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ASSESSMENT OF FAT IN MUTTON AND LAMB

R. A. Barton and A. H. Kirton*

IN RECENT YEARS fatness in meat has attracted considerable attention from consumers. They are reluctant to purchase meat which carries an excess of fat. This change in demand has been brought about by high meat prices, return to freedom of choice, and altered working and living conditions. As a consequence of these factors, distinct price differentials have been in operation which have favoured light-weight and less fatty carcasses.

The meat producer is aware of this change in demand and has made a worthwhile attempt to satisfy it. However, with certain classes of meat, particularly ewe mutton, there are often practical difficulties of some magnitude to be overcome if this meat is to be acceptable to the consumer in terms of carcass weight and state of fatness.

As a prelude to providing soundly based advice, research in the last few years at Massey Agricultural College has been concentrated on fatness in ewe mutton and in lamb. This paper will outline some of the work in this field.

Meat Industry Statistics

Meat industry statistics provide some information on state of fatness when considered in the light of the relationship between carcass weight and its fat content which will be mentioned later. Accordingly, Figs. 1, 2 and 3 illustrating trends in carcass weights between and within seasons are presented to give a background to the mutton and lamb section of the meat industry.

Figure 1 shows the Dominion yearly average carcass weights for ewe and wether mutton and for lamb for each of the last eight killing seasons. It is clear that there has been a downward trend in average weights for each of the three classes of meat. The weight reductions commenced before the return to free trade in October, 1955. Further decreases in average weight have occurred since that date. The downward trend is of too long a duration to be the result of adverse fattening conditions in a run of seasons. The only tenable interpretation is that farmers are marketing their prime stock at lighter weights in

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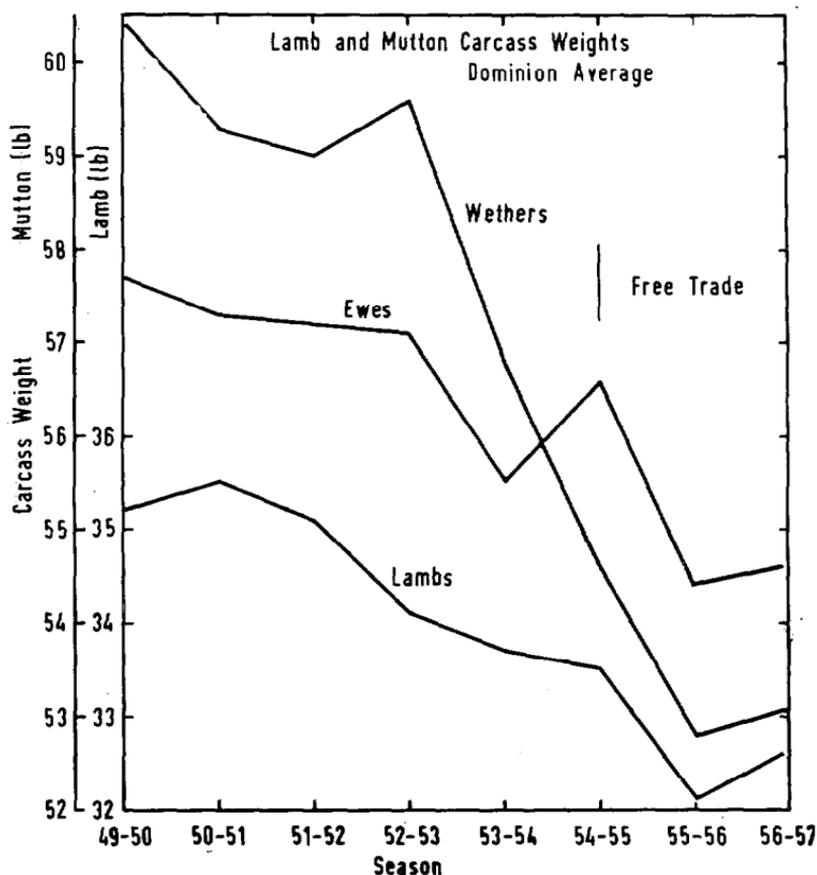


Fig. 1: Dominion average carcass weights of export ewe and wether mutton and lamb for the eight years, 1949-50 to 1956-57.

an attempt to qualify for price premiums operating to the advantage of light-weight carcasses. This is a desirable move on the part of producers.

