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Introduction

Nutritional studies in farm animals often require an assessment of the chemical composition and/or the energy content of the tissues, whereas more direct studies of meat production require data on the weights of physically separable tissues in the carcass. It would be beneficial to clarify the relation between physical and chemical composition for the purposes of research; of equal importance is the need to provide estimates of national food consumption trends, and whereas the statistics for meat consumption on a gross weight basis are well documented, this is not the case for the lipid and protein content of dietary meat.

Relations between the chemical and physical composition of beef carcasses have been examined by Hopper (1944), Callow (1944, 1947 and 1948), and more recently by Robelin, Geay and Beranger (1975) and Robelin and Geay (1978). Whereas the data from Hopper and Callow were derived from British breeds of cattle, considered to be representative of typical commercial animals of that era, those of Robelin et al. relate to continental breeds of beef and dairy type. In this study, more recent British data on cattle of various types have been combined with those for French breeds, and the relations between the amount of fatty tissue in the carcass and the chemical composition of the entire carcass, edible meat and lean tissue have been examined.

Materials and Methods

Carcasses came from two sources: (a) bulls slaughtered, dissected and chemically analysed at INRA, Theix, France, using the methods described by Robelin, Geay and Beranger (1975), and (b) young bulls, steers and heifers dissected at the Meat Research Institute, Langford, Bristol, UK using the method of Brown and Williams (1981) (24 carcasses) or Truscott, Wood and MacFie (1983) (34 carcasses). The animals are described in Table 1.

The dissection procedures were not identical at the two Centres, and in order to establish common units for data handling, some adjustments to the data were necessary. A common half-carcass weight was used which excluded any perirenal or retroperitoneal fat, and this is referred to as 'basic side weight'. The definitions of subcutaneous and intermuscular fat differed at the two Centres; to pool the data, MRI intermuscular fat did not include 'other tissues' (Williams, 1976), and both fat depots were combined to give 'fatty tissue'. The proportions of dissectible tissues have been expressed as percentages of basic side weight throughout this analysis, whereas the proportions of lipid and protein have been expressed as percentages of individual tissue weights. For per-cent lipid and protein in the carcass, the denominator was the sum of fatty tissue, lean tissue and bone, and for these constituents in edible meat, the denominator was the sum of fatty tissue and lean.

Table 1

Source	Breed	Sex	No.
INRA	Limousin	bull	33
"	Charolais	"	28
"	Friesian	"	26
"	Salers	"	21
MRI	Hereford	steer	17
"	Friesian	"	17
"	(various)	bull	15
"	(various)	heifer	9

Results and Discussion

Some of the more important aspects of the physical and chemical composition of the carcasses are shown in Table 2.

There was wide variation in carcass weight which adequately covered the commercial range of beef carcasses. Also, a wide range in fatness was achieved by including lean Limousin bulls at one extreme and fat Hereford steers at the other. The lipid in both the carcass and lean tissue varied considerably more than the proportion of protein in these same components.

Table 2 Dissectible and chemical composition of the carcasses

	Mean ($\bar{x}$)	Minimum	Maximum	Standard Deviation
Basic side weight (kg)	146.1	74.7	214.7	28.8
% lean tissue	67.8	49.6	79.2	7.8
% fatty tissue	16.8	7.8	37.5	7.2
% bone	14.0	10.7	18.6	1.6
% lipid in lean	4.08	.20	11.05	2.07
% protein in lean	20.30	17.94	23.32	0.93
% lipid in carcass	16.59	7.52	36.41	7.87
% protein in carcass	18.43	13.75	21.70	1.80

The relations between the weight and the proportion of fatty tissue in the carcass and the weight and proportion of lipid and protein in the carcass, edible meat and the lean tissue have been investigated using simple regression analysis. Data from both INRA and MRI were pooled for the first and third of these relations; INRA data only were used for the second. For each dependent variate there was a high correlation with % fatty tissue. This is shown in Table 3, together with the residual standard deviations obtained.

In the carcass containing the smallest proportion of lipid (a Limousin bull having 7.52% lipid), 18.85% of the lipid was in the lean tissue, 46.39% in the fatty tissue, and 34.76% in the bone. In the fattest carcass (a Hereford steer containing 36.41% lipid), 11.60% was in the lean tissue, and 88.40% in the fatty tissue and bone combined. Thus there is a large variation in the contribution of each tissue to total lipid, but the relations between % lipid and % fatty tissue are linear and these are shown in Figure 1. There was a significant effect of data source (INRA or MRI) on the regression of % lipid in carcass on % fatty tissue, but this may be partly due to breed. The differences in % lipid ranged from 1.9% at 8% fatty tissue, to 4.0% at 32% fatty tissue. However, the overall residual standard deviation of 1.297% is very similar to that reported by Hopper (1944) for this same relationship (RSD = 1.291%) although the regression formulated by Hopper (1944) gives estimates of % lipid which are approximately 4 percentage increments greater than those obtained in this study. There is no obvious explanation for the apparently higher lipid content of fatty tissue in Hopper's cattle.

