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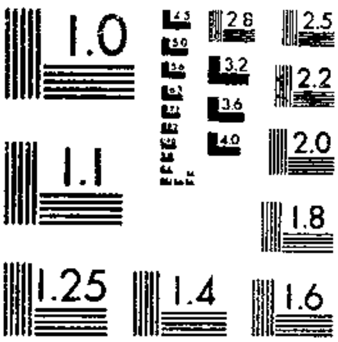

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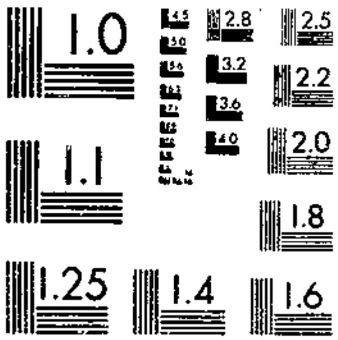

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Estimation of the Composition of Beef Carcasses and Cuts [1]

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CONTENTS

INTRODUCTION

Studies of the development of meat animals as affected by breeding and feeding are primarily concerned with changes in fat deposit, the muscular system, and skeletal structure. The proportions of fat, lean, and bone at any given stage of development are of interest to the producer, packer, retailer, and especially the consumer. Fatness affects greatly the acceptability of meat to the consumer, and it is well known that the fattening period is the most costly phase of animal feeding. It is important, therefore, that rapid, economical methods for estimating the physical and chemical composition of carcasses and cuts be available to workers in the field of livestock and meat research.

The most accurate method for determining the composition of a meat animal is to make a chemical analysis of the entire body after

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[2] On military leave.

[3] The authors give credit to N. R. Ellis, R. L. Hiner, W. R. Kauffman, H. E. McClure (resigned), J. M. Spadola (resigned), 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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having first eliminated the contents of the digestive tract and bladder. Probably the next best method is to analyze the dressed carcass. However, either of these undertakings is time consuming and expensive. Consequently, research workers have long been interested in simplified methods that would enable them to estimate composition—at least its more important components—with satisfactory accuracy.

REVIEW OF LITERATURE

A few investigators, in recognition of this interest and need, have worked on the problem and several methods relating to beef have been developed. Murray (*6*),[4] for example, stated that assuming the fat-free animal body to be constant in composition, the chemical composition of the live animal could be estimated provided the fatness was known. Trowbridge and Moulton reached the conclusion, as reported by Lush (*5*), that the composition of "the wholesale rib cut [5] rather adequately represented the carcass." This work by Trowbridge and Moulton involved fat as determined by chemical means.

Lush (*5*) also reported that the fat content of the entire live steer could be estimated from the dressing percentage by the use of the following equation: Percentage of fat in entire live animal $=1.782\times$ dressing percentage -86.40. The coefficient of correlation was $+0.84\pm0.04$. For estimating the fat content of the live animal from the percentage of caul fat, he offered the following equation: Percentage of fat in entire live animal $=14.55\times$ percentage of caul fat based on live weight $+5.19$. In this instance the correlation coefficient was $+0.89\pm0.03$. The most reliable indicator of fatness of the entire animal found by Lush was the percentage of fat in the edible portion of the wholesale-rib cut. The estimating equation was as follows: Percentage of fat in live animal $=0.603\times$ percentage of fat in rib flesh $+3.92$. The relationship was represented by the correlation coefficient of $+0.987\pm0.003$.

Hopper (*4*) reported on the analysis of data from 92 cattle to determine the relations that could be used for the prediction of the physical and chemical composition of the empty body, carcass, and edible portion of the carcass from the analysis of a rib cut. The wholesale-rib cut and the edible portion thereof, as well as the ninth-tenth-eleventh rib and the edible portion of that cut, were studied as indicators of both physical and chemical composition. Numerous relationships and estimating equations are presented. In summarization he states, for example, that the physical composition of the whole and edible portion of the wholesale-rib and ninth-tenth-eleventh-rib cuts is highly correlated with the physical composition of the empty body, carcass, and edible portion of the carcass. The correlations are especially high for the percentage of fat. Likewise, the chemical composition of the whole and edible portion of the wholesale-rib cut is highly correlated with the chemical composition of the empty body, carcass, and edible portion of the carcass.

Chatfield (*2*) stated that the protein content of the edible portion of fresh mature-beef sides is a curvilinear function of the fat content

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[4] Italic numbers in parentheses refer to Literature Cited, p. 20.

[5] Also known as the standing-rib cut and the prime-rib cut (sixth to twelfth ribs, inclusive).

and that the ash content, as a linear function of the fat content, can be estimated for sides or wholesale cuts with fair accuracy. This worker also reported that the bone content of the entire side or of certain standard wholesale cuts can be estimated roughly from the fat content but that there is too much variation in bone content to permit much accuracy in such an estimation; also that for any wholesale cut there is a close relation between the contents of ether extract and of visible or separable fat.

Workers in the Bureau of Animal Industry, United States Department of Agriculture (7), found that the percentage of bone in the ninth-tenth-eleventh-rib cut provided a basis for estimating the bone content of the dressed beef carcass. The correlation coefficient was $+0.83 \pm 0.02$, and the estimating equation was as follows: Percentage of bone in dressed carcass$=0.612\times$percentage of bone in ninth-tenth-eleventh-rib cut$+4.296$.

OBJECTIVES OF THE WORK

When the national project, Cooperative Meat Investigations, was in course of organization, the need was recognized for a relatively small, inexpensive sample that would furnish a good representation of the composition of the entire dressed beef carcass. The ninth-tenth-eleventh-rib cut was proposed, and in 1927 the Bureau of Animal Industry undertook a study of its suitability for this purpose. The usefulness of the composition of the entire wholesale, or standing-rib, cut for estimating the composition of the dressed carcass having previously been established, the first objective of this work was to determine the relationship of the fatness of the ninth-tenth-eleventh rib to the fatness of the standing-rib cut. The thought was that, provided a close relationship was found between these two, the former could safely be used as a carcass sample. The second purpose was to obtain more definite information on the relationships between the physical- and chemical-composition factors of the ninth-tenth-eleventh-rib cut and pertinent factors of the dressed carcass and to develop means for estimating the latter from the former. A further objective was to determine the relationships of (1) the fatness of the various primary cuts to the fatness of the dressed carcass and (2) the fatness of the ninth-tenth-eleventh-rib sample to that of the sixth-seventh-eighth-twelfth-rib sample and of each of the primary cuts. The derivation of estimating equations for some of the relationships was also an objective in those instances.