The within season pattern of average carcass weights for export ewe mutton on a Dominion basis is presented in Fig. 2 together with percentage killings at approximately two-weekly intervals for the season 1946-47—the last season for which adequate data are available. A third curve shows the weight of fat in pounds for each average carcass weight. This curve is based on the regression: $Y = 0.72X - 18.80$, where Y = chemical fat in pounds and X = carcass weight in pounds (Barton and Kirton, 1958).

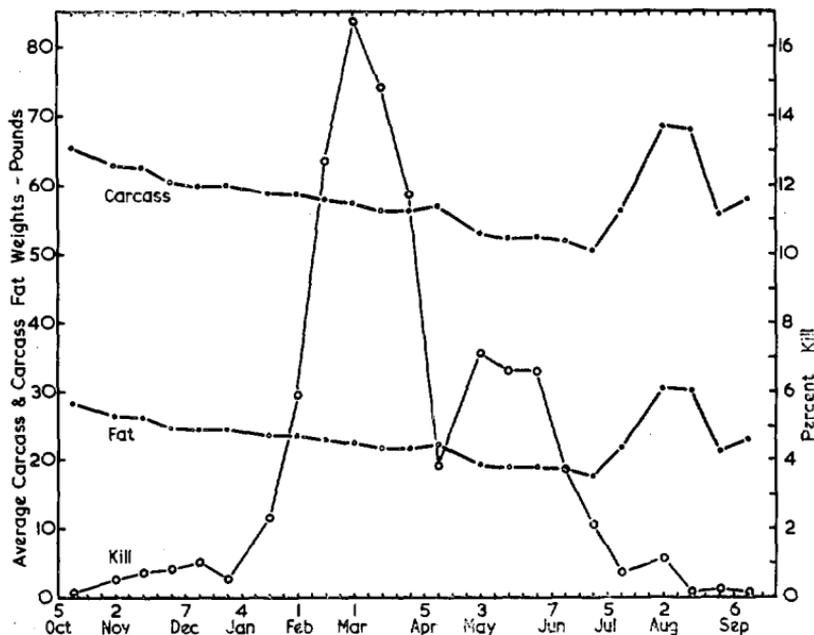


Fig. 2: Dominion average carcass weights of export ewe mutton for the season 1946-47. Percentage distribution of killings at approximately two-weekly intervals are also shown, together with fat weight in pounds for each average carcass weight.

It will be noted that ewe carcass weights on a Dominion basis are high both in the early and late parts of the meat export season (1 October to 30 September) and consequently such carcasses will tend to be excessively fat. The peak of the ewe kill in the 1946-47 season occurred, as would be expected, in the period early February to mid-April. It is suggested that barren ewes form the majority of those killed from August through to early December. Barrenness is the probable explanation for their high carcass weight. The reason for the high carcass weights in the late July-early August period in this particular season is not obvious; a carcass weight peak at that period in earlier seasons is not a recurring feature of the statistics.

The average mutton carcass weights at weekly intervals for the entire ewe killings of one freezing works for the season 1956-57 are presented in Fig. 3 along with the percentage of the season total killed each week. These data include carcasses which would not be exported in carcass form. In the season's ewe kill there were 3.4% rejects, 4.1% condemned carcasses and 11.0% of carcasses which were classified as lean and therefore

too thin for export. The average weights of these three classifications were 52.4 lb; 34.0 lb and 38.7 lb respectively. Of the total kill, 86.6% of the carcasses were graded as suitable for export and these averaged 56.6 lb. The average carcass weight of the entire kill was 53.6 lb.

The curves in Fig. 3 again indicate that high average carcass weights are a feature of killings in the spring of the year. During the autumn when the majority of ewes are killed, their average carcass weights are about the average for the whole season. It is apparent too that there are quite large week to week differences in average carcass weights, not all of which can be accounted for by small numbers.

