Report

UNDERSTANDING THE INEFFICIENCY OF TOO MUCH FAT

TENDER AHDB – EBLEX

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Contents

I) Executive Summary

The changes of fat trim and saleable meat during growth have been model in beef based on lipid and protein deposition and growth rates for different breeds, gender and under intensive and extensive feeding system. For example, the ratio of fat trim to saleable meat yield increased from 0.14 to 0.26 during growth from 440 to 630 days of age for a medium-sized breed of steers under intensive feeding. For lambs similar models have been developed and resulted for female lambs in an increase in the ratio of fat trim to saleable meat from 0.048 to 0.077 from 100 to 211 days of age. For beef, the energy required at a growth rate of 0.6 kg/d increased from 11.39 to 20.24 MJ/kg when the body weight increase from 200 to 500 kg, indicating the high effect of energy requirement for maintenance with increasing body weight. Doubling the growth rate to 1.2 kg/d increased the energy required to 12.61 and 22.42 MJ/kg for 200 and 500 kg body weight, respectively, suggesting the high efficiency of body growth at low body weight. The age dependent move through fat and conformation classes of R4L to R4H was 39 (37) and 53 (51) days for a medium-sized breed of steers (heifers) under intensive and extensive feeding system, respectively. For a large-sized breed corresponding age dependent move was 62 (39) and 78 (58) days, indicating the lower fat deposition of a large compared to a medium-sized breed. In particular heifer showed a short time period between those carcass classifications at a substantially lower body weight. For female lambs, the time of growth from fat class 2 to 3L or 3H was 26 or 47 days, respectively. For castrated lambs, corresponding time of growth from fat class 2 to 3L or 3H was 35 to 90 days, indicating the higher fat deposition of female lambs. Within the finishing period, the feed energy wasted over a range of carcass classifications, occurred in particular for intensive fed beef cattle (e.g. medium-sized breed of steers required during growth from fat class R4L to R4H 4760 MJ feed energy and resulted in negative profit of £-11.37), whereas extensive fed beef cattle still achieved a profit as defined as return from saleable meat minus costs for feed (e.g. medium-sized breed of steers required during growth from fat class R4L to R4H 5668 MJ feed energy and resulted in positive profit of £37.07).These calculations include the energy and feed costs associated with maintenance requirements in moving from one fat class to the next. However, the calculation does not include all other variable and fixed costs as well as the difference in return of investment associated with the different finishing systems. The profit decreased substantially with poorer conformation and fat classes. In lamb, the feed waste occurred when female animals had moved from fat class 3H to 4L and castrated lamb from 3L to 3H, at a live weight of 39 kg and above for both sexes, indicating the high maintenance requirements of lambs at those weights. For castrated lambs, the move from fat class 3L to 3H resulted in a deficit of £0.50, whereas the corresponding profit for female lambs was £0.73. The weight of castrated lambs was 2 kg higher so that the feed costs associated with higher maintenance requirement of castrated lambs due to higher body weight was the reason for the difference between genders in profit. In beef the average differences in fat trim between sexes were 0.23%, with highest difference of 0.7% in -U4H. Between beef breeds, Hereford showed at fat class 4H 1.8 to 2.4% higher fat trim than Charolais. At mean weight, the intensive fed cattle showed slightly less fat trim than extensive fed cattle. In sheep, with an increase in fat class from 1 to 5, the fat trim increased by 4.7%, whereas with an decrease in conformation classes from E to P, the fat trim increased by only 0.4%. For the UK, the upper level of the annual benefit of avoiding excess fat during processing was estimated to be £339m in beef and £66m in sheep.

II) Introduction

According to EBLEX, 13.6% of beef carcases and 23.3% of lamb carcases were over-fat in 2010. This represents a substantial inefficiency within the industry, both on-farm and in the processing sector. From the producer's perspective, the major factors influencing fatness are not fully understood, and the feed wasted including its associated costs by producing over-fat carcases is not known for specific production systems. From the processor's perspective, there is the issue of the time spent in the abattoir trimming the carcases and the time and costs involved in disposing of unwanted fat.

The objectives of the research project were:

1. *Review of the impacts of genetics, gender, diet and finishing systems on the production of excess fat.*
2. *Highlight the tendency to deposit saleable meat and fat trim over the lifetime of an animal.*
3. *Demonstrate, using most UK relevant production systems, the energy required to produce saleable meat and fat trim in mega joules.*
4. *Estimate the time taken to move through different fat classes for:*
    - *Finishing cattle – for different breeds as well as steers, heifers finished extensively and intensively;*
    - *Lambs of different gender.*
5. *Calculation of the amount of feed (in MJ and £) wasted for a variety of carcases, i.e. range of conformation and fat classes, and weights, and for the industry.*
6. *Assess the amount of fat trim for a range of carcases (range of conformation fat classes, and weights).*
7. *Estimate the time spent trimming and process of disposing of fat from the processing sector, with costs.*

1. Literature review

This section aims to identify the research carried out to investigate the inefficiencies of too much fat in cattle and sheep. The review will examine the key areas that determine fat deposition for both cattle and sheep, which include genetics, gender, diet and finishing system.

1.1 Fat development and types

Fat is a late maturing tissue, with different tissues maturing in the following order:

- Organs
- Skeleton
- Muscle
- Fat

There are four major categories of fat deposition:

- Internal fat, this surrounds the organs
- Seam fat, found between the muscles
- Subcutaneous fat, located under the skin
- Intramuscular fat, within the muscle, referred to as marbling.

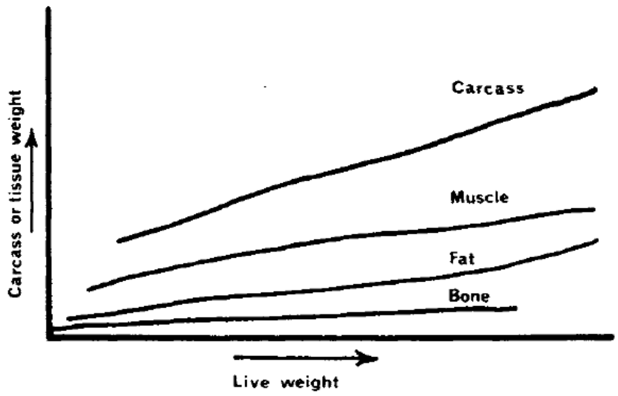


Figure 1.1 Growth of the carcass and their tissues relative to live weight (Berg *et al.*, 1976)

The development of carcass tissues is illustrated by Berg *et al.* (1976) in "New concepts of cattle growth". Figure 1.1 highlights this pattern of development using data from a mixed group of beef steers from birth to 450 kg live weight. This Figure shows the relationship between live weight and fat weight. Although fat comprises a relatively small amount at birth, its growth rate increases as the animal matures.

1.2 Cattle genetics

The common domesticated breeds of cattle represent a broad gene pool, with breeds being created to express different desirable characteristics, often under specific environmental conditions. This means that under the same conditions different breeds are expected to produce different levels of fatness.

Table 1.1 highlights these differences in fat deposition between major crosses of breeds used in the UK. Crosses of Limousin and Charolais sires with Friesian showed lower levels of total fat compared to Hereford, Simmental and Angus crosses with Friesian. Furthermore, Kempster *et al.* (1976) reported that dairy breeds compared to beef breeds deposit a greater proportion of their total fat as internal fat. In most cases, all cattle within group came from the same trial and were grown under similar conditions. However, between groups there were differences in age, weight and level of finish and thus not standardised.

Table 1.1 Means and standard deviations of total fat weight in the side and depots as a percentage of total fat (Kempster *et al.*, 1976)

Group		Total fat (kg)		Intermuscular fat (%)		Subcutaneous fat (%)		KKCF (%)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	Ayrshire (C)	33·4	4·82	47·7	3·47	28·2	3·12	19·8	4·21
2	Angus × Friesian (G/C)	30·1	3·98	48·5	2·16	29·0	1·81	18·0	2·34
3	Hereford × Friesian (C)	27·9	6·74	47·3	2·84	35·3	3·45	12·7	2·50
4	Friesian (C)	26·5	5·45	50·9	2·95	28·6	3·07	16·2	3·37
5	Limousin × Friesian (C)	23·7	6·75	50·2	2·64	29·5	3·86	15·7	4·06
6	Charolais × Friesian (C)	25·3	3·82	52·8	2·93	27·9	2·98	14·4	2·48
7	Hereford × Friesian (G/C)	28·0	5·90	49·3	3·03	31·3	3·51	14·6	2·49
8	Simmental × Friesian (C)	28·8	6·06	50·9	3·30	29·0	2·79	15·8	2·95
9	Angus crosses	44·3	6·26	46·6	2·34	36·0	2·42	12·9	1·71
10	Friesian (G/C)	31·2	8·77	49·6	2·91	27·4	2·91	18·4	3·62
11	Welsh Black crosses	27·3	5·13	46·9	3·13	31·5	4·02	16·3	3·46
12	Friesian × Ayrshire (G/C)	41·5	7·29	48·3	3·21	26·4	3·15	21·3	3·71
13	South Devon × Friesian (G/C)	34·9	7·73	50·1	1·98	26·7	2·68	19·0	2·21
14	Simmental × Ayrshire (G/C)	39·6	7·95	49·7	2·23	25·6	2·81	20·4	2·99
15	Simmental × Friesian (G/C)	38·1	7·20	50·2	3·27	27·9	3·08	17·1	3·30
Pooled within-group results		30·1	6·17	49·5	2·96	29·5	3·19	16·4	3·16

KKCF = Kidney knob and channel fat
C = Cereal diet
G/C = Grass/cereal diet

The breed variation is again supported by Berg *et al.* (1976) and Lohman (1971), who presented similar results as indicated in Figure 1.2. This Figure indicates differences in fat weight between Angus and its crosses with Holstein and Charolais as well as changes of rates of fat deposition during growth.

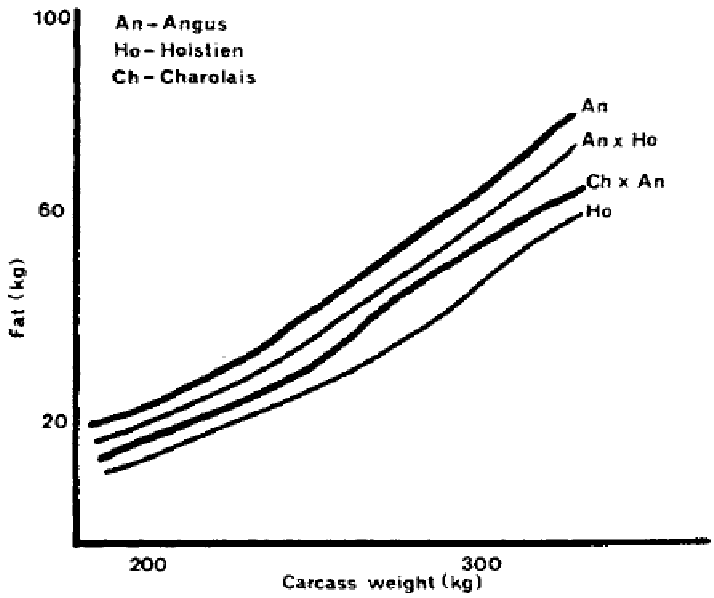


Figure 1.2 Weight of fat relative to carcass weight in different breeds and crosses (Berg *et al.*, 1976)

Therefore it can be concluded that genetic differences can be expected to occur between breeds for the amount of fat deposition in relation to carcass weight. Additionally the location of fat depots will vary depending on breed as well as the rate of fat deposition.
Based on scans of primals of the entire half carcass of beef cattle, Navajas *et al.* (2010) reported significant difference between Aberdeen Angus crosses and Limousin crosses, with fat tissue of 25% and 19%, respectively, on the dissected half carcass weight. Further information about breed difference of fatness and fatty acid profiles are given by Lambe *et al.* (2010) and Prieto *et al.* (2011).

1.3 Cattle gender

Numerous reports indicate that at equal weights and ages, heifers produce carcasses with higher fatness than steers and bulls. This trend is illustrated in Figure 1.3 by Berg *et al.* (1976), which shows that the weight of fat relative to sum of muscle and bone weight for heifers is similar to that of steers up to about 50 kg, but then increased substantially faster in heifers.

