: Percentage of fat in carcass$=0.70\times$percentage of fat in rib cut$+5.00$. The standard error of the estimate is 1.50 percent, which is less than that relating to any of the other five cuts.

TABLE 4.—*Relationships between physical-composition factors of the dressed carcasses and primary cuts of 64 lambs*

Relationship between carcass and indicated cut	Coefficients of correlation and probable errors for—		
	Fat	Muscle	Bone
Rib	+0.98±0.003	+0.92±0.01	+0.97±0.01
Loin	+.96± .01	+.51± .03	+.95± .01
Breast	+.94± .01	+.78± .03	+.96± .01
Leg	+.93± .01	+.86± .02	+.94± .01
Shoulder	+.91± .02	+.73± .04	+.95± .01
Neck	+.81± .03	+.77± .04	+.86± .02

The loin, breast, leg, shoulder, and neck cuts follow the rib in decreasing order with respect to the magnitude of the coefficients for the correlations with the carcass. However, all exceed 0.90

except the neck, which has a coefficient of correlation of +0.81. The standard error of the estimate in that instance is 4.81 percent.

In general the correlations for muscle were not so high as those for fat. but the closest relation was also found between rib and carcass. Figure 2, illustrating this relationship, indicates that the muscle content of the lamb carcass can be satisfactorily estimated from that of the rib cut, although the scatter about the regression line is slightly wider than in the case of the fat. For estimating the muscle of the carcass from that of the rib cut, the following equation was derived: Percentage of muscle in carcass $=0.656\times$ percentage of muscle in rib $+21.22$. The standard error of the estimate is 1.76 percent.

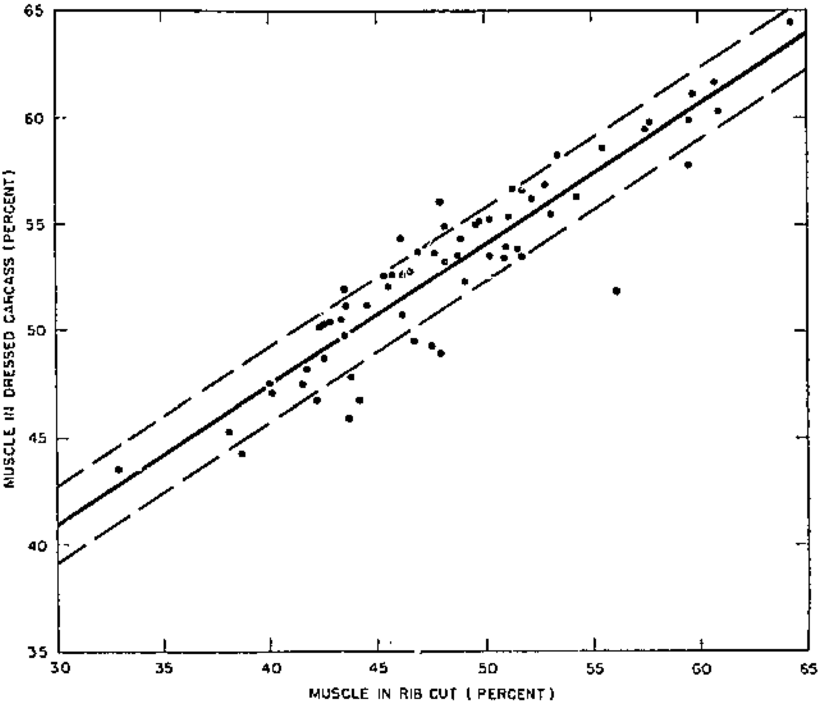

FIGURE 2.—Relation between muscle, or lean, content of the rib cut and of the dressed lamb carcass.