The pattern of killings of ewes yielding carcasses which are rejected, condemned or classified as lean, although not presented here, follow quite closely the percentage distribution of killings shown in Fig. 3. Thus these mainly very light-weight carcasses come to hand throughout the year with their peak incidence in the autumn months.

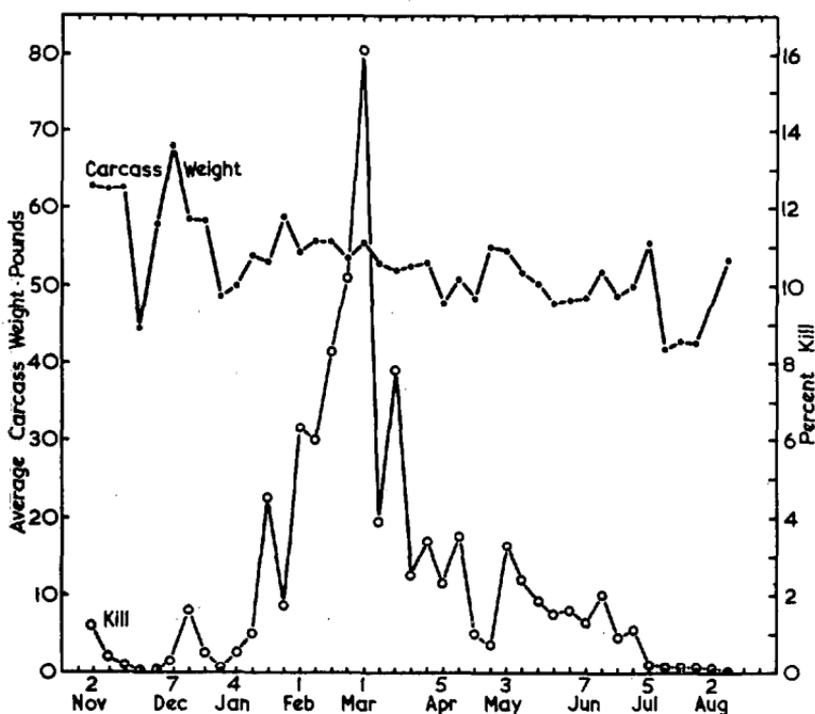


Fig. 3: Average carcass weights for the entire ewe kill at weekly intervals for one freezing works in the season 1956-57, together with percentage distribution of killings.

From the trends presented in Figs. 2 and 3 it is possible to say that heavy-weight and hence over-fat ewe carcasses may be associated with dry ewes in the spring and early summer months and with a proportion of ewes killed at other times throughout the season. Some practical measures designed to overcome this have been already discussed by Barton (1957) and need not be repeated here.

Carcass Fat Determinations

Traditional methods of determining fat in carcasses have involved the time-consuming and laborious procedure of physical separation or dissection of the main tissues of either the whole carcass or a sample joint or joints. This method will give the weights of bone, muscle and fat in the carcass and these components may then be analysed chemically. In certain studies, however, a more rapid method of determining the total water, fat, protein and ash in carcasses may be desired.

A simple, rapid and efficient procedure has been developed in the Sheep Husbandry Department, Massey Agricultural College, to enable large numbers of carcasses to be analysed for water, fat, protein and ash. The method involves cutting the frozen whole carcass or portions of it into slices $\frac{3}{8}$ to $\frac{1}{4}$ in. thick by means of a bandsaw. The still frozen slices are then minced to ensure a homogeneous mixture of bone, muscle and fat. Samples of the mince are drawn for chemical analyses. A whole mutton carcass of any weight can be sliced, minced and the mince samples taken and weighed within an hour by two persons.