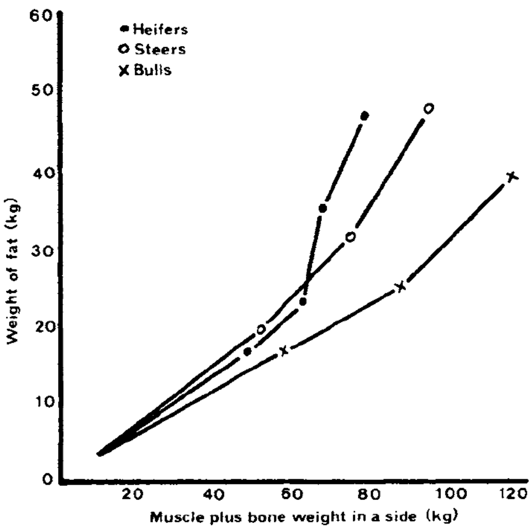


Figure 1.3 Fat relative to muscle plus bone (Berg *et al.*, 1976)

Table 1.2 Fat weight kg adjusted to mean total side weight (Berg *et al.*, 1979)

	Fat weight (kg)		
	Heifers	Steers	Bulls
Half carcass			
Total fat	31.32 *a*	25.72 *b*	17.62 *c*
Subcutaneous fat	12.40 *a*	9.36 *b*	6.07 *c*
Intermuscular fat	12.36 *a*	10.63 *b*	7.89 *c*
Body cavity fat	3.11 *a*	3.11 *a*	2.83 *c*
Kidney fat	3.16 *a*	2.42 *b*	1.61 *c*
Forequarter			
Total fat	14.67 *a*	11.71 *b*	7.99 *c*
Subcutaneous fat	4.93 *a*	3.44 *b*	2.49 *c*
Intermuscular fat	8.33 *a*	6.80 *b*	4.41 *c*
Hindquarter			
Total fat	16.63 *a*	14.09 *b*	9.83 *c*
Subcutaneous fat	7.45 *a*	5.88 *b*	3.71 *c*
Intermuscular fat	3.97 *a*	3.77 *a*	2.83 *b*

†53.56 kg half carcass muscle.
a-c Means in the same row with different letters differ significantly at $P < 0.05$.

The effect of the level of energy intake and the influence of breed and sex on fat is investigated by Fortin *et al.* (1981). They showed that heifers produced the greatest level of subcutaneous fat.
The result of heifers being fatter is confirmed by Berg *et al.* (1979) in their investigation of the pattern of carcass fat deposition in heifers, steers and bulls. This study investigated Shorthorn crosses and showed the same pattern, with heifers resulting in 5.6 kg more total fat than steers and 13.7 kg more total fat than bulls

(Table 1.2). The animals of this trial were slaughter over a wide weight range at random within each sex and breed-type of dam. Therefore, it could be shown that the difference in fattening pattern among the sexes was a result of a combination of more rapid fat deposition relative to muscle and an earlier onset of the fattening phase with respect to muscle weight.

Lambe *et al.* (2010) is reporting significant differences between sexes and Hyslop *et al.* (2009) estimated fat classes for heifers and steers of 10.76 and 9.10, respectively, in Aberdeen Angus crosses and 8.90 and 8.46, respectively, in Limousin crosses on the 15 point scale.

1.4 Cattle finishing system

The fat deposition level is determined by the energy intake of the cattle. The differences in utilisation and conversion efficiencies among breeds are expected to cause variation in fat deposition. The difference between intensively fed cereal diets and a mixed diet of grass and cereals was shown to affect fat deposition by Kempster *et al.* (1976). They found that the proportion of subcutaneous fat was lower for cattle fed on a mixed grass and cereal diet than the same breeds on a cereal diet. The results of their findings are presented in Table 1.1. Of particular interest are the differences between group 3 and 7 as both are Hereford Friesian crosses but on different diets. These groups had little difference in the mean total fat although the mean percentage of subcutaneous fat of the cereal fed group was 4% higher than the mixed grass cereal group.

Table 1.3 Comparison of two studies of the effect of nutrition on carcass composition (Berg, 1976)

Treatment	High-high	High-moderate	Moderate-high	Moderate-moderate	Sig. level
(a).					
Wt. of carcass (kg)	347.3	329.2	308.7	338.7	
% muscular tissue	55.2	59.2	56.5	58.7	*
% fatty tissue	30.6	25.5	29.0	26.2	*
% bone	11.8	12.8	12.3	12.7	
Muscle-bone ratio	4.7	4.6	4.6	4.6	
(b).					
Wt. of carcass (kg)	242.9	236.5	236.5	242.0	
% muscle†	55.8^{ce}	58.4^{c}	57.3^{e}	60.3	*
% fat†	31.9^{e}	27.4	29.5^{e}	25.9	*
% bone†	13.8^{c}	14.9	14.3^{c}	14.7	*
Muscle-bone ratio	4.0	3.9	4.0	4.1	n.a.

*$P < 0.05$
†Estimated from rib dissection
n.a.—not analysed.
Means with the same superscript do not differ at $P < 0.05$
Sources: (a) Callow, 1961; (b) Hendrickson *et al.*, 1965.

The effect of the level of nutrition on carcass composition has been reviewed by Berg *et al.* (1976) as shown in Table 1.3. In both reviewed studies, the percentage of fat was higher for animals fed on a higher nutrition diets. This relationship has been further investigated by Steen (1995) to give insight into how plane of nutrition and slaughter weights affect growth and feed efficiency in bulls, steers and heifers of three different crosses. This study showed a significant difference in fat gain in g/day for cattle on an *ad libitum* diet compared to those on an 80% restricted diet, with the greatest differences shown by steers and bulls who laid down an additional 100 g/day on the *ad libitum* diet.

This research was continued by Steen *et al.* (2000) to investigate the effects of the ratio of grass silage to concentrates in the diet and restricted dry matter intake on the performance and carcass composition of beef cattle. The dietary treatment consisted of grass silage offered ad libitum and supplemented with rolled barley which consisted of 0 to 360 g/kg total DM intake. Within each dietary treatment, animals were allocated to three slaughter weight groups of 510, 566 and 610 kg. Summarised in Table 1.4, which outlines the level of fat trim for cattle on different energy intakes, the results show an increasing level of fat trim from 94 to 106 g/kg carcass weight as the proportion of concentrates in the diet increased from 0 to 360 g/kg DM.

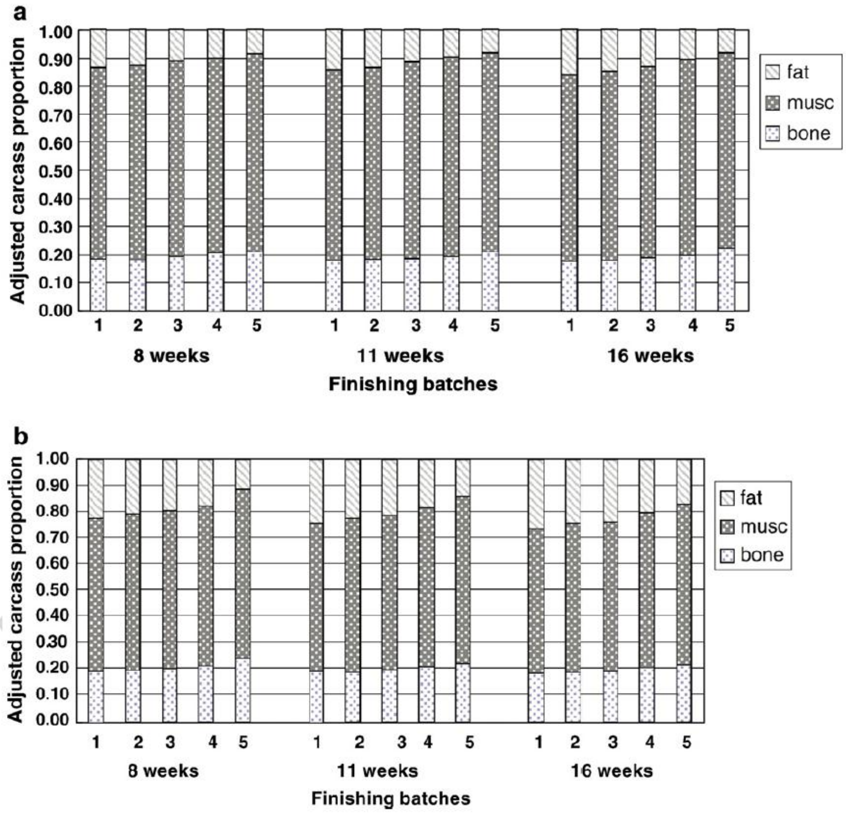
Table 1.4 Feed intake, animal performance and carcass data (Steen *et al.*, 2000)

Intake	Proportion of concentrates in diet (g/kg)						S.E.M.	Sig.
	0	120	240	360	0/360	360		
	ad libitum					0.8 of ad lib		
Food intake								
Silage DM (kg/day)	7.0^{a}	6.6^{b}	5.7^{d}	5.2^{e}	6.3^{c}	4.1^{f}	0.08	***
Total DM (kg/day)	7.0^{d}	7.5^{bc}	7.7^{b}	8.4^{a}	7.4^{c}	6.6	0.09	***
Metabolisable energy (MJ/day)	88^{d}	93^{e}	96^{b}	105^{a}	93^{c}	86^{d}	1.05	***
Animal performance								
Period on diet (days)	298^{a}	247^{b}	207^{c}	165^{d}	247^{b}	263^{b}	11.4	***
Carcass weight (kg)	298	298	301	298	298	301	2.1	
Live-weight gain (kg/day)	0.56^{a}	0.69^{b}	0.84^{c}	1.04^{d}	0.70^{b}	0.67^{b}	0.026	***
Dressing proportion (g carcass/kg live weight)	532	532	542	531	532	538	3.2	
Carcass gain (kg/day)	0.34^{a}	0.41^{b}	0.53^{c}	0.61^{d}	0.42^{b}	0.42^{b}	0.014	***
Lean gain (g/day)	166^{a}	199^{ab}	262^{cd}	306^{d}	224^{bc}	218^{bc}	17.9	***
Fat gain (g/day)	132^{a}	165^{b}	210^{c}	244^{d}	148^{ab}	155^{ab}	9.6	***
Bone gain (g/day)	41^{a}	46^{ab}	52^{bc}	61^{c}	51^{b}	46^{ab}	3.5	*
Carcass data								
Fat classification	3.4^{a}	3.4^{a}	3.5^{a}	3.5^{a}	3.1^{b}	3.4^{a}	0.09	*
Subcutaneous fat depth (mm)	8.0^{ab}	8.0^{ab}	8.9^{a}	8.7^{a}	6.7^{b}	7.6^{ab}	0.52	*
Marbling score	3.2^{a}	3.1^{a}	3.3^{a}	3.2^{a}	2.5^{b}	3.0^{ab}	0.18	*
Area of *L. dorsi* (cm^2)	59.6	60.0	64.2	62.5	63.1	62.1	1.45	
Total non-carcass fat (kg)	35.7^{bc}	37.8^{b}	37.9^{b}	41.5^{a}	37.3^{b}	33.5^{c}	1.29	***
Saleable meat concentration (g/kg)	695	705	702	697	716	706	5.2	*
Fat trim (g/kg)	94^{bc}	98^{ab}	102^{ab}	106^{a}	86^{c}	93^{bc}	4.0	*
High-priced joints (g/kg total joints)	458	451	451	454	452	456	3.8	
Composition of fore-rib joint (g/kg)								
Lean	563	560	557	562	576	574	7.6	
Fat	271^{abc}	280^{abc}	292^{a}	285^{ab}	262^{c}	267^{bc}	7.8	*
Bone	166^{a}	161^{ab}	151	153^{b}	163^{a}	159^{ab}	3.1	**
Estimated carcass composition (g/kg)								
Lean	608	606	606	608	616	614	4.6	
Fat	226^{abc}	232^{abc}	239^{a}	235^{ab}	220^{c}	225^{bc}	5.0	*
Bone	155^{a}	153^{ab}	149^{c}	150^{bc}	155^{a}	152^{abc}	1.4	**

^{a,b,c,d} Means with the same superscript are not significantly different.

1.5 Sheep breeds

The large range of breeds used in lamb production suggests that variation in fat deposition would be expected among breeds, particularly between the extensive hill breeds such as Scottish Blackface (SBF), Swaledale and Welsh Mountain and the more intensive terminal sire breeds such as Texel, Suffolk and Charollais. This difference has been investigated by Lambe *et al.* (2006), they found that carcass fat weight increased more quickly with growth in SBF than Texel, which resulted in an increased fat proportion and increased the fat to muscle ratio (Figure 1.4).