EXPERIMENTAL MATERIAL USED

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 State agricultural experiment stations of Arkansas, Colorado, Louisiana, Michigan, Mississippi, Missouri, Montana, Nebraska, North Carolina, Ohio, South Carolina, Texas, and Wyoming. In Arkansas, Missouri, Montana, and Texas the cattle were finished, or produced and finished, at the State Agricultural and Mechanical College, Jonesboro; Sni-a-Bar Farms, Grain Valley; United States Range Livestock Experiment Station, Miles City; and King Ranch, Kingsville, respectively. In

Louisiana, work was done both at the Louisiana Agricultural Experiment Station, Baton Rouge, and the Iberia Livestock Experiment Station, Jeanerette. In all other cooperative experiments the cattle were finished, or produced and finished, at the State agricultural experiment stations. The independent experiments were conducted by the Bureau of Animal Industry at the Agricultural Research Center of the United States Department of Agriculture, located at Beltsville, Md. Most of the animals were slaughtered at Beltsville, although in some cooperative experiments the animals were slaughtered elsewhere and carcass samples shipped to Beltsville. The analytical work, in all instances, was done at that place.

The experimental material was studied in three groups. In the first group, on which studies of the relation of the fatness of the ninth-tenth-eleventh-rib cut to that of the standing rib were made, 77 cattle were represented. Of this number, 2 were purebred Aberdeen Angus, 2 purebred Shorthorn, 10 grade Aberdeen Angus, 12 grade Brahman, 32 grade Hereford, 14 grade Shorthorn, 2 Hereford × Aberdeen Angus, 1 scrub, and 2 unreported with respect to breeding. There were 53 steers and 24 heifers. In age at time of slaughter the 77 cattle varied from approximately 9 to 35 months and in final feed-lot weight from 580 to 1,417 pounds. The weights of chilled, dressed carcasses ranged from 308 to 858 pounds.

The second group of material, on which studies of the physical and chemical composition of the ninth-tenth-eleventh-rib cut and of the entire dressed carcass were made, represented 120 cattle. There were 4 purebred Aberdeen Angus, 69 purebred Hereford, 30 purebred Shorthorn, 9 grade Hereford, 4 grade Shorthorn, 2 Hereford×Aberdeen Angus, and 2 scrubs. Of the total number, 84 were steers and 36 were heifers. In age at time of slaughter the cattle varied from approximately 10 to 21 months and in final feed-lot weight from 550 to 1,037 pounds. The weights of the chilled, dressed carcasses ranged from 284 to 628.5 pounds.

The third group of experimental material represented 22 of the 120 cattle that comprised the above-described second group. The smaller number of individuals provided the basis for determining the relationships of the fatness of the various primary cuts to that of the dressed carcass, as well as the relationship of the fatness of the ninth-tenth-eleventh-rib cut to that of the sixth-seventh-eighth-twelfth-rib sample and to that of each of the primary cuts. In breeding, 4 of the 22 cattle were purebred Aberdeen Angus, 1 purebred Hereford, 9 grade Hereford, 4 grade Shorthorn, 2 Hereford×Aberdeen Angus, and 2 scrub. Twelve were steers and 10 were heifers. These cattle varied from 11 to 15 months in age, from 557 to 985 pounds in final feed-lot weight, and from 284 to 569 pounds in weight of chilled, dressed carcass.

PROCEDURE

In the carcass studies, the procedure involved (1) weighing the warm carcasses about one-half hour after dressing, (2) shrouding the carcasses, and (3) chilling them at a temperature of approximately 34° F. for 48 to 72 hours. Only the right side of each carcass was used for analysis. The carcasses, sides, and larger, heavier cuts were weighed on a scale with a sensitivity of 0.5 pound and the smaller cuts to 0.1 pound. In the physical analysis of the various cuts, the different components were weighed to 0.01 pound.

The following directions adapted from the outline of the national project, Cooperative Meat Investigations, were observed in cutting the carcasses:

The ribs are numbered 1 to 13, No. 1 being next to the neck. Cutting methods are similar to those of the "Chicago-style," the carcass being divided as follows: The forequarter is removed between the twelfth and thirteenth ribs by a line that crowds the twelfth rib its full length. This cut severs the flank at a point level with the union of the sixth and seventh vertebrae, cutting down from the pelvic arch.

The shank is removed just above the bony rise (lateral condyle of the humorus) in the middle of the arm on a line parallel to the brisket. The plate and brisket are cut off on a line joining the shank cut with a point on the twelfth rib that is removed from the backbone a distance equal to two-thirds the length of the rib. The following is a uniform method of separating the plate from the rib. It is based on skeletal measurements and therefore is more or less fixed. Two instruments are necessary, a yardstick and a carpenter's try square. Point A (in figure 1) is the point of the body of the split vertebra. Point B is the cartilage or "button" of the thirteenth rib. The distance AB is measured and the distance from point A to point C is 61.5 percent of AB, measured to the nearest eighth of an inch. At point C a perpendicular is erected by means of the square. Where this line intersects the external circumference (point D) the separation is made, the cut being perpendicular to the external surface.

The prime-rib cut is removed between the fifth and sixth ribs by a line that crowds the fifth rib the entire distance.

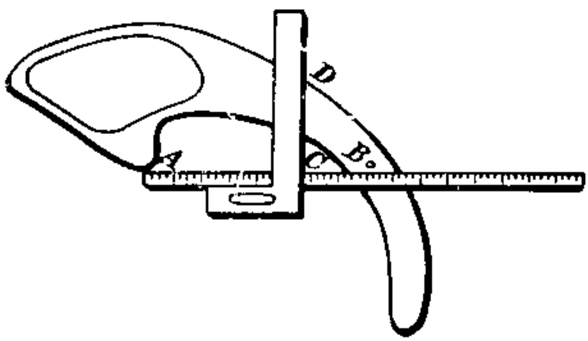

FIGURE 1.—Method of locating point D at which the plate is separated from the rib cut: A, Point of body of split vertebra; B, cartilage or "button" of thirteenth rib; C, point of erecting perpendicular by means of try square.

The chine bone and spinal processes are left on the wholesale-rib cut. This procedure is not only to give uniformity in the weights but also to insure uniform cooking. The chine bone is especially needed to support the roast in the roasting pan.

The kidney is removed and the fat thoroughly trimmed out of the inside of the loin. The flank is removed by a line that crowds the stifle joint just close enough to cut slightly into the lean and crosses the thirteenth rib at a point coincident with the plate cut. Scrotum fat and udder fat are trimmed off the face of the round and included with the flank cut. The loin is cut Chicago style, which is on a line about one-half inch forward from the pelvic bone just forward of the trochanter major of the femur. This line crosses the fourth sacral vertebra and cuts a small piece off the head of the femur in the coxofemoral joint. The underside of this cut should flare a little toward the round and be parallel with the line of the thirteenth rib.

The rump is removed from the round parallel to the pelvic bone and as close to it as the knife will cut. This cut removes a small piece from the head of the femur. The loin is divided into two parts: the loin end, which is cut off just in front of the hip bone (tuber coxae of the ilium), and the short loin, which is the piece remaining.