The bandsaw and mincing technique (Barton and Kirton, 1956) has several distinct possibilities apart from speed. For instance, one side of the carcass can be treated in this manner while the other side, once thawed out, can be dissected into its various components. Sample joints can be removed and these only can be sliced and minced and the comparable joints on the other side of the carcass can be dissected. The technique has also been used to provide material suitable for chemical analyses from intact, near full term, foetal lambs; furthermore, there is no barrier to similar analyses on adult sheep and pigs. The method also makes it possible to analyse the total constituents of the body or of the carcass because bones as well as other tissues are sliced and analysed. In this connection Shorland (pers. comm.) has shown that in a series of 10 femurs from ewes (Kirton and Barton, 1958), fat contents ranged from 35.3% to 43.8% of their total bone weight. Tibia-tarsal bones

from the same series had fat contents ranging from 25.8% to 37.3%. The fat contents of these bones are sufficiently high to justify their being taken into account in certain meat and body composition studies.

Carcass Specific Gravity (S.G.)

The bandsaw and mincing technique has provided a ready means for determining total carcass fat so that this can be related to carcass specific gravity. If the relationship between these two variables is strong, then carcass specific gravity would provide an easy means for predicting total carcass fat.

The density of carcass fat is considerably less than that of other carcass components, and hence the larger the proportion of fat, the lower will be the carcass S.G. This relationship has been investigated in meat carcasses so that it may be used to determine the fat content of the pig (Brown *et al.*, 1951), cattle (Kraybill *et al.*, 1952), and of the ewe (Barton and Kirton, 1956). Kraybill *et al.* (1952) reported a correlation coefficient of 0.956 between carcass S.G. and per cent. separable fat as estimated from the 9-10-11 rib cut in beef carcasses.

Specific gravity values were determined by weighing, under water, 48 ewe carcasses which were used in a study of the effects of *l*-thyroxine and a low plane of nutrition on carcass composition (Kirton and Barton, 1958). The carcasses had a range of from 24.9% to 54.3% chemical fat (ether-extract) and the specific gravities ranged from 1.009 to 1.054. The correlation coefficients between per cent. fat and S.G. and the reciprocal of S.G. were -0.84 and $+0.84$ respectively. The standard error of estimate of the regression equations for estimating carcass fat content from S.G. and the reciprocal of S.G. were 3.24% and 3.25% fat, respectively.

To determine whether this relationship is more accurately represented by a straight line or by a curve as suggested by theoretical considerations (Morales *et al.*, 1945), a series of 5 very fat carcasses and 4 lean carcasses were analysed to give a more complete range of fat contents likely to be found in practice. The fat carcasses ranged from 55.4% to 61.7% chemical fat (S.G. range = 0.990 to 1.004) and the lean carcasses ranged from 7.1% to 34.7% chemical fat (S.G. range = 1.030 to 1.058). A test of significance of departure from linear regression (Snedecor, 1956, p. 454) applied to the data from the 57 carcasses produced a result that was significant ($p < 0.025$) and so the equation $Y = 8371.3X - 4382.9X^2 - 3932.9$ best fits the data. (Where Y = per cent. fat in the carcass; X = carcass