(a) Proportions of carcass tissues at each scanning event, within each finishing batch, in Tex lambs. (b) Proportions of carcass tissues at each scanning event, within each finishing batch, in SBF lambs.

Figure 1.4 Proportions of carcass tissue at each scanning event for Texel and SBF lambs

Both McClelland *et al.* (1976) and Wood *et al.* (1980) analysed the effect of breed and maturity on carcass composition. Within these two studies, eight different breeds were analysed and summarised in Table 1.5. Some major differences in fat weight were shown among breeds. However, it has to be considered that some environmental differences between the study groups may contribute to some of these differences. The breeds examined by Wood *et al.* (1980) appeared to be more similar with total fat deviating at most by 4% and total fat by 0.8 kg, compared with those analysed by McClelland *et al.* (1976), who studied two more extreme breeds, the Soay and Oxford, for which fat weight differed by 8 kg.

McClelland *et al.* (1976) reported that the smaller Soay breed on average matured 36 days faster than the larger Oxford breed. The Finnish Landrace, although on average twice as heavy, matured almost as fast as the Soay.

Table 1.5 Comparison of two studies on carcass composition of different sheep breeds

Author Index		Breed			
		Clun	Colbred	Suffolk	Hampshire
1	Total fat (kg)	6.1	5.4	5.3	5.6
	Total fat (%)	34.1	29.9	29.6	31.6
		Breed			
		Soay	Southdown	Finnish Landrace	Oxford
2	Dissectible fat tissue (kg)	1.2	4.6	4.7	9.2
	Dissectible fat tissue (%)	16.5	29.5	30.8	33.1

1 Wood *et al.* (1980) Finishing criteria: Approximately equal number of males and females of each breed falling into four carcass weight groups: 13.6 to 15.8 kg, 15.9 to 18.1 kg, 18.2 to 20.4 kg and 20.5 to 22.7 kg.
2 McClelland *et al.* (1976) Finishing criteria: Approximately equal number of males and females of each breed falling into four classes of maturity (40, 52, 64, and 76%). The mature weight, M, for each female lamb was estimated as $M = 0.35\ D + 0.65\ D^b$, where D was the mature weight of the dam and D^b the least squares mean weight of mature ewes for each breed.

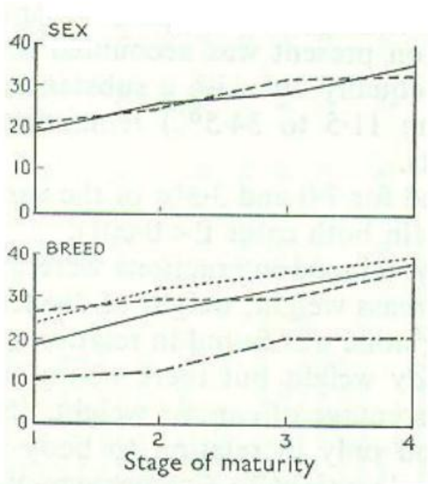
1.6 Sheep maturity

The effect of maturity on fat deposition in sheep has also been studied by McClelland *et al.* (1976) and Wood *et al.* (1980) as presented in Table 1.6 and Figure 1.5. The methods of determining maturity difference between studies; whereas Wood *et al.* (1980) chose the carcass weight after slaughter for grouping, McClelland *et al.* (1976) slaughtered the groups depending on the criteria when individuals reached a certain percentage of mature weight. Both studies did show an increase in the level of fatness with increasing maturity.

Table 1.6 Comparison of two studies on carcass composition at different stages of maturity

Author Index		Stage of maturity			
		1	2	3	4
1	Total fat (kg)	4.2	5.2	6.2	7.1
	Total fat (%)	28.5	30.7	32.3	33.3
		Stage of maturity			
		1	2	3	4
2	Dissectible fat tissue (kg)	2.1	3.9	5.7	7.8
	Dissectible fat tissue (%)	20	25.6	30.2	34

1 Wood *et al.* (1980)
2 McClelland *et al.* (1976)



Mean values of carcass components and ratios for two sexes (—— females and – – – – males) and four breeds (– · – · – Soay; —— Southdown; – – – – Finnish Landrace; · · · · · · Oxford Down) at each of four stages of maturity.

Figure 1.5 Carcass fat per carcass weight (%) (McClelland, 1976)

1.7 Sheep gender

The studies of McClelland *et al.* (1976) and Wood *et al.* (1980) also analysed the influence of gender on the deposition of fat. Both studies reported little difference between the genders, illustrated in Figure 1.5. Wood *et al.* (1980) found a difference in total fat percentage on the carcass weight between males and females of 1.1, with females showed higher fatness (Table 1.7). In contrast, McClelland *et al.* (1976) reported a difference of 0.6% of carcass dissectible fat tissue between genders, with males yielding a higher percentage.

McClelland *et al.* (1976) concluded that sex differences corresponded to longer time to reach maturity, with females taking 161 days to reach overall mean maturity, whereas males took 196 days to reach the same stage.

Table 1.7 Comparison of two studies on carcass conformation and sexes

Author		Sex	
Index		Male	Female
1	Total fat (kg)	5.4	5.8
	Total fat (%)	30.1	32.2

		Sex	
		Male	Female
2	Dissectible fat tissue (kg)	5.4	4.3
	Dissectible fat tissue (%)	27.8	27.2

1 Wood *et al.* (1980)
2 McClelland *et al.* (1976)

1.8 *Sheep finishing system (diet)*

The effect of energy intake on fat deposition has been reviewed by Rattray *et al.* (1974). This study used data from three of their previous studies Rattray *et al.* (1973a) (1973b) (1973c.). Details of the comparative slaughter experiments are presented in Table 1.8. Collectively these comparative studies covered 396 growing and fattening young sheep and 26 mature sheep and compared 9 different diet trials with different metabolisable energy (ME) values, made up by altering the percentage of roughage and concentrates in the feed ration.

The results shown in Table 1.9 suggest that ME intake has a substantial influence on fat deposition. Comparing trial I and II with VII and VIII, although split between wether and ewe lambs, showed that the ewes fed approximately half the ME of the wethers produced much less fat per day. Although differences between the two ewe groups and also the wether groups were small, this could be in part due to a difference in the time spent on the feed or breed differences. As expected for mature ewes almost all gain is due to fat deposition (trial IX).

This study estimated that the energy required to deposit a gram of fat would be 42.7 ± 14.99 kJ ME.

Table 1.8 Details of comparative slaughter experiments

Trial	Diet[a]	ME content[b] (kcal/gDM)	Animals	No. of animals	Days on feed
I[c]	10% roughage - 90% concentrate	3.00	Wether lambs	69	84 & 168
II[c]	50% roughage - 50% concentrate	2.46	Wether lambs	50	87 & 178
III[c]	50% roughage - 50% concentrate	2.46	Wether yearlings	60	87 & 178
IV[c]	100% roughage (Sudan hay)	1.37 to 1.96	Mixed sex lambs	50	105
V[c]	100% roughage (Sudan hay)	1.66 to 1.71	Mixed sex lambs	40	104
VI[d]	50% roughage - 50% concentrate	2.63	Wether lambs	84	33 to 82
VII[e]	20% roughage - 80% concentrate	2.58	Ewe lambs	26[f]	125 & 131
VIII[e]	75% roughage - 25% concentrate	2.35	Ewe lambs	28[f]	125 & 131
IX	75% roughage - 25% concentrate	2.41	Mature ewes	26	108 & 115

[a] In the mixed diets the roughage fraction was predominantly alfalfa hay and oat hay, and the concentrate fraction was predominantly rolled barley and molasses.
[b] Metabolizable energy content in kcal per g dry matter.
[c] Rattray *et al.*, 1973a.
[d] Rattray *et al.*, 1973b.
[e] Rattray *et al.*, 1973c using non-pregnant animals.
[f] Number of animals includes the same initial slaughter group of 11 lambs.

Table 1.9 Metabolic intake and fat deposition (Rattray et al., 1974 and amended for % weight gain as fat)

Trial	ME intake MJ/day	Metabolic body size $W^{0.75}$ kg[a]	Protein deposition g/day	Fat deposition g/day	Weight gain g/day[b]	% weight gain as fat %
I	12.67 ± 0.44	13.5 ± 0.2	22.1 ± 1.5	61.1 ± 3.3	93 ± 18.0	65.70
II	13.36 ± 0.67	15.0 ± 0.2	19.5 ± 2.6	59.5 ± 7.4	83 ± 14.6	71.69
III	15.29 ± 0.63	17.8 ± 0.2	19.5 ± 2.0	62.8 ± 16.4	98 ± 32.8	64.08
IV	10.64 ± 0.36	11.9 ± 0.1	18.9 ± 1.3	23.0 ± 2.8	60 ± 8.4	38.33
V	9.01 ± 0.38	13.3 ± 0.2	11.1 ± 1.0	18.1 ± 2.8	24 ± 7.6	75.42
VI	13.04 ± 0.68	12.8 ± 0.1	22.5 ± 2.1	55.0 ± 6.0	131 ± 14.9	41.98
VII	6.56 ± 0.65	10.8 ± 0.4	11.1 ± 1.6	21.5 ± 5.9	39 ± 11.2	55.13
VIII	7.13 ± 0.58	10.7 ± 0.3	11.5 ± 1.0	20.9 ± 4.9	42 ± 9.6	49.76
IX	17.65 ± 0.13	21.1 ± 0.5	13.2 ± 1.2	72.3 ± 15.2	75 ± 18.8	96.40

[a] W is initial plus final wool-free empty body weight divided by 2.
[b] Wool –free, ingesta-free basis

2. Change of deposition of lean and fat tissue over time

2.1 Finishing cattle

The changes of lean and fat tissue over lifetime are described in the literature review. To highlight the changes more specific to the objectives given for this report, the changes are presented for a specific scenario, i.e. a medium breed of steers under an intensive feeding system, using the developed model of this study. The developed model will be explained in more detail in later sections. In most studies, the changes of lipid and protein depending on empty body weight are presented. In the model developed, we used the ARC (1980) equations and a basic growth pattern obtained in a SAC beef finishing trial. Figure 2.1 presents the development of protein and lipid mass depending on the empty body weight. The empty body weight is defined as difference between body weight and weight of digesta in the gastrointestinal tract, including urine content of the bladder. The shapes of the curves indicate a quadratic increase in lipid mass whereas protein mass increased almost linearly. This information of protein and lipid mass is used to determine the nutritional requirements of animals and it highlights the substantial increase in lipid at the end of the growing finishing period. The difference between lipid and protein mass and empty body weight is mainly water and some ash (minerals).

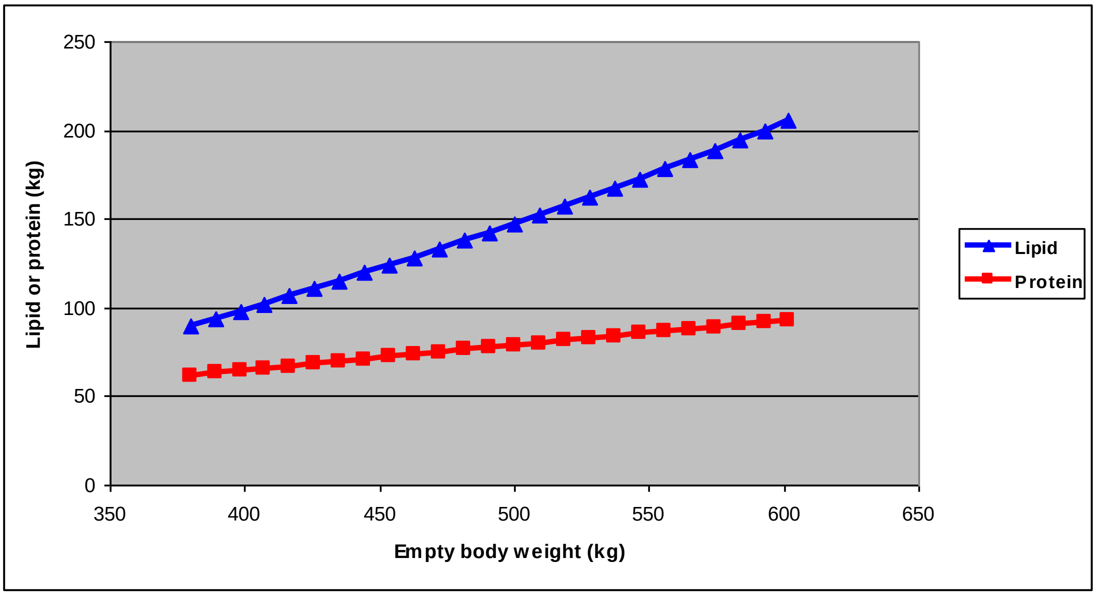


Figure 2.1 Development of lipid and protein mass in the empty body of a medium breed of steers under an intensive feeding system

Based on data from the beef yield project of EBLEX (2011), we transformed the protein and lipid mass into fat trim and saleable meat for this scenario (Figure 2.2). The saleable meat yield increases with increase in body weight, but not as linear as for protein. The fat trim is increasing quadratically but the absolute value is much less than for saleable meat. The difference in mass is due to the high water content of saleable meat in comparison with fat trim. The composition of chemical components of saleable meat and fat varies. Holland *et al.* (1991) reported that in purchased meat, the lean tissue in growing cattle comprises of 74% water, 20.3% protein and 4.6% lipid, whereas fat tissue comprises of 24% water, 8.8% protein and 66.9% fat.