The prime-rib cut is divided by ribs, each cut crowding the rear side of the next rib. In cutting out the sample (ninth-tenth-eleventh ribs) from the prime-rib cut (sixth to twelfth ribs, inclusive), the knife crowds the rear edges of the eighth and eleventh ribs, as in making the corresponding cut from the left side for cooking. In the separation of the eye muscle, the longissimus dorsi is taken without the superficial fascia or muscles. The eye sample represents only lean or lean with the fat of marbling. Particular care must be exercised not only in preparing the samples but also in mixing before analysis and in the temperatures at which weighings are made.

The naval end, often designated as the plate, is divided from the brisket by a line that crowds the rear side of the fifth rib.

After preparation of the cuts, the next step was the separation of each into lean tissue, fat tissue, and bone, and the prompt weighing of the three portions. After the physical analysis had been completed, the resulting components of standing ribs and the ninth-tenth-eleventh-rib and sixth-seventh-eighth-twelfth-rib portions thereof were treated either as three or two samples for determination of chemical composition. That is, they were treated either as eye lean, remaining lean, and fat, or as eye lean and a composite of the remaining lean and fat. In the instances of the other cuts, from the 22 animals mentioned above, either a lean and a fat sample were analyzed or a composite of the two was used. From the 98 remaining animals in the group of 120, a composite was made, from each animal, of all cuts except the rib and one sample taken from such composite for chemical analysis.

The material for each sample was ground three times in a grinder: the first time by the use of a plate with holes one-fourth inch in diameter and the subsequent times by the use of a plate with holes five sixty-fourths inch in diameter. After the first grinding the mass was thoroughly mixed by hand and then quartered. After the third grinding the sample was taken at random, placed in a glass-top fruit jar, and kept in the refrigerator or frozen until analyzed. For analysis the entire contents of the jar were mixed and, if necessary to obtain thorough mixing, passed through a hand grinder having a plate with holes five sixty-fourths inch in diameter.

Protein, fat, water, and ash determinations were made according to the methods of the Association of Official Agricultural Chemists (*1*) with the following modification:

In protein determinations the Kjeldahl-Gunning-Arnold method was followed, both $CuSO_4$ and HgO being used. For lean meat 30 cc. of H_2SO_4 was sufficient for digestion, but 40 cc. was usually necessary for samples high in fat. In fat determinations, the sample was spread in a thin layer on fat-free cotton and placed in the extraction tube. It was then dried in vacuum under 25 to 29 inches Hg, for about 6 hours, in an atmosphere of CO_2. Extraction was performed for at least 16 hours with the use of anhydrous ether. The extracted fat was then dried for 2 hours under vacuum and CO_2 at 100° C. An additional heating of 1 hour was sufficient to insure a constant weight. In water determinations, drying was carried on for 1 hour at 100° C. at atmospheric pressure and then continued for 4 hours at 100° C. in vacuum. The product was then weighed. Drying was repeated for 1 hour in vacuum to insure a constant weight. In ash determinations, the sample was held at 600° C. for about 2 hours or until it was nearly white. A few drops of HNO_3 was added and the sample was heated at 600° C. for another 2 hours.

The determination of ash in meat, especially in the fat portion, is a laborious process. Variations in total ash content of meat are not of such great significance as the proportions of the various elements in the ash. When the constituents of the ash are not being determined, the use of equations for estimating total ash may give satisfactory results. The following equations were developed from data on fat, protein, and ash obtained in the study of 55 rib cuts that varied from 7 to 56 percent in fat content: (1) Percentage of ash in edible portion of ninth-tenth-eleventh-rib cut$=1.1253-0.0114\times$percentage of ether extract in same sample. The standard error of estimate$=0.0357$. (2) Percentage of ash in edible portion of ninth-tenth-eleventh-rib cut $=1.0437+0.0036\times$percentage of protein$-0.0106\times$percentage of ether extract in same sample. The standard error of estimate$=0.0357$.

The statistical formulae (*3*) used in the analysis of the data were as follows:

$$\text{Coefficient of correlation}=\frac{\Sigma XY-\frac{(\Sigma X)(\Sigma Y)}{N}}{N(\sigma X\sigma Y)}$$

$$\text{Probable error of coefficient of correlation}=0.6745\left(\frac{1-r^2}{\sqrt{N-2}}\right)$$

$$\text{Coefficient of correlation adjusted for small numbers}=1-(1-r^2)\left(\frac{N-1}{N-2}\right)$$

$$\text{Regression equation } Y=a+bX$$

$$b\text{ of regression equation}=\frac{\Sigma XY-\frac{(\Sigma X)(\Sigma Y)}{N}}{\Sigma X^2-\frac{(\Sigma X)^2}{N}}$$

$$a\text{ of regression equation}=MY-bMX$$

$$\text{Standard error of } Y=\sqrt{\sigma Y^2(1-r^2)\left(\frac{N}{N-1}\right)}$$

RESULTS

Fatness of Ninth-Tenth-Eleventh-Rib Cut as Related to That of Standing-Rib Cut

In comparing the fatness of the ninth-tenth-eleventh-rib cut with that of the standing rib, the study was made on the first group of cattle, numbering 77. The edible portions of three samples each from the standing ribs were used. These three samples were the ninth-tenth-eleventh ribs and the two remaining portions consisting of the sixth-seventh-eighth and twelfth-rib cuts. From analyses of these samples it was determined that the fat (ether-extract) content of the ninth-tenth-eleventh-rib cuts varied from 11.3 to 56.0 percent; the mean was 30.54 and the standard deviation 11.03 percent. The standing-rib cuts varied from 7.4 to 52.0 percent in this respect; the mean in this instance was 28.16 and the standard deviation 10.56 percent.

Figure 2 is a scatter diagram showing the relationship between the fatness of these two cuts. The regression line and its standard error are also shown. The correlation coefficient, representing the relation between the fat (ether-extract) content of the two cuts, was found to be $+0.99 \pm 0.003$. The regression equation is: Percentage of ether extract in edible portion of standing rib cut=0. 947 $\times$ percentage of ether extract in edible portion of ninth-tenth-eleventh-rib cut -0.750. The standard error of the estimate is 1.58 percent.