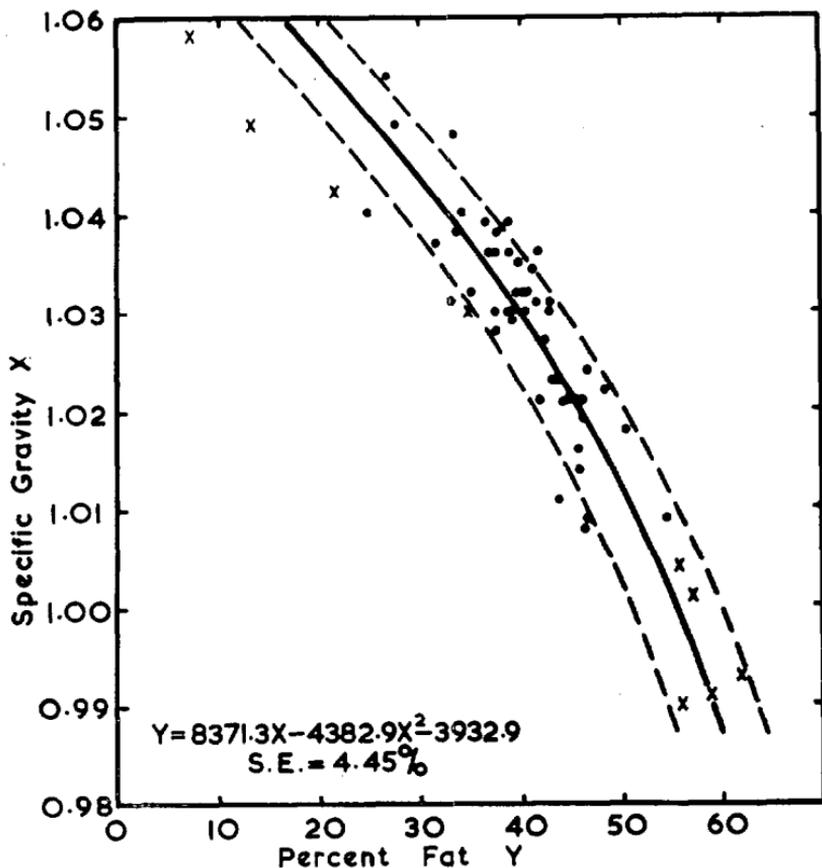


Fig. 4: Relationship between per cent. chemical fat in ewe carcasses and carcass specific gravity (57 observations).

S.G.; standard error of estimate = 4.45% fat). It should be noted in Fig. 4 that the biggest deviations from the regression curve occur at the lower fat percentages. The line predicted by the above regression equation curves in the opposite direction from the theoretical curve of Morales *et al.* (1945). The reason for this is not immediately known. A large factor in producing the observed curve is the data from the lean ewes; however, no reason is known why these data should not be included in the regression.

It can therefore be seen that carcass fat content can be estimated from carcass S.G., but this relationship does not appear to be accurate enough when the fat content of individual carcasses is required. However, the relationship may be of use to distinguish treatment effects on carcass fat between groups of animals.

Relationship Between Carcass Weight and Carcass Fat

The regression line in Fig. 5 indicates the relationship between carcass weight and dissectible fat in ewe mutton. The relationship is sufficiently high to enable a prediction of pounds of fat in the carcass to be made from the weight of the carcass (Barton and Kirton, 1958).

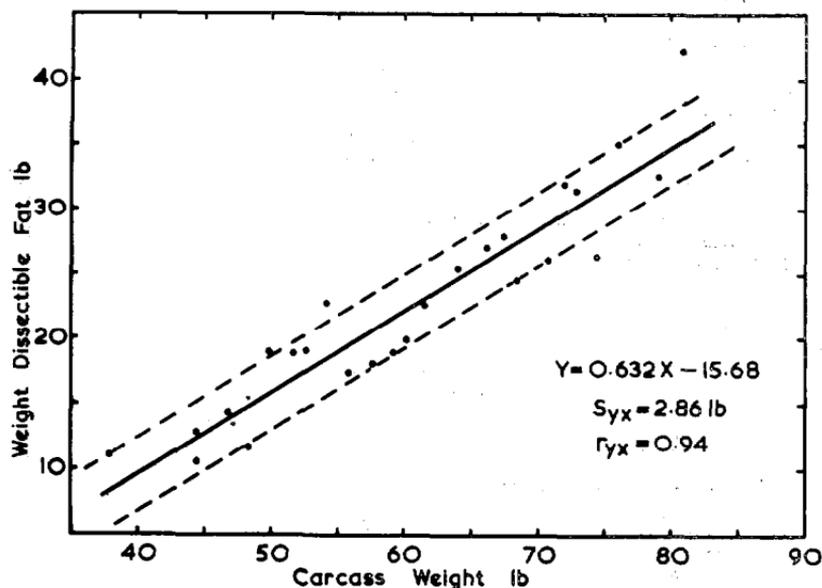


Fig. 5: Relationship between weight of carcass dissectible fat and carcass weight of ewe mutton (25 observations).

Accuracy of Various Indices for Predicting Carcass Composition

Apart from specific gravity and carcass weight as indices of carcass fat content, a number of other indices have been investigated (Kirton, 1957). The relative accuracy of all methods thus far considered is indicated in Tables 1 and 2 which present the correlation coefficients and the standard errors of estimate of regression equations for predicting carcass fat from these indices.