The influence of reduction in growth rate on the change of saleable meat and fat trim is shown in Figure 2.3. That means that with increase in age particularly the growth rate of saleable meat decreases whereas the rate of fat tissue growth decreases substantially less. To get a more obvious indication of the difference in change fat tissue growth rate to saleable meat growth rate, their ratio was presented in Figure 2.4.

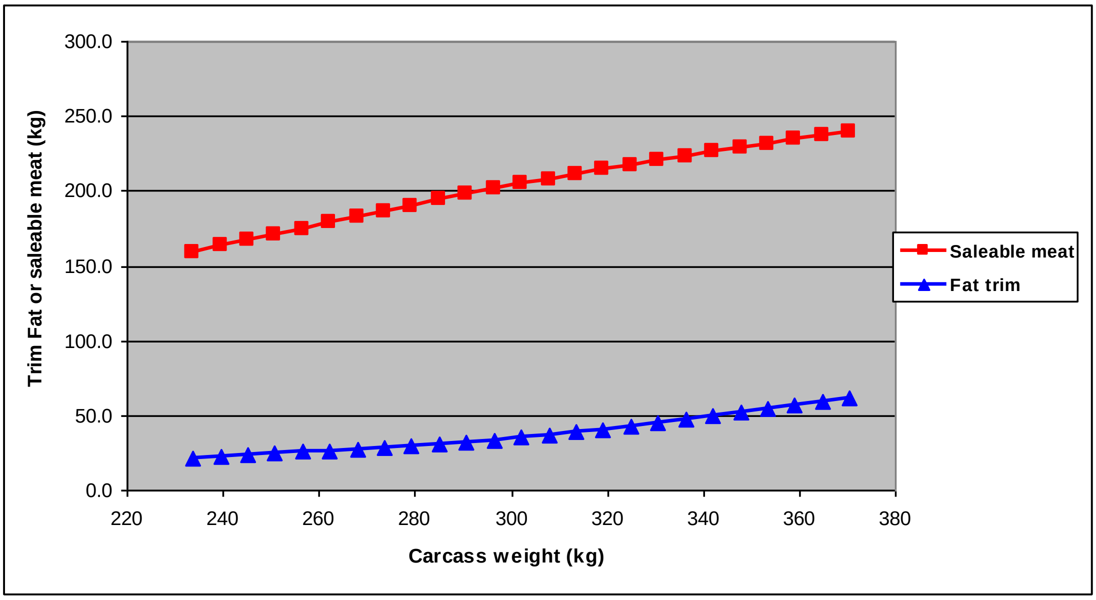


Figure 2.2 Change in fat trim and saleable meat depending on carcass weight of a medium breed of steers under an intensive feeding system

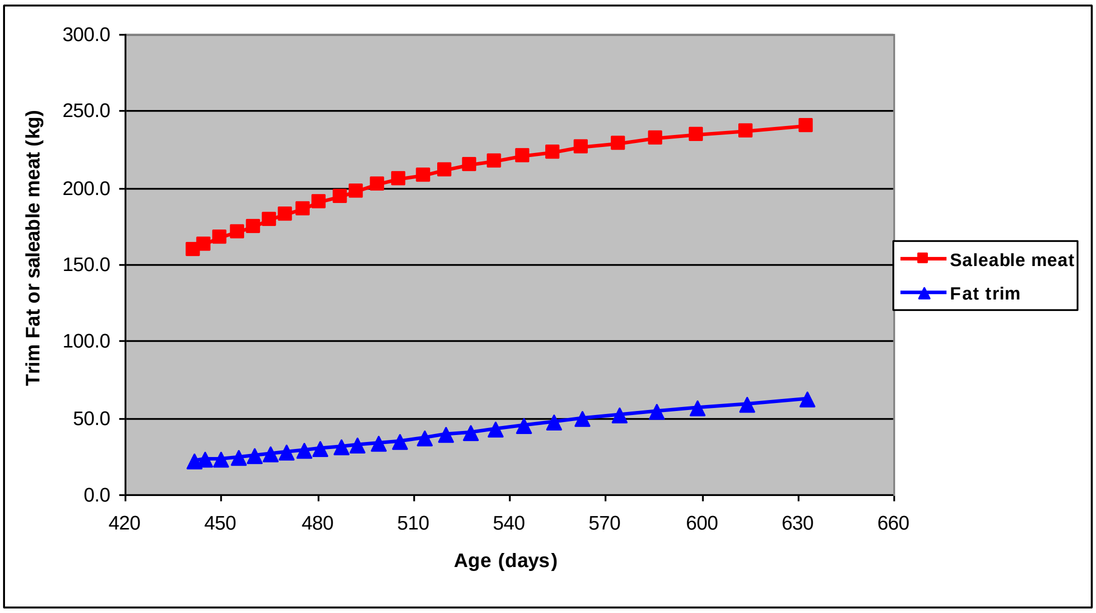


Figure 2.3 Change of fat trim and saleable meat depending on age of a medium breed of steers under an intensive feeding system

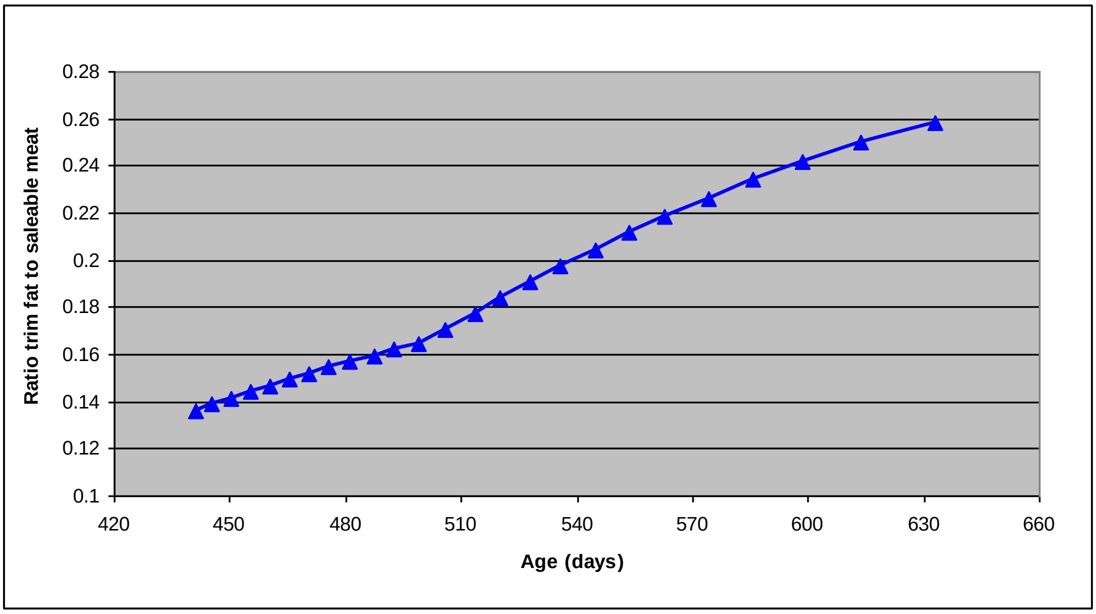


Figure 2.4 Change in the ratio of fat trim to saleable meat yield depending on age of a medium breed of steers under an intensive feeding system

The ratio of fat trim to saleable meat yield increase from 0.14 to 0.26 during growth from 440 to 630 days of age, i.e. that per 1 kg gain of saleable meat, the fat trim increased by 140 g and 260 g at 440 and 630 days of age, respectively. This indicates the substantial increase in fat tissue during the finishing phase of beef cattle. The slight break in the curve at 500 days of age is due to the methodology used for the transformation and is expected in reality to be smoother.

2.2 Lambs

For lambs the changes in saleable meat and fat trim were also derived based on changes of lipid and protein mass of the empty body during growth. The growth rate was determined using the Gompertz parameters as predicted by Lambe *et al.* (2006b) using the software provided by Bünger (personal communication). The scenario described here used the equations for female lambs as presented by ARC (1980) to predict the lipid and protein mass on the empty body weight. As for beef, the protein mass increased linearly whereas the lipid mass increased quadratically (Figure 2.5).

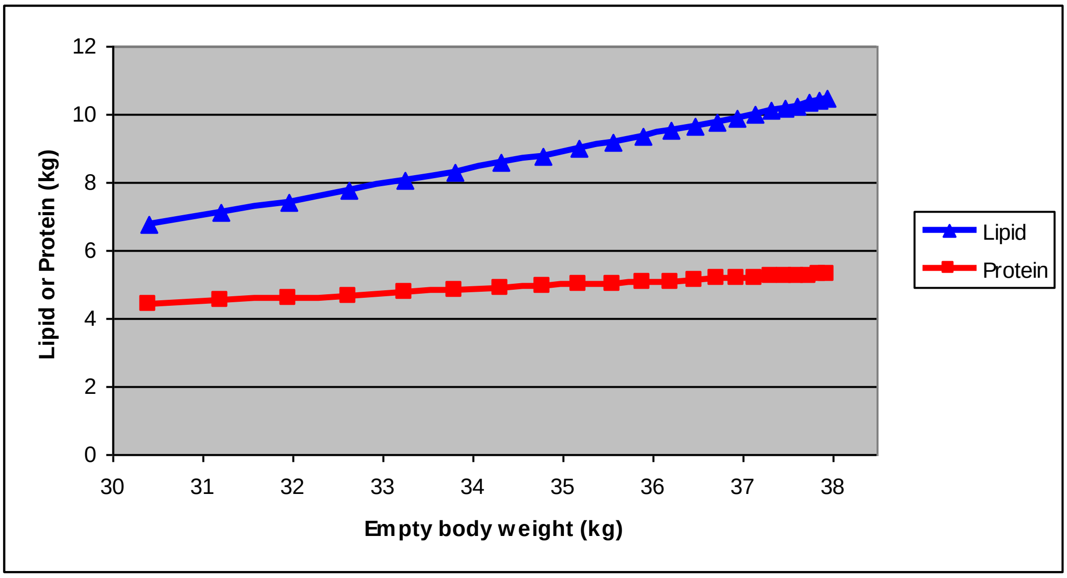


Figure 2.5 Development of lipid and protein mass in the empty body of female lambs

Based on data from the lamb VIA trial by EBLEX et al. (2007), the protein and lipid mass was transformed into fat trim and saleable meat (Figure 2.6). Due to the high water content in lean tissue in comparison to fat tissue, the transformed curves of saleable meat and fat trim are in magnitude substantially different from those of protein and lipid mass. In sheep, the amount of fat trim in comparison to saleable meat is substantially lower than in beef, so that its quadratic increase is not so obvious in Figure 2.6.