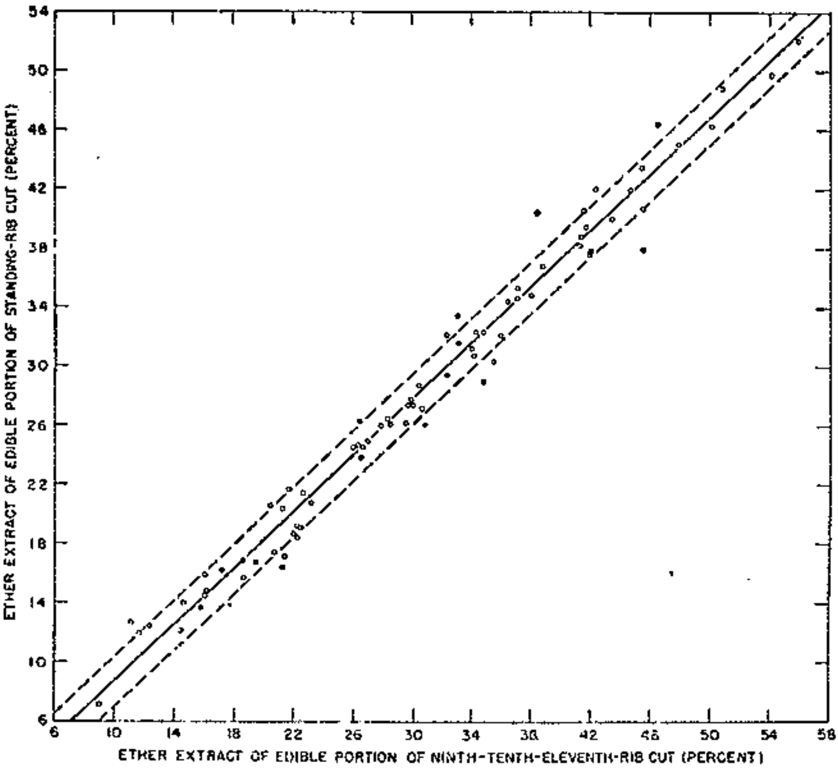

FIGURE 2.—Relation between ether-extract content of edible portion of ninth-tenth-eleventh-rib cut and that of the edible portion of standing-rib cut. Each symbol (o) represents 1 of 77 ribs.

Since the ninth-tenth-eleventh-rib cut is part of the standing-rib cut, one would expect the relationship between the ether-extract percentages of the two cuts to be rather close. In view of the very close relationship found in this respect between these two cuts in the study reported here and the fact that close relationships had previously been found (*5*) between the standing-rib cut on one hand and the live animal and carcass on the other hand, the ninth-tenth-eleventh-rib cut appears to be a satisfactory sample for estimating the fatness of the animal, both on the live basis and as a dressed carcass.

With further reference to the relation between the ninth-tenth-eleventh and standing-rib cuts, at subsequent points also it is noted that the situation occurs in which a composition factor of a relatively small sample is correlated with the same composition factor of a larger sample, consisting in part of the small sample. It is believed that under such conditions a theoretical minimum correlation of zero should not be expected. Nevertheless, as shown in a later section of this bulletin dealing with the ether-extract content of the several primary cuts in relation to that of the dressed carcass, for example, wide variation may occur in the coefficients. It appears that the relative magnitude of the coefficients under such conditions may be accepted as a good indication of the relative values of the samples for purposes of estimation.

Relations of Various Factors With Physical-Composition Factors of Ninth-Tenth-Eleventh-Rib Cut

As stated earlier, data on the composition of the ninth-tenth-eleventh-rib cuts and of the dressed carcasses were obtained on 120 cattle constituting the second group studied. The ranges, means, and standard deviations of the data for the various factors determined on the 120 cattle and on the two subgroups of 84 steers and 36 heifers are shown in table 1.

SEPARABLE FAT

As the first step in the study of the relationships among the 120 cattle, it was regarded as desirable to determine the usefulness of the separable fat of the ninth-tenth-eleventh-rib cut for estimating the ether-extract content of the edible meat of the same sample. Table 2 shows the correlations between the 2 factors mentioned.

The very close relationships, as shown by the high correlation coefficient and small probable error in all three groups of cattle, are noteworthy. It is apparent that the ether-extract content of the edible portion of the ninth-tenth-eleventh-rib cut can be estimated with a high degree of accuracy from the separable-fat content of the same cut. One may interpret this as meaning that the fat content of the ninth-tenth-eleventh-rib cut, as determined by careful physical analysis, can be used satisfactorily in studies of relationships with composition factors of the carcass and of other cuts.

Table 2 shows further that the separable fat of the ninth-tenth-eleventh-rib cut is a very useful factor for estimating the same component of the dressed carcass and the ether-extract content of the edible portion of the dressed carcass. It is practically as useful in one instance as in the other, but the relationships were somewhat closer for the 120 cattle and 84 steers than for the 36 heifers. Figure 3 presents in graphic form the relation between the separable-fat content of the ninth-tenth-eleventh-rib cuts and the ether-extract content of the edible portion of the dressed carcasses of the 120 cattle, steers being represented by one character and heifers by another.

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TABLE 1.—*Ranges, means, and standard deviations of composition data on ninth-tenth-eleventh-rib cuts, eye muscles, and dressed beef carcasses*

Sample analyzed and components	120 cattle			84 steers			36 heifers		
	Range	Mean	Standard deviation	Range	Mean	Standard deviation	Range	Mean	Standard deviation
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Ninth-tenth-eleventh-rib cut:									
Separable fat	10.7–43.4	27.12	7.17	10.7–40.0	25.37	6.87	14.0–43.4	31.19	6.13
Separable lean	40.8–61.3	52.04	5.07	43.0–61.3	52.82	5.05	40.8–57.5	50.22	4.64
Separable bone	13.8–29.3	20.94	3.14	15.8–29.3	21.82	2.88	13.8–28.5	18.87	2.72
Dressed carcass:									
Separable fat	12.4–39.1	25.39	6.35	12.4–37.2	23.77	5.88	14.4–39.1	29.16	5.78
Separable lean	44.4–67.0	57.52	4.79	48.6–67.0	58.27	4.47	44.4–60.5	55.75	5.04
Separable bone	12.5–22.5	17.12	2.31	13.3–22.5	17.98	2.07	12.5–16.5	15.10	1.42
Ninth-tenth-eleventh-rib cut (edible portion):									
Ether extract	16.9–49.9	34.48	7.92	16.9–43.9	32.75	7.70	18.4–49.9	38.53	6.87
Protein	10.6–19.2	14.72	1.81	10.6–19.2	15.10	1.80	11.4–17.5	13.84	1.49
Water	36.8–63.1	49.80	6.18	39.3–63.1	57.09	5.99	36.8–62.7	46.79	5.53
Ash	.46– .96	.704	.112	.46– .96	.720	.113	.49– .84	.670	.100
Eye muscle of ninth-tenth-eleventh-rib cut:									
Ether extract	1.1–13.1	3.93	2.13	1.1– 9.7	3.51	1.78	1.3–13.1	4.91	2.51
Dressed carcass (edible portion):									
Ether extract	15.2–44.8	29.29	6.54	15.2–42.8	27.73	6.23	16.4–44.8	32.92	5.76
Protein	11.8–19.1	15.74	1.42	11.8–19.1	16.00	1.41	12.3–18.0	15.12	1.23
Water	41.3–65.0	53.85	5.17	43.9–65.0	55.13	4.86	41.3–64.1	50.86	4.59
Ash	.56– .97	.772	.083	.56– .97	.778	.081	.58– .91	.758	.085