It will be noted that the three variables—namely, dressing percentage, carcass S.G., and carcass weight—give an estimate of the total carcass fat without the necessity of destroying the whole or part of the carcass. However, for more accurate prediction and when the composition of individual carcasses is required, the use of sample joints or complete carcass analysis is desirable.

TABLE 1: CORRELATION COEFFICIENTS AND STANDARD ERRORS OF ESTIMATE OF REGRESSION EQUATIONS FOR PREDICTING CARCASS CHEMICAL FAT.
(48 ewe carcasses)

| Independent Variate=X | r | S.E. (% Chemical Fat) |
|---|--------|--------------------------|
| Per cent. carcass water | -0.979 | 1.20 |
| Per cent. chemical fat 9-10-11 rib cut | +0.958 | 1.72 |
| Per cent. water 9-10-11 rib cut | -0.931 | 2.19 |
| Dressing per cent. (45 ewes) | +0.822 | 3.20 |
| Carcass S.G. | -0.842 | 3.24 |
| Weight carcass | +0.913 | 4.20° |
| Fat depth over "eye muscle" | +0.797 | 5.85 |
| Weight omental fat | +0.782 | 6.44° |

°The standard error in these cases was originally expressed as weight of fat, but was converted (for comparative purposes) to percentage fat by using mean carcass weight.

TABLE 2: CORRELATION COEFFICIENTS AND STANDARD ERRORS OF ESTIMATE OF REGRESSION EQUATIONS FOR PREDICTING DISSECTIBLE CARCASS FAT.
(25 ewe carcasses)

| Independent Variate=X | r | S.E. (% Dissectible Fat) |
|--------------------------------------|--------|-----------------------------|
| Weight dissectible fat leg + loin | +0.984 | 2.38° |
| Weight dissectible fat loin | +0.974 | 2.94° |
| Weight dissectible fat leg | +0.945 | 4.27° |
| Weight carcass | +0.939 | 4.49° |

°The standard error in these cases was originally expressed as weight of fat, but was converted (for comparative purposes) to percentage fat by using mean carcass weight.

Influence of l-Thyroxine and a Low Plane of Nutrition on Fat

Smith-Pilling and Barton (1954) showed that in one season (1951-52) 29.7% of the entire ewe killings at one freezing works were in the carcass weight range of 65 lb and over. This high percentage of heavy-weight carcasses indicates the magnitude of the overfatness problem. It is economically desirable, therefore, that a solution to this problem should be found.

A large body of evidence is available which shows that thyroxine in high doses causes a loss of body weight. Some evidence is also available to show that this loss is in part composed of body fat. The literature on starvation also suggests that when body weight is lost, fat is the first tissue removed, and at a proportionately greater rate than any other body tissue (Kirton, 1957).

An experiment, involving 50 Romney ewes, was carried out to investigate the effects on their carcass fat of thyroxine and a low plane of nutrition (Kirton and Barton, 1958). The ewes were allotted to 10 groups by restricted randomization. Thyroxine tablets were implanted subcutaneously. Table 3 shows the treatments used and the liveweight losses recorded at the end of the 28-day experimental period. The normal plane ewes had access to pasture at all times. Ewes on a low plane of nutrition were on pasture for about one hour per day and the remaining time was spent in a grass-free yard. The low plane of nutrition was defined largely in terms of the liveweight loss produced. Thyroxine treatment and a low plane of nutrition both produced highly significant liveweight losses.

TABLE 3: MEAN LIVELWEIGHT LOSSES OF THE TREATMENT GROUPS (LB.)
(5 ewes/group)

| | Normal Plane Nutrition | Low Plane Nutrition |
|---|---------------------------|------------------------|
| Control ewes; beginning experiment | 0.0 | |
| Control ewes; end experiment | 2.2 | 16.2 |
| 150 mg <i>l</i> -thyroxine (implanted) | 14.6 | 24.4 |
| 210 mg <i>l</i> -thyroxine (implanted) | 17.2 | 23.6 |
| 270 mg <i>l</i> -thyroxine (implanted) | 16.2 | 23.2 |
| 5 mg <i>l</i> -thyroxine (injected daily) | | 30.0 (3 ewes) |

However, no significant effect was produced on the weight of carcass fat except perhaps for the daily thyroxine injection group as can be seen from Table 4.