On the whole, as shown in table 4, the relationships between bone content of the six cuts and that of the lamb carcass were closer than those for muscle or even for fat. The highest correlation between the various cuts and the carcass, which again was that representing the rib-carcass relation, was slightly lower than the corresponding correlation for fat content. Both were extremely high, however, and the difference between them is of little practical significance. A diagram for bone content, corresponding to figures 1 and 2 for fat and muscle, respectively, which was used in the analysis of the data, was very similar to those two figures. For the purpose of estimation, the following equation was derived: Percentage of bone and ligament in carcass=0.78×percentage of bone and ligament in rib cut+3.96. The standard error of the estimate is 1.68 percent. The neck-carcass relationship is the only one concerned with bone content that is represented by a correlation coefficient lower than 0.90. In that instance there is the relatively high standard error of estimate of 3.28 percent.

Relations Between Chemical Components of Carcass and Cuts

The study of the chemical components of the edible portion of the dressed carcass in relation to those of certain primary cuts was based on data from the group of 42 lambs (table 2). Table 5 presents the ranges, means, and standard deviations of the percentages of ether extract, protein, water, and ash in the edible meat of the dressed carcasses and of the leg, rib, and shoulder cuts. The wide variations in these chemical components give additional basis for the belief that the 42 lambs were a highly suitable group for the investigation.

Table 5.—*Ranges, means, and standard deviations of chemical-composition data on the edible meat of the carcasses and three primary cuts of 42 lambs*

Sample analyzed and components	Range	Mean	Standard deviation
	Percent	*Percent*	*Percent*
Dressed carcass:			
Ether extract	5.8-45.8	25.78	10.18
Protein	11.5-18.3	15.62	1.83
Water	41.1-74.3	56.77	8.20
Ash	.58-1.10	.806	.108
Leg:			
Ether extract	3.2-26.4	10.03	5.79
Protein	16.0-19.8	17.79	1.05
Water	56.4-76.2	65.05	4.98
Ash	.74-1.17	.926	.089
Rib:			
Ether extract	4.4-59.8	31.22	13.96
Protein	8.7-19.7	14.89	2.74
Water	30.4-74.7	52.91	11.07
Ash	.46-1.27	.771	.183
Shoulder:			
Ether extract	6.1-40.8	24.15	8.40
Protein	13.2-17.2	15.46	1.48
Water	45.9-75.1	59.39	7.01
Ash	.57-1.18	.820	.121

The coefficients of correlation and the respective probable errors for the relationships between chemical-composition factors of the edible portion of the dressed carcasses and the corresponding factors of the rib, shoulder, and leg cuts appear in table 6. With respect

Table 6.—*Relationships between chemical-composition factors of the edible portion of the dressed carcasses and the rib, shoulder, and leg cuts of 42 lambs*

Relationship between carcass and indicated cut	Coefficients of correlation and probable errors for—			
	Ether extract	Protein	Water	Ash
Rib	+0.98±0.004	+0.97±0.01	+0.98±0.004	+0.73±0.05
Shoulder	+.96±.01	+.91±.02	+.97±.01	+.89±.02
Leg	+.96±.01	+.77±.04	+.96±.01	+.81±.04

to ether-extract content, the rib-carcass relationship was slightly closer than the shoulder-carcass and leg-carcass relations. Moreover, the correlation value for rib with carcass was extremely high. For purposes of estimation the following equation was derived: Percentage of ether extract in edible meat of carcass=0.72×percentage of ether extract in edible meat of rib cut+4.20. The standard error of the estimate is 1.90 percent.