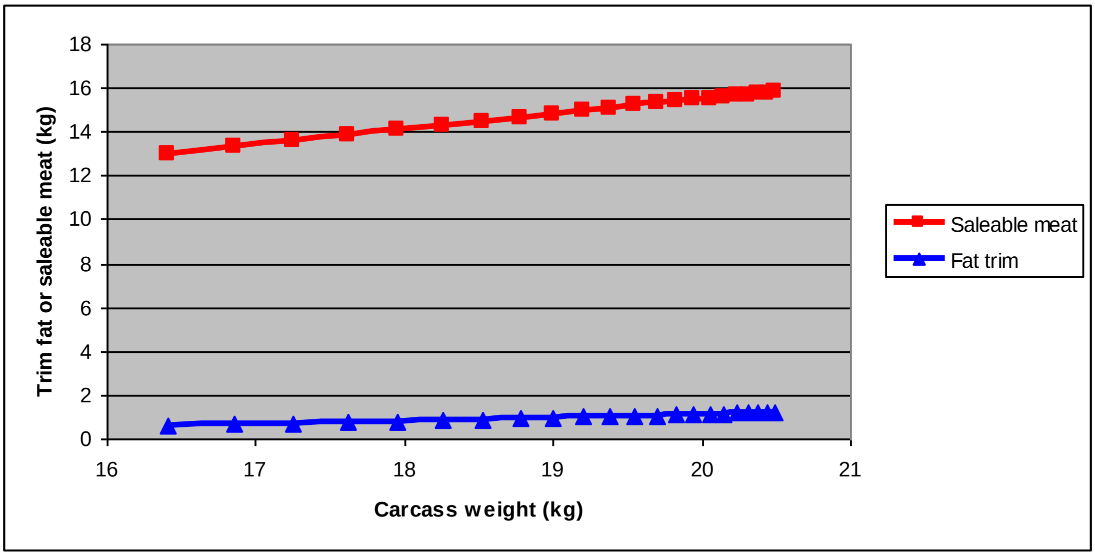


Figure 2.6 Change in fat trim and saleable meat depending on carcass weight of female lambs

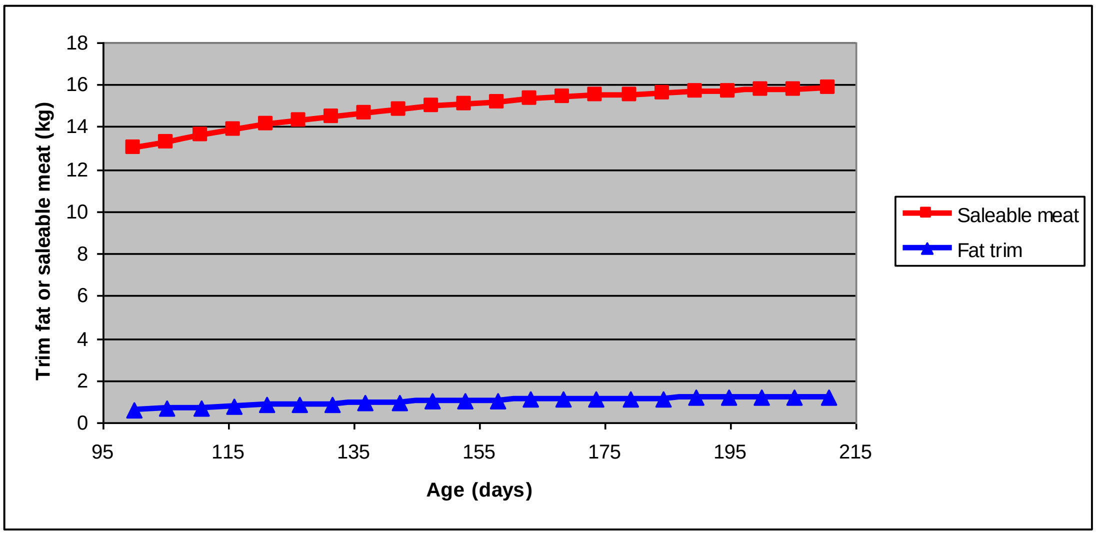


Figure 2.7 Change of fat trim and saleable meat depending on age of female lambs

Based on age, there is a decrease in growth rate of saleable meat (Figure 2.7). The ratio of fat trim to saleable meat changed from 0.048 at 100 days of age to 0.077 at 211 days of age, i.e. that per 1 kg gain of saleable meat, the fat trim increased by 48 g and 77 g at 100 and 211 days of age, respectively (Figure 2.8).

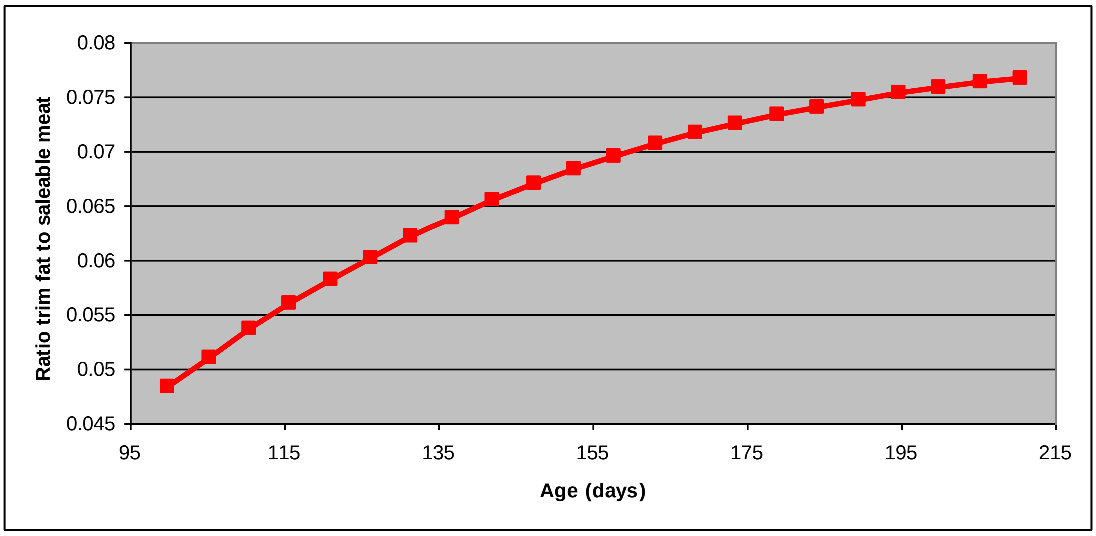


Figure 2.8 Change in the ratio of fat trim to saleable meat yield depending on age of female lambs

3. Energy requirements for lean and fat tissue growth

As shown in the previous section, body composition of an animal changes as it grows to maturity, with a gradual increase in the proportion of fat deposited and a decrease in the proportion of lean tissue growth. Since the object of this study is to assess the nutritional costs involved in growth and since water has no cost and lean tissue is essentially comprised of water and protein, this section will firstly examine the deposition of protein and lipid and secondly transform this into saleable meat yield and fat trim.

3.1 Growing cattle

The ARC (1980) and NRC (2000) provide equations that allow the calculation of protein and lipid deposition with increase in empty body weight (EBW) of the animal. In the case of the ARC (1980) the composition of the empty body of a castrated male of medium breed with a growth rate of 0.6 kg/d is predicted as:

$\log_{10}$ body protein /kg) = 0.8893$\log_{10}$EBW(kg)-0.5037
$\log_{10}$ body lipid /kg) = 1.788$\log_{10}$EBW(kg) -2.657

where EBW = live weight/1.08.

ARC (1980) then provides correction factors for protein and energy gains to allow for;
breed: small -10% for protein and + 15% for lipid; large +10% and -15%, respectively,
sex: female -10% for protein and +15% for lipid; entire male +10% and -15%, respectively, and rate of gain: for each 0.1 kg/d above 0.6 kg/d -1.3% for protein and +2% for lipid and below 0.6 kg/d +1/3% and -2%, respectively.

The NRC (2000) predicts weight of protein and lipid for castrates as:

protein (kg) = 0.235EBW(kg) – 0.00013EBW^2 – 2.418
lipid (kg) = 0.037EBW(kg) + 0.00054EBW^2 -0.610

where EBW = 0.891SBW and SBW is shrunk body weight and = 0.96 live weight.

The two sources of prediction of protein and lipid content are compared in Table 3.1:

Table 3.1 Protein and lipid content (kg) of the empty body of growing cattle.

EBW (kg)	Protein (kg)		Lipid (kg)	
	ARC	NRC	ARC	NRC
50	10.17	9.01	2.4	2.59
100	18.83	19.78	8.3	8.49
150	27.01	29.91	17.13	17.09
200	34.88	39.38	28.66	28.39
300	50.03	56.38	59.17	59.09
400	64.62	70.78	98.97	100.59
500	78.79	82.58	147.49	152.89

It is evident that, although the two sources derived their equations from different published data sets, there is fair agreement between them. This is especially the case for the amount of lipid, which is the pertinent component of this study.

3.2 Growing sheep

The ARC (1980) provides equations that allow the calculation of protein and lipid deposition with increase in empty body weight (EBW) of the animal. Separate equations are provided for protein growth of males (including castrates) and females and for lipid growth separately for males, castrates, females and merino castrates.

$\log_{10}\text{protein(kg)} = 0.8955\log_{10}\text{EBW} – 0.6451$ (males and castrates)
$\log_{10}\text{protein(kg)} = 0.8164\log_{10}\text{EBW} – 0.5660$ (females)

$\log_{10}\text{lipid (kg)} = 1.987\log_{10}\text{EBW} – 2.239$ (males)
$\log_{10}\text{lipid (kg)} = 1.821\log_{10}\text{EBW} – 1.918$ (castrates)
$\log_{10}\text{lipid (kg)} = 1.975\log_{10}\text{EBW} – 2.100$ (females)

Table 3.2 Protein and lipid content (kg) of the empty body of growing sheep

EBW (kg)	Protein (kg)		Lipid (kg)		
	Male	Female	Male	Castrate	Female
10	2.08	1.78	0.56	0.8	0.75
15	2.98	2.48	1.25	1.67	1.67
20	3.88	3.13	2.22	2.83	2.95
25	4.72	3.76	3.46	4.24	4.58
30	5.56	4.36	4.97	5.91	6.57
40	7.19	5.52	8.8	9.99	11.59

In both cattle and sheep the rate of protein gain decreases and lipid increases with increases in EBW as the animal approaches maturity. For example in cattle an increase of 100 kg in EBW from 200 to 300 kg results in an increase in body protein of 15.15 kg and of lipid of 30.51 kg whereas a 100 kg increase in EBW from 400 to 500 kg results in an increase of protein of 14.17 kg and of lipid of 48.52 kg. This has consequences for the calculation of the energy value of the gain (see below).

3.3 Energy requirements for lean tissue and fat growth

The energy values (gross energy) of protein and lipid are 23.6 and 39.3MJ/kg (ARC, 1980). Since lean tissue is about 80% water and only 20% protein, the energy value of lean tissue is considerable less than that of fat tissue. When considering the energy cost of tissue deposition it is the protein and lipid fractions that are relevant since water associated with the tissues has no energy cost. As the animal matures, the rate of lean tissue deposition decreases and fat tissue deposition increases (see section 2) and thus the energy deposited increases with increasing EBW. Both the ARC (1980) and the NRC (2000 and 2007) give equations for the energy value of gain that are based on body weight (W kg) and rate of gain (ΔW kg/d) but do not separate out requirements according to protein and lipid gain. Thus, the energy value of gain (EV_g) as calculated by the ARC (1980) for cattle is

$$EV_g\ (\text{MJ/kg}) = (4.1 + 0.0332W – 0.000009W^2)/(1 – 0.1475\Delta W)$$

The effect of W in the numerator reflects the curvilinear (linear and quadratic regression) increase in energy value as the animal grows and deposits more fat tissue as it reaches maturity. The effect of ΔW in the denominator is to give an increase in energy value as the rate of weight gain increases and again more fat tissue is deposited. These effects can be seen in the Table 3.3.

Table 3.3 Effect of weight (W kg) and rate of weight gain (ΔW kg/d) on energy value of gain (EV_g MJ/kg).

W (kg)	ΔW (kg/d)			
	0.6	0.8	1.0	1.2
200	11.39	11.77	12.18	12.61
300	14.54	15.02	15.54	16.1
400	17.49	18.07	18.7	19.37
500	20.24	20.92	21.64	22.42

The calculation of EV_g is then subject to the correction factors applied to fat gain according to breed type and sex, as presented above. The NRC (2000) includes standard reference weight for the expected final body fat in the calculation of net energy requirement for gain.

For weaned sheep the energy value of gain is (ARC, 1980)

EV_g (MJ/kg) = $2.5 + 0.35W$ entire males
$4.4 + 0.32W$ castrates
$2.1 + 0.45W$ females

and again the effect of W is to increase the energy value as the animal increases fatness as it approaches maturity. These effects can be seen in the Table 3.4.