The mean weights of kidney fat, mesenteric fat and omental fat were not significantly reduced by the thyroxine and under-nutrition treatments. Thyroxine was shown to have significantly dehydrated the carcasses of the treated animals, and to have reduced the weight of the gastro-intestinal contents (fill) and the weight of the liver and the empty stomach. The low plane of nutrition was shown to have reduced the weight of carcass water and protein, and to have decreased the weights of most of the organs that were studied.

TABLE 4: WEIGHT OF CHEMICAL FAT IN THE CARCASSES (LB.)
Group means and standard deviations

| | Normal Plane Nutrition | | Low Plane Nutrition | |
|---|---------------------------|------|------------------------|--------------|
| | Mean | S.D. | Mean | S.D. |
| Control ewes; beginning experiment | 30.7 | 4.0 | | |
| Control ewes; end experiment | 25.1 | 9.0 | 23.8 | 4.7 |
| 150 mg <i>l</i> -thyroxine (implanted) | 25.6 | 3.7 | 21.7 | 6.3 |
| 210 mg <i>l</i> -thyroxine (implanted) | 27.2 | 3.7 | 27.5 | 8.1 |
| 270 mg <i>l</i> -thyroxine (implanted) | 21.1 | 4.5 | 24.4 | 3.8 |
| 5 mg <i>l</i> -thyroxine (injected daily) | | | 16.8 | 6.7 (3 ewes) |

Fat in Cooked Meat

Studies which are concerned only with the fat content in uncooked meat will not necessarily indicate the amount of fat that may be consumed when such meat is cooked. Research into this aspect of meat has not received the attention it obviously deserves. Such work is difficult to carry out and some aspects of the results can only be subjective and therefore lack precision.

Some preliminary investigations were carried out in this field a number of years ago using lamb carcasses from an experiment in which two contrasting types of Southdown sires were mated to Romney ewes grazing pasture at two different stocking intensities (Barton, Phillips and Clarke, 1949; Barton and Phillips, 1950). Retail legs from 16 carcasses which had been selected as representative of the group means for certain measurements were used. One leg from each carcass was dissected while the other leg was cooked under standard conditions (Barton and McGillivray, unpublished data).

TABLE 5: MEAN FAT PERCENTAGES FOR UNCOOKED AND COOKED LEGS OF LAMBS (16 Observations).

| | | % of Total Chemical Fat | |
|---|-------------|----------------------------|-------|
| Chemical fat as per cent. of dissected leg weight | 26.0 | | 100.0 |
| Chemical fat in edible cooked meat as per cent. of uncooked leg weight | 9.5 | 36.5 | |
| Chemical fat in 'inedible' material as per cent. of uncooked leg weight | 9.7 | 37.3 | |
| Drained-off fat as per cent. of uncooked leg weight | 7.3 | 28.1 | |
| | <u>26.5</u> | <u>101.9</u> | |

Mean leg weight = 5.75 lb

The means for those items of interest here are set out in Table 5. These data show that the legs of lamb averaging 26.0% chemical fat lose 28.1% of fat in the drainings following cooking and that there is a further fat loss as 'inedible' material which amounts, in these data, to 37.3% of the total fat. ('Inedible' material includes plate waste and scrapings from the bones.) The fat in the 'inedible' material was determined chemically. The plate waste fat in the 'inedible' material was, of course, a subjective estimate of what consumers would possibly reject when eating the meat. The drained-off fat was determined by weighing the material when solidified. There was a slight over-recovery of fat amounting to 1.9% because the drained-off fat was not analysed chemically and because some bone fat may be included in this figure. Bone fat had not been analysed

before cooking but may have exuded from the bones during roasting.