The relation between the protein content of the rib cut and that of the carcass was closer than the relation involving either the leg or the shoulder. Furthermore, the coefficient of correlation was very high. This relationship is presented graphically in figure 3, which shows a

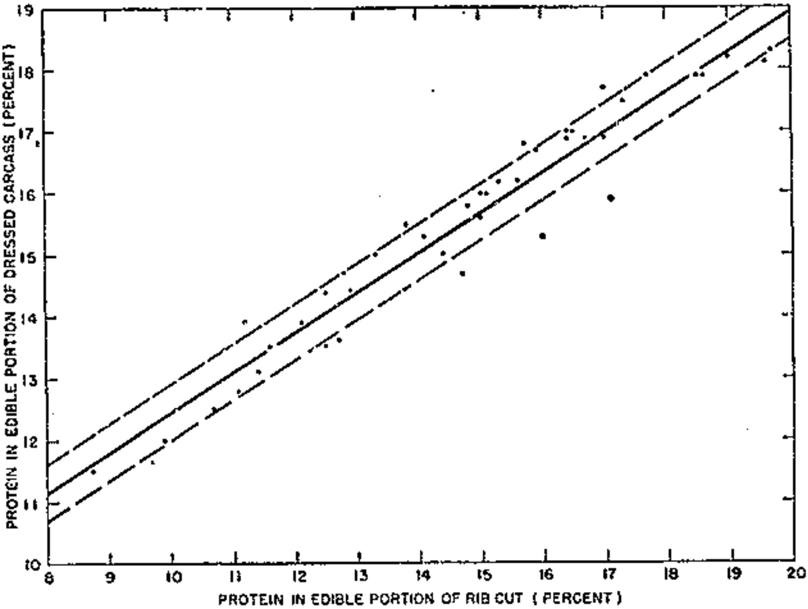

FIGURE 3.—Relation between protein content of edible portion of rib cut and same component of edible portion of dressed lamb carcass.

marked tendency of one factor to vary with the other. With a standard error of only 0.452 percent, the regression equation for estimating the protein content of the edible portion of the dressed lamb carcass from the corresponding component of the rib cut is as follows: Percentage of protein in edible meat of carcass=0.65×percentage of protein in edible meat of rib+5.97.

The water content of the edible meat of the dressed lamb carcass was closely related to that of all three cuts included in the study. However, as with ether extract and protein, the rib-carcass relationship was closer than the other two. A diagram of this relation, employed in the analysis of the data, brought out clearly the great tendency for the water content of the rib and of the carcass to vary with each other. The appearance of this diagram was similar to that of figure 1. The equation derived for estimating the water content of the carcass from that of the rib cut is as follows: Percentage of water in edible meat of carcass = 0.73 × percentage of water in edible meat of rib cut + 18.02. The standard error of the estimate is 1.60 percent.

In general, the relationships between the rib, shoulder, and leg cuts on the one hand, and the carcass on the other hand, with respect to ash content of the edible meat, were lower than those involving ether extract, protein, and water. Only one, the shoulder-carcass relation, had a correlation value closely approaching 0.90. This relationship is illustrated in figure 4. Attention is called in particular to the moderately wide scatter about the regression line. Comparison with figure 3, with regard to the variability of the observations, is of special interest.