Table 2.—*Relationships between physical-composition factors of the ninth-tenth-eleventh-rib cuts and physical and chemical-composition factors of dressed beef carcasses*

Relationships studied	120 cattle			84 steers			36 heifers		
	Coefficient of correlation and probable error	Estimating equation	Standard error of estimate	Coefficient of correlation and probable error	Estimating equation	Standard error of estimate	Coefficient of correlation and probable error	Estimating equation	Standard error of estimate
Separable fat of ninth-tenth-eleventh-rib cut with—									
Ether extract of ninth-tenth-eleventh-rib cut (edible portion)	$+0.96\pm0.01$	$Y=5.73+1.06X$	*Percent* 2.24	$+0.95\pm0.01$	$Y=5.67+1.07X$	*Percent* 2.35	$+0.96\pm0.01$	$Y=4.87+1.08X$	*Percent* 1.90
Separable fat of dressed carcass	$+.93\pm.01$	$Y=3.06+.82X$	2.34	$+.93\pm.01$	$Y=3.54+.80X$	2.14	$+.88\pm.03$	$Y=3.14+.83X$	2.89
Ether extract of dressed carcass (edible portion)	$+.93\pm.01$	$Y=6.38+.85X$	2.48	$+.92\pm.01$	$Y=6.47+.84X$	2.40	$+.89\pm.01$	$Y=6.85+.84X$	2.68
Separable lean of ninth-tenth-eleventh-rib cut with—									
Separable lean of dressed carcass	$+.85\pm.02$	$Y=15.56+.81X$	2.51	$+.90\pm.01$	$Y=16.08+.80X$	1.94	$+.72\pm.05$	$Y=16.09+.79X$	3.56
Protein of dressed carcass (edible portion)	$+.82\pm.02$	$Y=3.74+.23X$	.81	$+.82\pm.02$	$Y=3.86+.23X$	.80	$+.77\pm.07$	$Y=4.69+.21X$	.79
Separable bone of ninth-tenth-eleventh-rib cut with—									
Separable bone of dressed carcass	$+.83\pm.02$	$Y=4.30+.61X$	1.29	$+.80\pm.03$	$Y=5.52+.57X$	1.26	$+.83\pm.04$	$Y=6.88+.44X$	.80

For all the cattle as one group the coefficient of correlation and probable error were $+0.93 \pm 0.01$. The standard error of the regression line was 2.48 percent.

SEPARABLE LEAN

Study was made of the relations between the separable-lean content of the ninth-tenth-eleventh-rib cut, on one hand, and the same component of the dressed carcass, as well as the protein content of the edible portion of the dressed carcass, on the other hand (table 2).

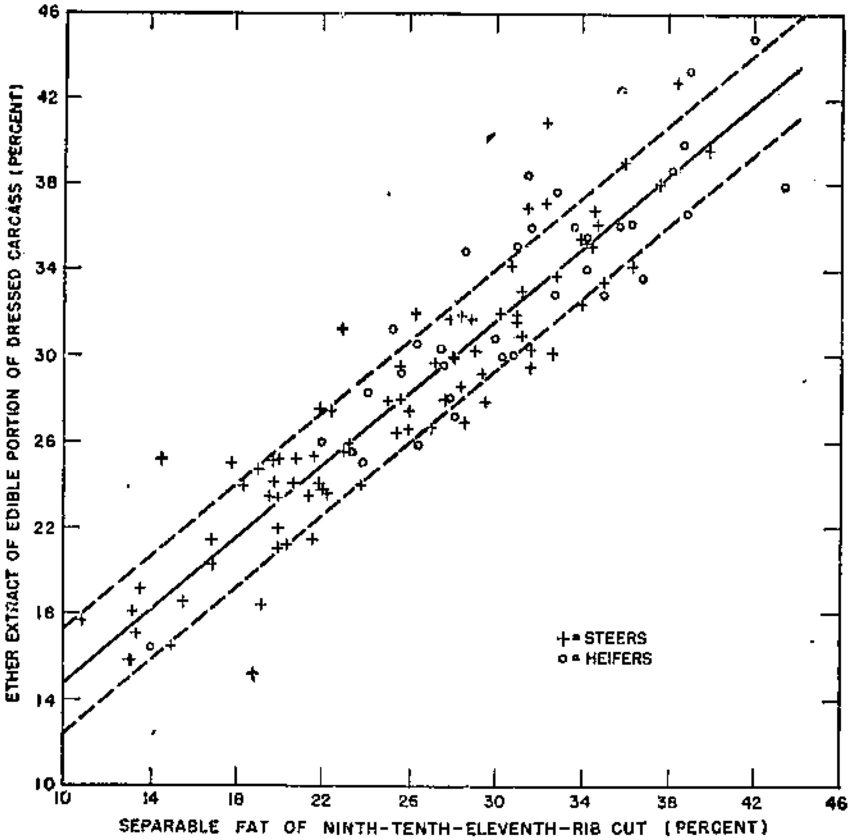

FIGURE 3.—Relation between separable-fat content of ninth-tenth-eleventh-rib cut and ether-extract content of edible portion of dressed beef carcass. Each symbol, x for steers and o for heifers, represents 1 of 120 carcasses.

The correlation between lean of the rib cut and lean of the carcass was highest for the steers, lowest for the heifers, and intermediate for the 120 cattle as one group. The value for the heifers was low enough $(+0.72 \pm 0.05)$ to make questionable the use of the lean-meat content of the ninth-tenth-eleventh-rib cut for estimating that of the carcass for cattle of that sex. Moreover, the standard error of the estimate was relatively large.

The lean-meat content of the ninth-tenth-eleventh-rib cut was equally good for estimating the protein content of the edible portion of the dressed carcass for the 120 cattle and for the steers. Again, however, as in the relationship between lean of the carcass and lean of the ninth-tenth-eleventh-rib cut, the correlation between protein content of the edible portion of the carcass and separable lean-meat content of the rib cut was lower for heifers than for the other groups although in this case the difference was much less. The standard error of the estimate was such as to suggest that the lean-meat content of the rib cut could be used for estimating the protein content of the heifer carcasses as safely as that of steer carcasses.

BONE

Table 2 shows that in comparison with the 5 sets of coefficients obtained from the studies on fat and lean, the set relating to bone is on the whole next to the lowest in magnitude. The relatively low coefficients are believed to be due, at least in part, to the error introduced into the percentage of bone in the three-rib sample, and probably also in the dressed carcass, by inaccurate splitting of the latter into the 2 sides. It is practically impossible, even for the most expert butchers, entirely to avoid deviations from the middle line of the back in splitting the carcass. Despite the fact that these coefficients are relatively low, they are of sufficient magnitude to indicate a useful relationship. Moreover, the maximum standard error of the estimate applying to the 120 cattle was only 1.29 percent.