Table 3 Regression of lipid in carcass, edible meat and lean tissue on weight and % fatty tissue in carcass

Dependent variate (y)	Independent variate (x)	Correlation coefficient (r)	Residual standard deviation (RSD)	a	b
Lipid in carcass (%)	Fatty tissue (%)	0.986	1.297	-1.361	1.071
Lipid in carcass (kg)	Fatty tissue (kg)	0.989	1.495	-1.160	0.982
Lipid in edible meat (%)	Fatty tissue (%)	0.955	1.051	-1.878	0.997
Lipid in edible meat (kg)	Fatty tissue (kg)	0.970	1.251	-2.468	0.856
Lipid in lean tissue (%)	Fatty tissue (%)	0.913	0.848	-0.285	0.260
Lipid in lean tissue (kg)	Fatty tissue (kg)	0.849	0.827	0.711	0.130

The % lipid in the lean tissue was less well correlated with % fatty tissue than was % lipid in the carcass, and this is indicated by the residual coefficients of variation which were 20.8% and 7.8% respectively. Despite this relatively large variation, there appeared to be breed effects on the proportion of fat in the musculature at the same carcass fatness. This was examined using data from another source in which extreme dairy types (Jersey, Friesian) were compared with an extreme British beef type (Hereford). Carcasses from steers of these breeds were analysed at the MRI, and % lipid in a sample of M. longissimus was determined at three levels of dissectible fat, corresponding (approximately) to EAAP fat scores (de Boer et al, 1974) of 2^o, $2+/3^-$ and 3^o. The results are shown in Table 4.

Table 4 % lipid in M. longissimus in three breeds of cattle at three levels of dissectible fat.

	Carcass fat 17.5 - 20.5% (EAAP fat score 2^o)	Carcass fat 20.5 - 24% (EAAP fat score 2+/3-)	Carcass fat 24 - 27% (EAAP fat score 3^o)
Jersey	2.066	3.440	3.812
Friesian	1.416	2.250	2.731
Hereford	-	1.514	1.945

There is a tendency for the dairy breeds to contain more intramuscular fat at the same proportion of dissectible fat, which fits in with other observed differences in the partitioning of body fat (Williams, 1978).

The relations between the fatty tissue in the carcass and the protein in the carcass, edible meat and lean tissue are shown in Table 5.

Table 5 Regression of % protein in the carcass, edible meat and lean tissue on fatty tissue in the carcass.

Dependent variate (y)	Independent variate (x)	Correlation coefficient (r)	Residual standard deviation (RSD)	a	b
Protein in carcass (%)	fatty tissue (%)	-0.924	0.691	22.267	-0.229
Protein in carcass (kg)	fatty tissue (kg)	NS	-	-	-
Protein in edible meat (%)	fatty tissue (%)	-0.778	0.559	21.820	-0.209
Protein in edible meat (kg)	fatty tissue (kg)	0.221	4.664	22.095	0.180
Protein in lean tissue (%)	fatty tissue (%)	-0.520	0.798	21.422	-0.067
Protein in lean tissue (kg)	fatty tissue (kg)	-0.273	5.554	24.039	-0.153

The residual coefficient of variation for % protein in the carcass was less than the corresponding value for lipid (3.75% and 7.8% respectively), and this was also true for % protein and % lipid in the lean tissue (3.93% and 7.8% respectively). However, the predictions of weight of protein in the different components are less good than for lipid, the regression for protein in the carcass being non-significant.

There is practically no difference between the % protein in the carcass and % protein in the edible meat at the same % fatty tissue. This is because the % protein in the edible meat is approximately the same magnitude as the % protein in bone.

For many purposes it would be an advantage to predict the chemical composition of carcasses using indirect means, as opposed to determination of amounts of fatty tissue from dissection. For the MRI carcasses, EAAP fat scores (numerical value 1-15) were used to relate to % lipid in the carcass only. The regression obtained was:

$$\% \text{ lipid in carcass} = 3.26 + 2.24 \text{ (fat score)}$$

$$r = 0.937, \text{ RSD} = 2.51\%$$

Thus, the magnitude of the residual standard deviation obtained is approximately twice as large as that obtained using % dissectible fat, but may provide a valuable estimate in some investigations.

Summary

Dissection and chemical composition data from beef carcasses obtained at INRA and MRI were combined to derive equations which can be used to predict the lipid and protein content of carcasses, edible meat or lean from the dissected fatty tissue content. By combining both sets of data, a wide range of values was investigated. All relations were linear and although there was a source effect (INRA/MRI) in the data, the RSD for % carcass lipid was similar to that previously reported for a large data set. The source effect may be due to breed: separate results were used to show that lean tissue from dairy breeds contains more lipid than that from British beef breeds at the same % fatty tissue in the carcass. The overall variation in protein was less than in lipid, and the relationship between fatty tissue and protein was weaker than for lipid. The relation between the EAAP fat score and % lipid in the MRI carcasses gave an RSD approximately double that using % fatty tissue as the independent variate.

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Figure 1. Regressions of % lipid in the carcass, edible meat and lean tissue on % fatty tissue in the carcass.