Table 3.4 Effect of weight (W kg) on energy value of gain (EVg MJ/kg

W (kg)	Entire male	Castrate	Female
10	6.00	7.60	6.60
15	7.75	8.20	8.85
20	9.50	10.80	11.10
25	11.25	12.40	13.35
30	13.00	14.00	15.60
35	14.75	15.60	17.85
40	16.50	17.20	20.10

The NRC (2007) includes mature weight in the calculation of net energy requirement for gain as a means of varying fatness.

The energy requirements for gain are a function of the energy in the tissue and the efficiency of use of metabolisable energy (ME) for protein and fat gain. As seen above, the ARC (1980) calculation for EV_g combines the effects of reducing protein and increasing fat in the gain as the animal grows and separate calculations for protein gain and fat gain are not used. The calculation of requirements given by the NRC for cattle (NRC, 2000) and sheep (NRC, 2007) similarly do not differentiate between protein and fat gain.

Although the gross energy of protein is less than that of lipid, there is considerable turn over of body protein and this leads to a poorer efficiency of use of ME for protein deposition than for lipid deposition. As a consequence of this, the ME requirement for the two components is similar and variations in protein deposition and lipid deposition do not have a great effect on the overall efficiency of use of ME for gain (ARC, 1980). Therefore, energy requirement in this study have been formulated based on body weight and weight gain, assuming no differences in energy requirement of protein and lipid deposition. In ruminating cattle and sheep the efficiency of use of ME for growth and fattening (k_f) is a function of the ME concentration of the diet (ARC, 1980, AFRC, 1993).

4. Age dependent move through different fat and conformation classes

4.1 Finishing cattle

The age dependent move through different fat classes was based on the ARC (1980) equations described in section 3 for protein and lipid mass and presented for a medium breed of steers under an intensive feeding system in Table 4.1.

Table 4.1 Change in protein, lipid, fat trim and saleable meat during growth of a medium breed of steers under an intensive feeding system

LW kg	AGE days	Protein kg	Lipid kg	Fat trim %	SMY %	£ SMY £/day
400	436	-	-	-	-	-
410	441	61.7	90.1	9.3	68.1	-
420	445	63.0	94.1	9.5	68.1	3.28
430	450	64.3	98.1	9.6	68.1	2.62
440	455	65.7	102.3	9.8	68.1	2.62
450	460	67.0	106.5	10.0	68.1	2.62
460	465	68.3	110.7	10.2	68.1	2.62
470	471	69.6	115.1	10.3	68.1	2.62
480	476	71.0	119.5	10.5	68.1	2.62
490	481	72.3	124.0	10.7	68.1	2.62
500	487	73.6	128.5	10.9	68.1	2.19
510	493	74.9	133.2	11.0	68.1	2.63
520	499	76.2	137.9	11.2	68.1	2.19
530	506	77.5	142.6	11.6	67.8	1.82
540	513	78.8	147.5	12.0	67.6	1.54
550	520	80.1	152.4	12.4	67.4	1.77
560	528	81.4	157.4	12.8	67.1	1.49
570	536	82.7	162.5	13.2	66.9	1.47
580	545	84.0	167.6	13.6	66.6	1.27
590	554	85.3	172.8	14.0	66.4	1.25
600	563	86.5	178.1	14.5	66.1	1.23
610	574	87.8	183.4	14.9	65.8	0.96
620	586	89.1	188.8	15.3	65.6	0.95
630	599	90.4	194.3	15.8	65.3	0.84
640	614	91.6	199.8	16.2	65.0	0.70
650	633	92.9	205.5	16.7	64.7	0.56

The calculation was concentrated on the finishing period from 400 to 650 kg for which the information of fatness is of most importance within this study. The age distribution and the average daily gain was based on a finishing trial at SAC carried out on intensively finished animals from a rotational cross of Aberdeen Angus and Limousin. The growth efficiency was assumed to be 88% for the medium intensive breed. The growth efficiency was approximately derived from the mean growth performance of Hereford in comparison to Charolais as presented in Table A1 of the Annex. Based on the lipid distribution over weight, the percentages of fat trim were calculated using the mean fat trim of the specific breed, sex and finishing methods from the beef yield project (EBLEX, 2011). The classification grid was aligned to these percentages of fat trim based on the predicted distribution of percentages of fat trim over conformation and fat classes for Hereford (Table 6.10) and their crosses using estimated correction factors for gender (half of the differences of Tables 6.7 and 6.4 for heifers added and steers subtracted) and finishing system (half of the difference Tables 6.19 and 6.16 for extensive feeding added and for intensive feeding subtracted) obtained from the data of the beef yield project (EBLEX 2011). Based on this prediction, the change from R4L to R4H occurred when medium breed steers under an intensive feeding system were finished 39 days longer (Table 4.2). The corresponding difference for intensive finished medium breed heifers was 37 days (Table 4.3). Medium breed steers under an extensive feeding system resulted in a substantial longer period between R4L to R4H of 53 days (Table 4.4). For the corresponding scenario of heifers, the time period between R4L to R4H was only 51 days (Table 4.5), indicating the higher fat deposition rate of heifers in comparison the steers.

Large breeds and their crosses showed in comparison to corresponding scenarios in medium breeds in a lower fat trim percentage within the same carcass classification. Additionally, the growth period through move of R4L to R4H was for corresponding scenarios longer, i.e. 62 (39) days for a large breed of steers (heifers) under an intensive feeding system (Tables 4.6 and 4.7), 78 (58) days for a large breed of steers (heifers) under an extensive feeding system (Tables 4.8 and 4.9). Females showed a substantial higher fatness and a shorter growth period through the fatness classes, indicating their higher fat deposition rate.

Table 4.2 Number of days of growth to a higher fat class within conformation class and the resulting change in fat trim for a medium breed of steers under an intensive feeding system

Change in fat class		Number of	Change in fat trim	
from	to	Days	from (%)	to (%)
-U4L	-U4H	37	11.2	13.2
R4L	R4H	39	11.6	13.6
O+4L	O+4H	41	12.0	14.0
-O4L	-O4H	43	12.4	14.5
P4L	P4H	46	12.8	14.9

Table 4.3 Number of days of growth to a higher fat class within conformation class and the resulting change in fat trim for a medium breed of heifers under an intensive feeding system

Change in fat class		Number of	Change in fat trim	
from	to	Days	from (%)	to (%)
-U4L	-U4H	35	11.8	13.0
R4L	R4H	37	12.0	13.5
O+4L	O+4H	40	12.2	13.9
-O4L	-O4H	41	12.4	14.4
P4L	P4H	42	12.6	14.8

Table 4.4 Number of days of growth to a higher fat class within conformation class and the resulting change in fat trim for a medium breed of steers under an extensive feeding system

Change in fat class		Number of	Change in fat trim	
from	to	Days	from (%)	to (%)
-U4L	-U4H	62	11.3	12.8
R4L	R4H	53	11.6	13.3
O+4L	O+4H	57	11.8	13.7
-O4L	-O4H	60	12.0	14.1
P4L	P4H	64	12.4	14.6

Table 4.5 Number of days of growth to a higher fat class within conformation class and the resulting change in fat trim for a medium breed of heifers under an extensive feeding system

Change in fat class		Number of	Change in fat trim	
from	to	Days	from (%)	to (%)
-U4L	-U4H	49	11.5	13.8
R4L	R4H	51	12.0	14.3
O+4L	O+4H	55	12.4	14.8
-O4L	-O4H	55	12.9	15.3
P4L	P4H	59	13.6	15.8

Table 4.6 Number of days of growth to a higher fat class within conformation class and the resulting change in fat trim for a large breed of steers under an intensive feeding system

Change in fat class		Number of	Change in fat trim	
from	to	Days	from (%)	to (%)
-U4L	-U4H	53	9.5	11.0
R4L	R4H	62	9.8	11.3

Table 4.7 Number of days of growth to a higher fat class within conformation class and the resulting change in fat trim for a large breed of heifers under an intensive feeding system

Change in fat class		Number of	Change in fat trim	
from	to	Days	from (%)	to (%)
-U4L	-U4H	39	9.7	11.4
R4L	R4H	39	10.1	11.8
O+4L	O+4H	42	10.4	12.1
-O4L	-O4H	46	10.7	12.5
P4L	P4H	49	11.1	12.9

Table 4.8 Number of days of growth to a higher fat class within conformation class and the resulting change in fat trim for a large breed of steers under an extensive feeding system

Change in fat class		Number of	Change in fat trim	
from	to	Days	from (%)	to (%)
-U4L	-U4H	72	9.6	11.2
R4L	R4H	78	9.9	11.5
O+4L	O+4H	83	10.2	11.8
-O4L	-O4H	93	10.5	12.2
P4L	P4H	108	10.8	12.5

Table 4.9 Number of days of growth to a higher fat class within conformation class and the resulting change in fat trim for a large breed of heifers under an extensive feeding system

Change in fat class		Number of	Change in fat trim	
from	to	Days	from (%)	to (%)
-U4L	-U4H	56	10.0	11.6
R4L	R4H	58	10.2	12.0
O+4L	O+4H	62	10.6	12.4
-O4L	-O4H	64	10.9	12.8
P4L	P4H	68	11.3	13.2

4.2 Lambs

As for beef, the age dependent move through different fat classes was based on the ARC (1980) equations for lambs as described in section 3 for protein and lipid kg and presented for female lambs in Table 4.10. The growth rate was determined using the Gompertz parameters for the raw data estimated for Texel as predicted by Lambe *et al.* (2006b) using the software provided by Bünger (personal communication). This data fitted well the data from the lamb VIA trial of EBLEX *et al.* (2007). Based on the lipid distribution over weight, the percentages of fat trim were calculated using the mean fat trim of the specific gender obtained from the lamb VIA trial (EBLEX *et al.*, 2007). The classification grid was aligned to these fat trim based on the in section 6 predicted distribution of percentages of fat trim over conformation and fat classes for female lambs obtained from the data lamb VIA trial of EBLEX *et al.* (2007) and the results are presented in Table 4.11.

Table 4.10 Change in protein, lipid, fat trim and saleable meat during growth of female lambs

LW kg	AGE days	Protein kg	Lipid kg	Fat trim %	SMY %	£ SMY £/day
31.86	95	-	-	-	-	-
32.82	100	4.41	6.74	3.8	79.1	-
33.70	105	4.51	7.10	4.0	78.9	0.28
34.51	111	4.59	7.44	4.2	78.7	0.25
35.24	116	4.67	7.75	4.4	78.6	0.23
35.91	121	4.75	8.04	4.6	78.4	0.21
36.51	126	4.81	8.31	4.7	78.3	0.19
37.06	132	4.87	8.56	4.9	78.2	0.17
37.56	137	4.92	8.79	5.0	78.1	0.15
38.01	142	4.97	9.00	5.1	78.0	0.14
38.41	147	5.01	9.19	5.2	77.9	0.12
38.77	153	5.05	9.36	5.3	77.8	0.11
39.10	158	5.09	9.52	5.4	77.7	0.10
39.39	163	5.12	9.66	5.5	77.6	0.09
39.66	168	5.15	9.79	5.6	77.6	0.08
39.89	174	5.17	9.90	5.6	77.5	0.07
40.10	179	5.19	10.01	5.7	77.5	0.06
40.29	184	5.21	10.10	5.7	77.4	0.06
40.46	189	5.23	10.19	5.8	77.4	0.05
40.62	195	5.25	10.26	5.8	77.3	0.04
40.75	200	5.26	10.33	5.9	77.3	0.04
40.88	205	5.28	10.39	5.9	77.3	0.04
40.98	211	5.29	10.44	5.9	77.2	0.03

Table 4.11 Number of days of growth to a higher fat class and the resulting change in fat trim for female lambs

Change in fat class		Number of	Change in fat trim	
from	To	Days	from (%)	to (%)
2	3L	26	3.7	4.5
3L	3H	21	4.5	5.1
3H	4L	42	5.1	5.7
4L	4H	22	5.7	6.2

Table 4.12 Number of days of growth to a higher fat class and the resulting change in fat trim for castrated lambs

Change in fat class		Number of	Change in fat trim	
from	To	Days	from (%)	to (%)
2	3L	35	3.5	4.4
3L	3H	55	4.4	5.0

For female lambs, the time of growth from fat class 2 to 3L or 3H was 26 or 47 days, respectively. For castrated lambs, corresponding time of growth from fat class 2 to 3L or 3H was 35 to 90 days, indicating the higher fat deposition of female lambs.