SEPARABLE FAT IN RELATION TO ETHER EXTRACT OF CARCASS

To supplement the results concerned with the relationships between physical-composition factors of the ninth-tenth-eleventh-rib cut and physical- and chemical-composition factors of the dressed carcass, study was made of the separable-fat content of the dressed carcass as a whole in relation to the ether-extract content of the edible portion thereof. The coefficients of correlation with probable errors for these two measures of carcass fatness, representing the 120 cattle, 84 steers, and 36 heifers, were found to be $+0.97\pm0.004$, $+0.97\pm0.005$, and $+0.95\pm0.011$, respectively. The values show clearly that when careful work is done in separating the fat of the dressed beef carcass from the other components, the separated fat closely approaches ether extract as an accurate measure of fatness. Estimating equations, with Y representing the percentage of ether extract in the edible portion of the dressed carcass and X the percentage of separable fat in the dressed carcass as a whole, are as follows: $Y=4.06+0.99X$, $Y=3.28+1.03X$, and $Y=5.25+0.95X$, for the 120 cattle, 84 steers, and 36 heifers, respectively. The corresponding standard errors of estimate are 1.71, 1.58, and 1.80 percent.

RELATIONS OF VARIOUS FACTORS WITH CHEMICAL-COMPOSITION FACTORS OF NINTH-TENTH-ELEVENTH-RIB CUT

ETHER EXTRACT

Percentages of ether extract in the edible portion of the ninth-tenth-eleventh-rib cut were correlated with those in the edible portion of the dressed carcass and in the eye muscle of the three-rib

Table 3.—*Relationships between chemical-composition factors of the ninth-tenth-eleventh-rib cuts and other such factors of the same cut, as well as chemical-composition factors of the dressed carcasses*

Relationships studied	120 cattle			84 steers			36 heifers		
	Coefficient of correlation and probable error	Estimating equation	Standard error of estimate	Coefficient of correlation and probable error	Estimating equation	Standard error of estimate	Coefficient of correlation and probable error	Estimating equation	Standard error of estimate
Ether extract of edible portion of ninth-tenth-eleventh-rib cut with—									
Ether extract of edible portion of dressed carcass	+0.93±0.01	Y=2.82+0.77X	*Percent* 2.42	+0.91±0.01	Y=3.49+0.74X	*Percent* 2.52	+0.94±0.01	Y=2.73+0.78X	*Percent* 2.10
Ether extract of eye muscle of ninth-tenth-eleventh-rib cut	+.65± .04	Y=0.97+ .14X	1.45	+.59± .05	Y=−5.18+ .26X	1.78	+.72± .06	Y=−2.12+.18X	1.62
Protein of edible portion of ninth-tenth-eleventh-rib cut	−.93± .01	Y=22.01− .21X	.69	−.93± .01	Y=22.25−.22X	.65	−.91± .02	Y=21.40−.20X	.64
Water of edible portion of ninth-tenth-eleventh-rib cut	−.99± .001	Y=76.49− .77X	.75	−.99± .002	Y=77.76−.81X	.95	−.99±.002	Y=77.50−.80X	.75
Ether extract of eye muscle of ninth-tenth-eleventh-rib cut with—									
Ether extract of edible portion of dressed carcass	+.66± .04	Y=21.33+2.03X	4.93	+.58± .05	Y=20.58+2.04X	5.09	+.73± .05	Y=24.67+1.68X	3.93
Protein of edible portion of ninth-tenth-eleventh-rib cut with—									
Protein of edible portion of dressed carcass	+.84± .02	Y=5.98+ .66X	.76	+.83± .02	Y=6.19+ .65X	.79	+.81± .04	Y=5.64+ .69X	.73
Water of edible portion of ninth-tenth-eleventh-rib cut with—									
Water of edible portion of dressed carcass	+.93± .01	Y=14.90+ .78X	1.85	+.92± .01	Y=16.83+ .75X	1.90	+.94± .01	Y=14.28+.78X	1.58
Protein of edible portion of ninth-tenth-eleventh-rib cut	+.90± .01	Y=1.61+ .26X	.79	+.91± .01	Y=1.17+ .27X	.76	+.84± .03	Y=3.28+ .23X	.82
Ash of edible portion of ninth-tenth-eleventh-rib cut with—									
Ash of edible portion of dressed carcass	+.46± .05	----------	----------	+.51± .06	----------	----------	+.32± .10	----------	----------

sample. They were also correlated with the percentages of protein and water in the same sample.

Figure 4 is a scatter diagram showing the relation between the ether-extract content of the edible portion of the ninth-tenth-eleventh-rib samples and that of the edible portion of the dressed carcass. The regression line and its standard error are also shown. In table 3 are presented the coefficients of correlation, with their probable errors, indicating the relationships that existed among the 120 cattle, 84 steers, and 36 heifers. In all three groups the coefficient exceeded 0.90. For all the cattle the coefficient is the same and for the steers practically the same as that between the separable fat of the three-rib cut and the ether extract of the edible portion of the carcass (table 2). In the heifers, however, the ether extract of the three-rib cut was somewhat better than the separable fat as an index of the ether extract of the edible portion of the carcass. Equations for estimating the ether-extract content of the latter (Y) from that of the three-rib sample (X) are also given in table 3.

Of the three correlation coefficients between the percentage of ether extract of the edible portion of the three-rib cut and that of the

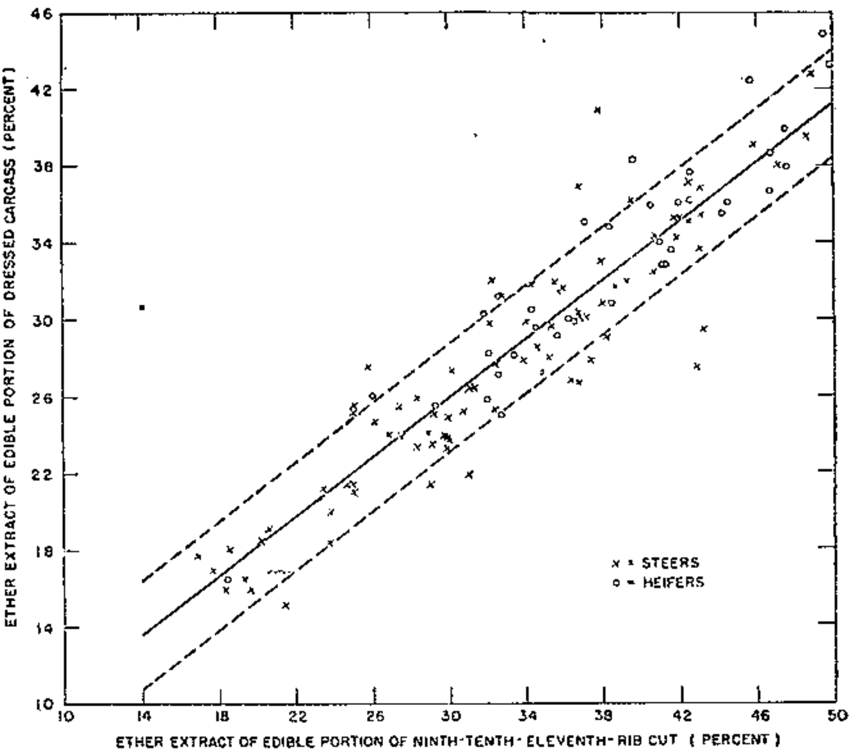

FIGURE 4.—Relation between ether-extract content of edible portion of ninth-tenth-eleventh-rib cut and ether-extract content of edible portion of dressed beef carcass. Each symbol, x for steers and o for heifers, represents 1 of 120 carcasses.