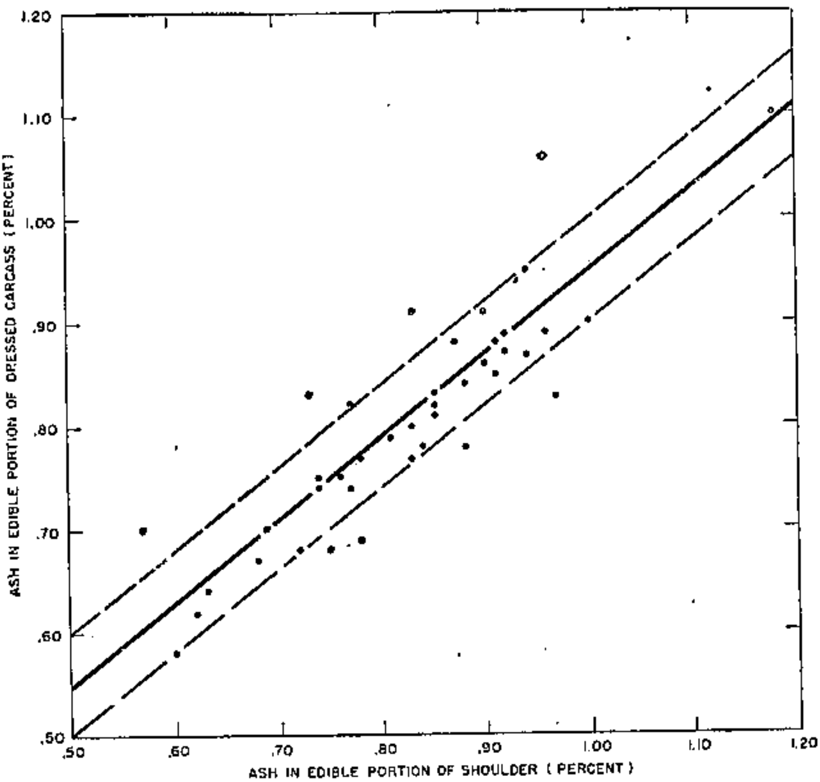

FIGURE 4.—Relation between ash content of edible portion of shoulder and same component of edible portion of dressed lamb carcass.

There is little doubt that the ash content of the shoulder is of less value for estimating that of the carcass than are the ether extract, protein, and water contents of the rib for estimating the corresponding components of the carcass. Nevertheless the coefficient of correlation involving ash content is moderately high and probably in many instances the percentage of ash in the shoulder could be used satisfactorily for estimating that in the dressed carcass. For making such estimates the following regression equation is offered: Percentage of ash in edible meat of dressed carcass=0.80×percentage of ash in edible meat of shoulder+0.15, the standard error of the estimate being 0.05 percent.

Relations Between Physical Components of Rib and Other Cuts

The advantage in having a means for estimating the composition of all other primary cuts from that of one cut is obvious. Since the rib cut proved generally the most satisfactory for estimating the composition of the carcass with respect to both physical and chemical constituents, it seemed logical to determine the usefulness of that same cut for obtaining calculated composition values for the other cuts. In this phase of the study, data on the group of 64 lambs previously described were used.

Table 7 shows the relationships between the fat, muscle, and bone of the rib cut, on one hand, and the corresponding components of the breast, leg, loin, neck, and shoulder cuts, on the other hand. It also shows the equations derived for estimating the physical composition of the other cuts from that of the rib and the corresponding standard errors of estimate.

Table 7.—*Relationships between physical-composition factors of the rib cut and those of other primary cuts of 64 lambs*

Relationships studied	Coefficient of correlation and probable error	Estimating equation	Standard error of estimate
Fat of rib cut with fat of—			*Percent*
Breast	+0.91±0.01	$Y=0.91+0.75X$	3.86
Leg	+.88±.02	$Y=3.41+.44X$	2.75
Loin	+.94±.01	$Y=3.72+.86X$	3.50
Neck	+.61±.03	$Y=-.58+.64X$	4.78
Shoulder	+.88±.02	$Y=7.88+.48X$	2.93
Muscle of rib cut with muscle of—			
Breast	+.63±.05	$Y=16.23+.57X$	4.32
Leg	+.81±.03	$Y=44.29+.47X$	2.14
Loin	+.77±.04	$Y=16.45+.83X$	4.27
Neck	+.60±.05	$Y=6.15+.91X$	6.02
Shoulder	+.51±.06	$Y=34.82+.49X$	4.83
Bone of rib cut with bone of—			
Breast	+.92±.01	$Y=0.44+.95X$	3.35
Leg	+.85±.02	$Y=4.96+.53X$	2.57
Loin	+.93±.01	$Y=-1.10+.71X$	2.27
Neck	+.83±.03	$Y=12.03+.89X$	4.72
Shoulder	+.91±.02	$Y=3.97+.70X$	2.60

With respect to fat content, the closest relation between the rib and the other cuts occurred in the case of loin. The breast followed closely, the leg and shoulder being somewhat lower with equal correlation coefficients. The cut having the least relation to the rib was the neck. The standard errors involved in estimating the fat content of all other cuts from that of the rib varied from 2.75 percent for the leg to 4.78 percent for the neck.