5. Feed wasted over a range of carcass classifications

5.1 Finishing cattle

To calculate the feed wasted and the cost involved with the feed, ration and their cost have been developed specifically for the different beef scenarios. The cost of feed used was silage £25/t, barley £160/t, rapeseed meal £200/t, straw £60/t (included at 0.12 x dry matter intake in the intensive finishing system), intensive mineral and vitamin supplement £350/t (included at 120 g/d in the intensive finishing system) general purpose mineral and vitamin supplement £400/t (included at 80g/d in extensive finishing system). To obtain the profit only the higher return for growth of saleable meat yield (£3.4/kg) and the costs for feed (including the feed costs associated with maintenance requirements) have been considered, i.e. the return for fat tissue and other costs in involved in production have not been considered. A full economic analysis was beyond this study. For steers of a medium-sized breed in an intensive feeding system, total feed energy required during growth from fat class R4L and R4H was 4760 MJ/class with feed cost of £71.93 and return of £60.56 for saleable meat yield and a deficit of £11.37 excluding all other returns and costs (Table 5.1). The feed costs include the maintenance costs involved in moving from one class to the next i.e. daily energy or feed cost multiplied by the number of days. Return for saleable meat was kept constant at £3.4/kg, which in practice reduces with poorer classes. This has not been considered because of the variability of prices at different fat classes but can be easily considered by multiply the return of saleable meat by the new price divided by 3.4. Therefore, the results can be easily adjusted to specific price conditions so that the presented results can be used as basis for very flexible profit calculations. For a move from class R4L to R4H, the profit was £-11.37 and £37.07

for medium-sized breeds of steers under intensive and extensive feeding system, respectively (Tables 5.1 and 5.3). This indicates that medium beef breeds can be kept under extensive feeding system longer profitable; even in high fat classes due to the lower feed costs (including the feed costs associated with maintenance requirements). Under intensive feeding system the optimisation of the finishing conditions is very important to obtain no deficit. The lower deficit of heifers compared to steers under intensive feeding systems at corresponding classes is slightly misleading, because heifers have a much lower body weight at the same class associated with substantially lower maintenance requirements (Tables 5.1 and 5.2). However, under extensive feeding systems, the profit of steers was always higher than for heifers (Tables 5.3 and 5.4) indicating the reduced feed costs due to lower fat deposition of steers more than offset the lower feed costs due to less maintenance requirements of heifers as result of their lower body weight at corresponding conformation and fat classes.

For large breeds, the move from class R4L to R4H resulted in a profit of £-19.44 and £29.23 for steers under intensive and extensive feeding system, respectively (Tables 5.5 and 5.8). This indicates that for large breeds the optimisation of the finishing conditions are even more important than for medium-sized breeds.

Table 5.1 Feed metabolic energy (MJ), feed cost, income for saleable meat (SMY) and profit occurring during growth to a higher fat class within conformation for a medium breed of steers under an intensive feeding system

Change in fat class from	to	Feed energy MJ	Feed cost £	SMY £	Profit £
-U4L	-U4H	4629	69.90	61.24	-8.66
R4L	R4H	4760	71.93	60.56	-11.37
O+4L	O+4H	4840	73.24	58.88	-14.36
-O4L	-O4H	4967	75.27	59.27	-16.00
P4L	P4H	5191	78.72	59.18	-19.54

Table 5.2 Feed metabolic energy (MJ), feed cost, income for saleable meat (SMY) and profit occurring during growth to a higher fat class within conformation for a medium breed of heifers under an intensive feeding system

Change in fat class from	to	Feed energy MJ	Feed cost £	SMY £	Profit £
-U4L	-U4H	5868	88.31	77.71	-10.60
P4L	P4H	5921	89.11	74.14	-14.97

Table 5.3 Feed metabolic energy (MJ), feed cost, income for saleable meat (SMY) and profit occurring during growth to a higher fat class within conformation for a medium breed of steers under an extensive feeding system

Change in fat class from	to	Feed energy MJ	Feed cost £	SMY £	Profit £
-U4L	-U4H	6553	76.33	129.88	53.55
R4L	R4H	5668	65.08	102.15	37.07
O+4L	O+4H	5992	67.54	101.85	34.31
-O4L	-O4H	6225	70.03	94.88	24.85
P4L	P4H	6614	73.65	93.45	19.80

Table 5.4 Feed metabolic energy (MJ), feed cost, income for saleable meat (SMY) and profit occurring during growth to a higher fat class within conformation for a medium breed of heifers under an extensive feeding system

Change in fat class from	to	Feed energy MJ	Feed cost £	SMY £	Profit £
-U4L	-U4H	5413	66.10	90.80	24.70
R4L	R4H	5638	68.02	92.41	24.39
O+4L	O+4H	6037	71.43	93.50	22.07
-O4L	-O4H	6126	72.45	88.87	16.42
P4L	P4H	6520	75.93	93.39	17.46

Table 5.5 Feed metabolic energy (MJ), feed cost, income for saleable meat (SMY) and profit occurring during growth to a higher fat class within conformation for a large breed of steers under an intensive feeding system

Change in fat class from	to	Feed energy MJ	Feed cost £	SMY £	Profit £
-U4L	-U4H	5247	79.81	66.47	-13.34
R4L to	R4H	5736	87.39	67.95	-19.44

Table 5.6 Feed metabolic energy (MJ), feed cost, income for saleable meat (SMY) and profit occurring during growth to a higher fat class within conformation for a large breed of heifers under an intensive feeding system

Change in fat class from	to	Feed energy MJ	Feed cost £	SMY £	Profit £
-U4L	-U4H	4711	71.18	67.68	-3.50
R4L	R4H	4790	72.45	66.13	-6.32
O+4L	O+4H	4856	73.6	66.87	-6.73
-O4L	-O4H	5076	76.97	67.14	-9.83
P4L	P4H	5291	80.27	66.86	-13.41

Table 5.7 Feed metabolic energy (MJ), feed cost, income for saleable meat (SMY) and profit occurring during growth to a higher fat class within conformation for a large breed of steers under an extensive feeding system

Change in fat class from	to	Feed energy MJ	Feed cost £	SMY £	Profit £
-U4L	-U4H	7087	75.22	109.71	34.49
R4L	R4H	7614	80.23	109.46	29.23
O+4L	O+4H	8115	84.79	108.52	23.73
-O4L	-O4H	8892	91.72	110.11	18.39
P4L	P4H	10104	102.27	112.37	10.10

Table 5.8 Feed metabolic energy (MJ), feed cost, income for saleable meat (SMY) and profit occurring during growth to a higher fat class within conformation for a large breed of heifers under an extensive feeding system

Change in fat class from	to	Feed energy MJ	Feed cost £	SMY £	Profit £
-U4L	-U4H	6030	69.12	111.96	42.84
R4L	R4H	6229	70.63	105.86	35.23
O+4L	O+4H	6559	73.25	105.35	32.10
-O4L	-O4H	6781	75.55	102.77	27.22
P4L	P4H	7105	78.25	103.76	25.51

5.2 Lambs

To calculate the feed wasted and the cost involved with the feed, ration and their cost have been developed specifically for female and castrated lambs. The cost of feed used was silage £25/t, barley £160/t, soya bean meal £300/t, and mineral and vitamin supplement £400/t at 10 g/d. To obtain the profit only the higher return for growth of saleable meat yield (£4.4/kg) and the costs for feed have been considered, i.e. the return for fat tissue and other costs in involved in production have not been considered. Total feed energy required for growth from fat class 3L to 3H was 468 MJ/class with a cost of £5.50 and return of £5 for saleable meat yield and a deficit of £0.50 excluding all other returns and costs. The return for saleable meat was kept constant at £4.4/kg, which in practice reduces with poorer classes. This has not been considered because of the variability of prices at different fat classes but can be easily considered by multiply the return of saleable meat by the new price divided by 4.4. Therefore, the results can be easily adjusted to specific price conditions so that the presented results can be used as basis for very flexible profit calculations. For castrated lambs, the move from fat class 3L to 3H resulted in a deficit of £0.50, whereas the corresponding profit for female lambs was £0.73 (Tables 5.9 to 5.10). However, in the used data from the VIA trial (EBLEX *et al.* 2007), the weight of castrated lambs was 2 kg higher in equivalent fat classes, so that the difference in maintenance requirement at different body weight was the reason for the difference between gender.

Table 5.9 Feed metabolic energy (MJ), feed cost, income for saleable meat (SMY) and profit occurring during growth to a higher fat class for castrated lambs

Change in fat class from	to	Feed energy MJ	Feed cost £	SMY £	Profit £
2	3L	253	4.9	7.42	2.52
3L	3H	468	5.5	5	-0.5

Table 5.10 Feed metabolic energy (MJ), feed cost, income for saleable meat (SMY) and profit occurring during growth to a higher fat class for female lambs

Change in fat class from	to	Feed energy MJ	Feed cost £	SMY £	Profit £
2	3L	289	3.9	6.07	2.17
3L	3H	206	2.52	3.25	0.73
3H	4L	370	4.2	3.62	-0.58
4L	4H	178	1.98	0.91	-1.07

6. Fat trim for a range of carcass classifications

6.1 Finishing beef

The fat trimmed for a range of carcass classifications was predicted from data of the beef yield project of EBLEX (2011). The data included carcasses from the major beef breeds of both sexes and the age at slaughter of the animals. The data comprises of 149 beef sides dissected into trimmed primals providing the information of percentages of total saleable meat yield, percentage of total fat trim and percentage of total bone and waste of the carcass side. The data provided a good representation of carcasses in the central portion of the classification grid (-U2 to –O4H).

Regression analysis was carried out to predict the fat trim over a range of carcass classifications. To enable the regression analysis, EUROP conformation classes were converted to a 15 point scale and the fat classes to Sfe classes as published by Kempster *et al.* (1986). For the majority of carcasses the UK dressing specification was used except for a minority the EU dressing specification. For the latter the side weight was corrected to the UK dressing specification and the total fat trim adjusted accordingly using the coefficients published in Annex III of Commission Regulation 1249/2008. The final regression model consisted of converted conformation (15 point scale), converted fat classes (Sfe) and adjusted carcass side weight.

Based on the regression analysis the following percentages of fat trim over the conformation and fat classes has been predicted for the entire data with an average carcass weight of 144.6 kg (Table 6.1) as well as for carcass weights one standard deviation above and below this mean (Tables 6.2 and 6.3). The results indicate that the percentage of fat trim mainly increases with fat class and slightly increase with conformation class. With increase (decrease) in carcass weight by one standard deviation, the percentage of fat trim in each class increased (decreased) by on average 0.4 (0.5)% compared to carcasses at mean weight (Table 6.2 vs. 6.1).

Table 6.1 Total percentage fat trim across the classification grid for an average side weight of 144.6 kg in beef using the whole data (EBLEX Report, 2011)[a]

Conformation class	Fat class			
	2	3	4L	4H
-U	4.9	8.4	11.1	12.9
R	5.2	8.8	11.4	13.2
O+	5.6	9.1	11.7	13.5
-O	5.8	9.4	12.0	13.8
P	6.0	9.6	12.2	14.0

[a)] Model: fat trim = -1.89 – 0.111 C15 + 1.18 Sfe + 0.0308 adjCSW

Table 6.2 Total percentage fat trim across the classification grid for an average side weight of 159.2 kg (mean +1 SD) in beef using the whole data[a]

Conformation class	Fat class			
	2	3	4L	4H
-U	5.3	8.9	11.5	13.3
R	5.7	9.2	11.9	13.6
O+	6.0	9.5	12.2	14.0
-O	6.3	9.8	12.5	14.2
P	6.4	10.0	12.6	14.4

a) Model: fat trim = -1.89 – 0.111 C15 + 1.18 Sfe + 0.0308 adjCSW

Table 6.3 Total percentage fat trim across the classification grid for an average side weight of 130 kg (mean -1 SD) in beef using the whole data

Conformation class	Fat class			
	2	3	4L	4H
-U	4.4	8.0	10.6	12.4
R	4.8	8.3	11.0	12.7
O+	5.1	8.6	11.3	13.1
-O	5.4	8.9	11.6	13.3
P	5.5	9.1	11.7	13.5

a) Model: fat trim = -1.89 – 0.111 C15 + 1.18 Sfe + 0.0308 adjCSW

6.1.1 Sex effect on fat trim in finishing cattle

Differences between the sexes level of fat trim were observed for finishing cattle, with the heifers showing a greater proportion of fat trim than steers (Tables 6.4 and 6.7). This difference was expected as studies presented in the literature review (section 1) followed a similar pattern. However the observed sex differences were smaller compared to those reported in the literature. This will mainly be due to the fact that the complete data set was used in this analysis, so that a variety of different breeds, ages and feeding systems influencing the results. In addition, heifers showed on average 5.1 kg less weight than steers. The average differences in fat trim between sexes were 0.23%, with greatest difference of 0.7% at the highest obtained fat classes (4H) of the best obtained conformation class (-U). Similar pattern of difference were obtained for prediction of fat trim with increased (decreased) body weight by on standard deviation from the mean (Tables 6.5, 6.6, 6.8 and 6.9).