eye muscle, also shown in table 3, only one, that for heifers, exceeds 0.70. This set of coefficients, in general, is the lowest reported on the three groups of cattle up to this point. One would hesitate to make use of the equations presented for estimating ether extract of the eye muscle from that of the three-rib cut.

The close relation between the ether-extract content of the edible portion of the three-rib cut and that of the dressed carcass, and the relatively low correlation between the former and the ether-extract content of the eye muscle of the three-rib cut, suggest that the last-mentioned factor would not be highly useful in the estimation of the ether-extract content of the edible portion of the dressed carcass. This belief is substantiated by results given in table 3.

If the content of one component, such as protein, can be estimated with satisfactory accuracy from the content of another component, such as ether extract, in meat-composition studies, obviously there is marked saving in work and expense. Consequently, determination was made of the relation between the percentages of ether extract and protein in the edible portion of the three-rib cut, the three groups of cattle again being considered. In all cases the relationship, although negative, was close, the coefficient of correlation exceeding 0.90. It is apparent from these results that the protein content of the edible portion of the ninth-tenth-eleventh-rib cut of beef can be estimated with a fairly high degree of accuracy from the ether-extract content of the edible portion of the same sample.

A study also was made of the correlation between the percentage of ether extract of the edible portion of the three-rib cut and the percentage of water. The relationship was represented by the coefficient of −0.99 for each of the three groups of cattle, and the standard errors for use with the estimating equations were low. Obviously, instead of being determined by means of actual analysis, the water content of the edible portion of the three-rib cut can be estimated from the ether-extract content with little sacrifice in accuracy.

PROTEIN

Protein unquestionably is the principal nutritive constituent of meat for which consumers purchase that product. There is great need, therefore, for satisfactory methods for estimating the protein content of the dressed carcass. In studies having this objective, it was found, as shown in table 3, that the correlation coefficients between the percentage of protein in the edible portion of the ninth-tenth-eleventh-rib cut and in the dressed carcass were moderately high, and the standard errors for use with the estimating equations correspondingly small.

WATER

Water is present in fresh meat in greater proportion than any other constituent. Since the difference between the total content and the water content is dry matter, which includes the relatively expensive nutrients, it is important to have a rapid, satisfactory method for estimating the water content of the dressed carcass. In the three groups of cattle, the correlations between the water content of the edible portion of the three-rib sample and that of the dressed carcass were high, exceeding 0.90 in each instance. The water content of the edible portion of the three-rib cut is highly useful, therefore, for estimating the water content of the dressed-beef carcass.

It has been shown that the protein content of the edible portion of the ninth-tenth-eleventh-rib cut could be estimated from its ether-extract content with a high degree of accuracy. Study was also made of the relation between the water content of this cut and its protein content. As shown in table 3, the value of the percentage of water in the three-rib cut as an index of the percentage of protein was not so great as the value of the ether extract. However, the difference between the two indices was small.

ASH

As previously stated, variations in total ash content of meat are not of such great significance as the proportions of the various elements in the ash. Yet conditions may arise which make it desirable to know the total ash content of each of certain beef carcasses, or at least to have estimates of that component. In the light of correlations reported in table 3, however, it does not appear that the ash content of the edible meat of the ninth-tenth-eleventh-rib cut is a satisfactory index of that of the edible meat of the dressed beef carcass.

Fatness of Dressed Carcass in Relation to That of Primary Cuts

In determining the relation of the fatness of the edible portion of the dressed carcass to that of 11 primary cuts, 22 of the 120 cattle constituting the second group were used, as already stated. The fatness of the dressed carcasses, as represented by the ether-extract content of the edible portion of the 22 right sides, varied from 21.4 to 44.8 percent. Supplementary to study of the relations between the carcass and primary cuts, consideration was also given to two subsamples of the standing rib as indices of the carcass. These subsamples were the ninth-tenth-eleventh-rib cut and the sixth-seventh-eighth-rib with the twelfth-rib cut.

The 12 steers and 10 heifers were considered as one group. Consequently, for the relation between each cut and the carcass, as shown in table 4, only one coefficient is reported. All coefficients based on data from the 22 cattle were adjusted for the small number. Estimating equations, based on all 22 cattle, are also presented in the table.

As previously indicated, there has been considerable interest in the standing-rib cut, and portions thereof, as samples for representing the entire dressed beef carcass. In the work on the 22 cattle the opportunity was provided to obtain further information on the usefulness of the standing rib as a carcass sample. The results show that the relationship is close, although not so close as between flank, brisket, or chuck and dressed carcass, or even between the ninth-tenth-eleventh-rib cut and the dressed carcass. At the other extreme is the loin end and the kidney knob. The correlation between the latter and the carcass is especially low and the standard error of estimate outstandingly high.

TABLE 4.—*Relationships between fat (ether-extract) content of edible portion of dressed beef carcass and the fat content of various primary cuts*

Cut	Coefficient of correlation, and probable error	Estimating equation	Standard error of estimate	Ether extract in edible portion	
				Mean	Standard deviation
			Percent	*Percent*	*Percent*
Flank	+0.95±0.02	Y= −0.50+0.59X	1.84	58.30	8.97
Brisket	+ .93± .02	Y= 1.29+ .73X	2.00	43.58	7.26
Chuck	+ .91± .02	Y= 0.40+ .90X	2.01	21.53	5.52
Ninth-tenth-eleventh rib cut	+ .93± .02	Y= 1.77+ .80X	2.07	38.70	6.53
Standing rib	+ .91± .03	Y= 4.30+ .79X	2.37	36.00	6.48
Navel end	+ .89± .03	Y= 3.32+ .89X	2.62	43.22	7.34
Round with shank	+ .87± .04	Y= 10.42+1.29X	2.88	17.40	3.79
Short loin	+ .84± .05	Y= 7.94+ .67X	3.14	37.38	7.10
Sixth-seventh-eighth-twelfth rib cut	+ .81± .05	Y= 10.38+ .66X	3.38	34.37	7.01
Foreshank	+ .78± .06	Y= 16.25+1.08X	3.62	15.44	4.10
Rump	+ .74± .07	Y= 14.77+ .55X	3.93	32.94	7.57
Loin end	+ .68± .08	Y= 12.40+ .64X	4.20	31.00	6.11
Kidney knob	+ .51± .11	Y= 7.57+ .31X	4.99	80.91	6.63