Under the conditions of this investigation, the results indicate that there is a minimum of 28.1% of fat or a maximum of 65.4% of the fat (drained-off fat plus chemical fat in the 'inedible' material) in the uncooked leg which will not be consumed. In other words the edible cooked meat contained only 9.5% chemical fat, whereas the uncooked meat contained 26.0% chemical fat; this is a reduction of 65.4% from the original amount of fat present in the soft tissues of the leg.

Conclusion

The importance of studies on fat is obvious. It is the tissue in meat which very largely determines the carcass grade and the price the retailer and consumer are prepared to pay. In the human dietary, some fat is a necessity for the well-being of the consumer but there is an optimum level of daily consumption if health is to be maintained; this optimum level has not yet been accurately described by nutritionists.

The work here reported considers only briefly a small facet of the problem. Attention has thus far been paid to problems of technique in assessing fat levels in mutton and lamb and appraising the short-term influence of *L*-thyroxine and a low plane of nutrition on reducing carcass fat contents of ewes.

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DISCUSSION

Q: : *Have the authors an explanation for the failure of undernutrition to affect carcass fat? I would also like to know what loss in carcass weight occurred in the underfed sheep.*

A: : The fat of the carcasses studied were highly variable, therefore, large differences were needed for statistical significance. Furthermore, the relatively short period of the undernutrition treatment will also contribute to the lack of a significant reduction of carcass fat. Although the mean weights of the carcasses of all treated groups were lower than those of the normal plane control carcasses, this reduction was not statistically significant. However, the weight of the chemical fat-free carcasses had been highly significantly reduced by both treatments and this reduction could account for from 4 to 10 lb of the liveweight loss. For details of the other liveweight components which were reduced by treatment effects see Kirton and Barton (1958).

D. McFARLANE: : There seems some room to doubt whether fat is in fact greatly catabolized in starvation since no decrease is apparent in the internal fat depots of animals which have virtually starved to death.

DR. C. P. McMEEKAN: : I think that there is little doubt that fat is catabolized in starvation. Perhaps the doubt arises by virtue of different extents and duration of undernutrition.

DR. M. C. FRANKLIN: : I agree that the effect on fat is a function of the degree of starvation. In the course of drought starvation experiments in Australia, we have fed animals on drought rations for up to a year which resulted in an almost complete disappearance of the fat depots.

Q: : *Since in the present experiment the animals were allowed access to pasture for a limited period each day it would seem that the treatment did not lead to any noticeable degree of starvation. In view of the data described by Dr. L. R. Wallace for cattle, this would indicate that an hour's grazing could suffice for the animal to obtain its maintenance requirements.*

A: : It must be remembered that in the present experiment the low plane of nutrition was defined largely in terms of the liveweight loss produced and it can be seen from Table 3 that on a comparative basis it was, in fact, a low plane of nutrition. It was of interest to note that at slaughter the mean weights of the contents of the gastrointestinal tracts of the control ewes on the normal and low planes of nutrition were 12.3 lb and 11.0 lb respectively. This suggests that the low plane of nutrition was not very severe and this small difference could probably be accounted for by the longer pre-slaughter starvation period undergone by the low plane ewes (41 h versus 23 h for the normal plane ewes). It also shows that highly significant differences in liveweight between the two planes of nutrition were not caused by differences in fill.

Q: : *Can the animal metabolize fat efficiently in the absence of adequate carbohydrate?*

DR. F. B. SHORLAND: : It is conceivable that if oxaloacetate, which is normally derived from carbohydrate sources, were lacking, there could be accumulation of acetoacetate and fat catabolism thus might be deranged.

Q: : *Have the authors looked into the question of utilizing more than one of the measures correlated singly with chemical fat in a multiple regression?*

A: : Not yet.

Q: : *Did Callow's figure of 77 per cent. water in fat-free muscular tissue apply to these data?*

A: : We found 77.5 per cent. water on a fat-free basis in the muscular tissue of the 9-10-11 rib cut from the control ewes. This was the only carcass region where this particular relationship was analysed. Thyroxine treatment caused a highly significant reduction to 76.4 per cent. water on a fat-free basis; this was indicative of muscular dehydration.