On the whole, the correlations between the percentage of muscle of the rib cut and the same component of the other cuts were only moderately high. The highest was between the rib and leg; the lowest, between rib and shoulder. The standard errors involved in estimating the muscle content of the five cuts from that of the rib ranged from 2.14 percent for the leg to 6.02 percent for the neck. The muscle content of the rib cut appears to be of doubtful value for estimating that of the neck and shoulder and possibly also of the breast.

All the correlation coefficients involving bone content, particularly those between the rib cut and the breast, loin, and shoulder, were high. The standard errors of estimate ranged from only 2.27 to 4.72 percent. There can be little question concerning the usefulness of the bone content of the rib cut for estimating that of the other five cuts.

Considering the results of this phase of the study as a whole, it appears that the fat, muscle, and bone content of the breast, leg, loin, neck, and shoulder cuts of lamb can be estimated with satisfactory accuracy from the corresponding components of the rib cut, with the probable exception of the percentage of muscle in the neck, shoulder, and breast.

SUMMARY

The proportions of bone, muscle, and fat in a meat animal at any given stage of growth or fattening mean a great deal to the producer, packer, retailer, and consumer. In normal development, skeletal growth ceases first, muscle growth next, and the final stage consists mainly of the deposition of fat.

Chemical analysis of the entire animal body, excluding the contents of the digestive tract and bladder, produces the most satisfactory composition data. Similar analysis of the dressed carcass is the next best method. Because of the time and expense involved in either of these procedures, however, a short cut is often necessary. Research workers have long been interested in simplified procedures for estimating at least the major components with adequate accuracy. Studies were therefore conducted to bring out more clearly the relationships between certain composition factors and to develop improved methods for estimating such factors. Physical-composition data on 64 lambs and chemical-composition data on 42 lambs were involved.

Standard methods were employed in slaughtering, chilling, and cutting, and in making the physical analyses. Methods previously reported were used in preparing the material and making the chemical and statistical determinations.

The fat content of the rib cut was very closely related to that of the dressed carcass. The coefficient was higher than that for the correlation between the carcass and any of the other cuts with respect to this component, although all except the neck exceeded 0.90.

In muscle content the closest relation between the carcass and the cuts occurred in the case of the rib. The leg was next in order.

With respect to bone content, the rib cut was also the most closely related to the carcass, but the coefficients involving the breast, shoulder, loin, and leg were only slightly lower and all of them were high.

The relation between the ether-extract content of the edible meat of the rib cut and that of the carcass was very close. The leg-carcass and shoulder-carcass correlations were only slightly lower.

The protein content of the edible meat of the rib cut was very closely related to that of the carcass. The relationship was distinctly closer than those for the leg and shoulder, especially the former.

The water content of the edible meat of the dressed carcass was very closely related to that of the rib, leg, and shoulder. However, the

carcass-rib relationship was slightly higher than the relationships involving the other two cuts.

With respect to ash content of the edible meat, the shoulder was most closely, and the rib least closely, related to the carcass. In general the ash relationships were at a lower level than those involving ether extract, protein, and water.

The closest relation between the rib and the other five cuts in fat content occurred in the case of loin. The breast followed closely, the leg and shoulder being somewhat lower with equal correlation coefficients. With a coefficient of $+0.84 \pm 0.03$, the rib-neck relationship was least close.

On the whole the correlations between muscle content of the rib cut and the same component of the other cuts were only moderately high. The muscle content of the rib appeared to be of doubtful value for estimating that of the neck, the shoulder, and possibly the breast.

The bone content of the rib cut was found to be very satisfactory for estimating that of the other five cuts.

Numerous regression equations were derived and presented to provide means for the estimation of unknown from known factors.

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