FATNESS OF NINTH-TENTH-ELEVENTH-RIB CUT IN RELATION TO THAT OF OTHER CUTS

There is urgent need for information that will make possible the estimation of the fat content of other cuts from a carcass when the fat content of one cut is known. The analytical work done on the group of 22 cattle provided data for making a study of the fat relationships between cuts. The opportunity was also furnished to develop equations for estimating the ether-extract content of the standing rib, chuck, brisket, flank, and other cuts from the ether-extract content of the ninth-tenth-eleventh-rib cut. For these 22 cattle the mean percentage of ether extract in the edible portion of the ninth-tenth-eleventh-rib cut was 38.70 and the standard deviation 6.53.

In table 5 are shown, in decreasing order of magnitude, correlation coefficients with probable errors for the relationships between the percentage of ether extract in the edible portion of the ninth-tenth-eleventh-rib cut and percentages of ether extract in the edible portion

TABLE 5.—*Relationships between fat (ether-extract) content of edible portion of ninth-tenth-eleventh-rib cut and the fat content of indicated cuts*

Cut	Coefficient of correlation, and probable error	Estimating equation	Standard error of estimate	Ether extract in edible portion	
				Mean	Standard deviation
			Percent	*Percent*	*Percent*
Chuck	+0.94±0.02	Y= −6.43+0.80X	1.89	21.53	5.52
Standing rib	+ .89± .03	Y= 1.52+ .89X	2.93	36.00	6.48
Flank	+ .89± .03	Y= 8.94+1.22X	4.27	58.30	8.97
Brisket	+ .88± .04	Y= 5.57+ .98X	3.57	43.58	7.26
Short loin	+ .84± .04	Y= 1.65+ .92X	3.94	37.38	7.10
Navel end	+ .83± .05	Y= 0.74+ .94X	4.19	43.22	7.31
Round with shank	+ .76± .06	Y= .09+ .45X	2.52	17.40	3.79
Sixth-seventh-eighth-twelfth rib cut	+ .74± .07	Y= 2.97+ .81X	4.84	31.37	7.01
Rump	+ .74± .07	Y= − .60+ .87X	5.22	32.94	7.57
Loin end	+ .71± .07	Y= 5.54+ .68X	4.30	31.00	6.11
Foreshank	+ .66± .09	Y= −1.02+ .43X	3.21	15.41	4.10
Kidney knob	+ .26± .21	Y= 67.79+ .31X	6.55	80.91	6.63

of 11 primary cuts from the beef carcass. Also given are the equations developed for estimating the fat content of the various primary cuts from that of the ninth-tenth-eleventh-rib cut. The wide variation in these relationships is noteworthy. Although the ether-extract content of the edible portion of all or most of the other cuts could be estimated more or less satisfactorily from that of the ninth-tenth-eleventh-rib cut, it is obvious that this is not true in the case of the kidney knob.

SUMMARY

The composition of a meat animal at any given stage of development is of interest to the producer, packer, retailer, and especially the consumer. Workers in the field of livestock and meat research have need of rapid, economical methods for estimating the composition of carcasses and cuts. Studies were therefore conducted to determine the relationships between certain composition factors and to develop methods for estimating such factors. Carcasses of 197 cattle were involved.

The method given in the outline of the national project, Cooperative Meat Investigations, was employed in separating the dressed carcasses into primary cuts. Physical analyses of the cuts from the right side only were made. Chemical analyses of the edible portions of the cuts also were made by the methods of the Association of Official Agricultural Chemists, with certain modifications. The following results were obtained.

The ether-extract content of the edible portion of the ninth-tenth-eleventh-rib cut was very closely related to that of the standing-rib cut.

The separable-fat content of the ninth-tenth-eleventh-rib cut was a very good index of the ether-extract content of the edible portion thereof. It was only slightly less valuable as an index of the separable fat of the dressed carcass and of the ether extract of the edible portion of the dressed carcass.

The correlation between percentage of separable lean in the ninth-tenth-eleventh-rib cut and that of the carcass was highest for steers, lowest for heifers, and intermediate for steers and heifers as one group. In the heifers the use of the lean meat of the three-rib cut for estimating that of the carcass appeared questionable. As an index of protein content of the edible portion of the dressed carcass, the lean meat of the three-rib cut was somewhat less valuable for steers and heifers together and for steers alone, but more valuable for heifers, than as an index of separable-lean content of the carcass.

In comparison with coefficients obtained from the studies on separable fat and lean of the three-rib cut, the coefficients for bone of that sample as related to bone of the carcass were, on the whole, next to lowest in magnitude. Yet they were sufficiently large to indicate a useful relationship.

The relation between separable fat of the carcass and ether extract of the edible portion thereof was very close.

Percentage of ether extract in the edible portion of the ninth-tenth-eleventh-rib cut was highly correlated with that of the dressed carcass. For heifers it was a better index of ether-extract content of the edible portion of the dressed carcass than was the separable fat content

of the three-rib cut. The correlation between ether extract of the three-rib sample and that of the eye muscle was relatively low.

The protein content of the edible portion of the three-rib cut was closely related to the ether-extract content; even more close was the relation of the water content to the latter.

Between the protein content of the edible portion of the ninth-tenth-eleventh-rib cut and that of the dressed carcass the correlation was moderately high, the coefficients ranging from $+0.81 \pm 0.04$ to $+0.84 \pm 0.02$ for steers, heifers, and the two sexes as one group. However, water content of the three-rib sample was a distinctly better index of water content of the edible portion of the carcass. The relation between water and protein of the three-rib sample was close, but more so for steers and for steers and heifers as a group than for heifers.

The correlations between ash content of the edible portion of the three-rib cut and that of the carcass were low, indicating that the former is of little value for estimating the latter.

In the study of 22 steers and heifers, made to determine the closeness of relation between ether-extract content of the edible portion of various cuts and that of the carcass, flank ranked first with brisket, chuck, ninth-tenth-eleventh rib, and standing rib following, but all with coefficients exceeding $+0.90$. Less closely related were the navel end, round with shank, short loin, and sixth-seventh-eighth-twelfth-rib cuts. Still less valuable as indices of ether-extract content of the carcass were foreshank, rump, loin end, and kidney knob.

In the group of 22 steers and heifers, chuck was most closely related to the ninth-tenth-eleventh-rib cut with respect to ether-extract content of edible portion. Standing rib and flank followed rather closely, with no difference between them. The least relation was found between kidney knob and the three-rib cut.

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