Table 6.4 Total percentage fat trim across the classification grid for an average side weight of 147.7 kg in steers[a]

Conformation class	Fat class			
	2	3	4L	4H
-U	4.6	8.0	10.5	12.2
R	5.1	8.5	11.0	12.7
O+	5.7	9.0	11.5	13.2
-O	6.1	9.5	12.0	13.7
P	6.4	9.7	12.2	13.9

a) Model: fat trim = -1.56 -0.175 C15+ 1.12 Sfe + 0.0321 adjCSW

Table 6.5 Total percentage fat trim across the classification grid for an average side weight of 163.9 kg (mean +1 SD) in steers[a]

Conformation class	Fat class			
	2	3	4L	4H
-U	5.1	8.5	11.0	12.7
R	5.7	9.0	11.5	13.2
O+	6.2	9.5	12.1	13.7
-O	6.6	10.0	12.5	14.2
P	6.9	10.2	12.8	14.4

a) Model: fat trim = -1.56 -0.175 C15+ 1.12 Sfe + 0.0321 adjCSW

Table 6.6 Total percentage fat trim across the classification grid for an average side weight of 131.5 kg (mean -1 SD) in steers[a]

Conformation class	Fat class			
	2	3	4L	4H
-U	4.1	7.5	10.0	11.7
R	4.6	8.0	10.5	12.2
O+	5.1	8.5	11.0	12.7
-O	5.6	8.9	11.5	13.1
P	5.8	9.2	11.7	13.4

a) Model: fat trim = -1.56 -0.175 C15+ 1.12 Sfe + 0.0321 adjCSW

Table 6.7 Total percentage fat trim across the classification grid for an average side weight of 142.6 kg in heifers[a]

Conformation class	Fat class			
	2	3	4L	4H
-U	4.8	8.4	11.1	12.9
R	5.2	8.8	11.5	13.3
O+	5.6	9.2	11.9	13.6
-O	5.9	9.5	12.2	14.0
P	6.1	9.7	12.4	14.2

a) Model: fat trim = -2.38 -0.128 C15+ 1.19 Sfe + 0.0355 adjCSW

Table 6.8 Total percentage fat trim across the classification grid for an average side weight of 156.3 kg (mean +1 SD) in heifers[a]

Conformation class	Fat class			
	2	3	4L	4H
-U	5.3	8.9	11.6	13.4
R	5.7	9.3	12.0	13.7
O+	6.1	9.7	12.3	14.1
-O	6.4	10.0	12.7	14.5
P	6.6	10.2	12.9	14.6

a) Model: fat trim = -2.38 -0.128 C15+ 1.19 Sfe + 0.0355 adjCSW

Table 6.9 Total percentage fat trim across the classification grid for an average side weight of 128.8 kg (mean -1 SD) in heifers[a]

Conformation class	Fat class			
	2	3	4L	4H
-U	4.4	7.9	10.6	12.4
R	4.7	8.3	11.0	12.8
O+	5.1	8.7	11.4	13.2
-O	5.4	9.0	11.7	13.5
P	5.6	9.2	11.9	13.7

[a)] Model: fat trim = -2.38 -0.128 C15+ 1.19 Sfe + 0.0355 adjCSW

6.1.2 Breed effect on fat trim in finishing cattle

The differences between Hereford and Charolais in percentage of fat trim across classification grid are presented in Tables 6.10 to 6.15. At mean weight, Hereford showed a higher increase in fat trim percentage with increased fat class than Charolais (Tables 6.10 and 6.13). Moreover, the magnitude of the percentages of fat trim of Hereford at high fat classes 4L and 4H were higher than in corresponding classes of Charolais. For example Hereford showed at fat class 4H 0.8 to 2.4% more fat than Charolais with decrease in conformation classes. A further difference between breeds was that in Hereford the percentage of fat trim slightly increased with decrease in conformation class, whereas in Charolais the opposite was obtained.

Table 6.10 Total percentage fat trim across the classification grid for an average side weight of 143.3 kg in Hereford[a]

Conformation class	Fat class			
	2	3	4L	4H
-U	5.1	8.8	11.5	13.4
R	5.3	9.0	11.8	13.6
O+	5.5	9.2	12.0	13.8
-O	5.7	9.4	12.1	14.0
P	5.8	9.5	12.2	14.1

[a)] Model: fat trim = -2.50 - 0.0711 C15+ 1.23 Sfe + 0.0326 adjCSW

Table 6.11 Total percentage fat trim across the classification grid for an average side weight of 160.1 kg (mean +1 SD) in Hereford[a]

Conformation class	Fat class			
	2	3	4L	4H
-U	5.6	9.3	12.1	13.9
R	5.8	9.5	12.3	14.1
O+	6.1	9.7	12.5	14.4
-O	6.2	9.9	12.7	14.5
P	6.3	10.0	12.8	14.6

[a)] Model: fat trim = -2.50 - 0.0711 C15+ 1.23 Sfe + 0.0326 adjCSW

Table 6.12 Total percentage fat trim across the classification grid for an average side weight of 126.5 kg (mean -1 SD) in Hereford[a]

Conformation class	Fat class			
	2	3	4L	4H
-U	4.5	8.2	11.0	12.8
R	4.7	8.4	11.2	13.0
O+	5.0	8.6	11.4	13.3
-O	5.1	8.8	11.6	13.4
P	5.2	8.9	11.7	13.5

a) Model: fat trim = -2.50 - 0.0711 C15+ 1.23 Sfe + 0.0326 adjCSW

Table 6.13 Total percentage fat trim across the classification grid for an average side weight of 140.1 kg in Charolais[a]

Conformation class	Fat class			
	2	3	4L	4H
-U	6.2	9.0	11.2	12.6
R	5.9	8.8	10.9	12.3
O+	5.6	8.5	10.6	12.0
-O	5.4	8.2	10.4	11.8
P	5.3	8.1	10.2	11.7

a) Model: fat trim = 1.29 + 0.093 C15 + 0.948 Sfe + 0.0074 adjCSW

Table 6.14 Total percentage fat trim across the classification grid for an average side weight of 153.9 kg (mean +1 SD) in Charolais

Conformation class	Fat class			
	2	3	4L	4H
-U	6.3	9.1	11.3	12.7
R	6.0	8.9	11.0	12.4
O+	5.7	8.6	10.7	12.1
-O	5.5	8.3	10.5	11.9
P	5.4	8.2	10.3	11.8

a) Model: fat trim = 1.29 + 0.093 C15 + 0.948 Sfe + 0.0074 adjCSW

Table 6.15 Total percentage fat trim across the classification grid for an average side weight of 126.2 kg (mean -1 SD) in Charolais[a]

Conformation class	Fat class			
	2	3	4L	4H
-U	6.1	8.9	11.1	12.5
R	5.8	8.7	10.8	12.2
O+	5.5	8.4	10.5	11.9
-O	5.3	8.1	10.3	11.7
P	5.2	8.0	10.1	11.6

a) Model: fat trim = 1.29 + 0.093 C15 + 0.948 Sfe + 0.0074 adjCSW

6.1.3 *Feeding system effect on fat trim in finishing cattle*

The differences between intensive and extensive feeding systems are presented in Tables 6.16 to 6.21. At mean weight, the intensive fed animals showed slightly less fat trim percentages than the extensive fed animals (Tables 6.16 and 6.19). The differences were partly due to different mean weights, which were 139.8 kg and 147.8 kg for intensively and extensively fed animals respectively.

Table 6.16 Total percentage fat trim across the classification grid for an average side weight of 139.8 kg in an intensive feeding system[a]

Conformation class	Fat class			
	2	3	4L	4H
-U	4.8	8.4	11.1	12.9
R	5.0	8.6	11.3	13.1
O+	5.2	8.8	11.5	13.3
-O	5.4	9.0	11.7	13.5
P	5.5	9.1	11.8	13.6

a) Model: fat trim = -1.39 - 0.0659 C15 + 1.20 Sfe + 0.0239 adjCSW

Table 6.17 Total percentage fat trim across the classification grid for an average side weight of 151.4 kg (mean +1 SD) in an intensive feeding system[a]

Conformation class	Fat class			
	2	3	4L	4H
-U	5.1	8.7	11.4	13.2
R	5.3	8.9	11.6	13.4
O+	5.5	9.1	11.8	13.6
-O	5.7	9.3	12.0	13.8
P	5.8	9.4	12.1	13.9

a) Model: fat trim = -1.39 - 0.0659 C15 + 1.20 Sfe + 0.0239 adjCSW

Table 6.18 Total percentage fat trim across the classification grid for an average side weight of 128.2 kg (mean -1 SD) in an intensive feeding system[a]

Conformation class	Fat class			
	2	3	4L	4H
-U	4.5	8.1	10.8	12.6
R	4.7	8.3	11.0	12.8
O+	4.9	8.5	11.2	13.0
-O	5.1	8.7	11.4	13.2
P	5.2	8.8	11.5	13.3

a) Model: fat trim = -1.39 - 0.0659 C15 + 1.20 Sfe + 0.0239 adjCSW

Table 6.19 Total percentage fat trim across the classification grid for an average side weight of 147.8 kg in an extensive feeding system[a]

Conformation class	Fat class			
	2	3	4L	4H
-U	5.2	8.7	11.3	13.0
R	5.5	9.0	11.6	13.4
O+	5.9	9.4	12.0	13.7
-O	6.2	9.6	12.2	14.0
P	6.3	9.8	12.4	14.1

[a)] Model: fat trim = - 1.84 - 0.111 C15 + 1.16 Sfe + 0.0324 adjCSW

Table 6.20 Total percentage fat trim across the classification grid for an average side weight of 161.1 kg (mean +1 SD) in an extensive feeding system[a]

Conformation class	Fat class			
	2	3	4L	4H
-U	5.6	9.1	11.7	13.5
R	6.0	9.5	12.1	13.8
O+	6.3	9.8	12.4	14.1
-O	6.6	10.1	12.7	14.4
P	6.7	10.2	12.8	14.6

[a)] Model: fat trim = - 1.84 - 0.111 C15 + 1.16 Sfe + 0.0324 adjCSW

Table 6.21 Total percentage fat trim across the classification grid for an average side weight of 134.5 kg (mean -1 SD) in an extensive feeding system[a]

Conformation class	Fat class			
	2	3	4L	4H
-U	4.8	8.3	10.9	12.6
R	5.1	8.6	11.2	12.9
O+	5.4	8.9	11.5	13.3
-O	5.7	9.2	11.8	13.6
P	5.9	9.4	12.0	13.7

[a)] Model: fat trim = - 1.84 - 0.111 C15 + 1.16 Sfe + 0.0324 adjCSW

6.2 Sheep

6.2.1 Fat trim in lambs

The distribution of total percentage fat trim across the classification grid is presented for the entire sheep data in Table 6.22. With increase in fat class from 1 to 5 the fat trim percentages increased by 4.7%. In contrast, with decrease in conformation classes from E to P, the fat trim increased by only 0.4%. An increase (decrease) in weight by one standard deviation increased (decreased) the fat trim percentages slightly (Tables 6.23 and 6.24).

Table 6.22 Total percentage fat trim across the classification grid at carcass weight of 19.6 kg in lambs using the whole data[a]

Conformation class	Fat class						
	1	2	3L	3H	4L	4H	5
E	2.13	3.31	4.19	4.78	5.37	5.96	6.85
U	2.23	3.41	4.29	4.88	5.47	6.06	6.95
R	2.33	3.51	4.40	4.99	5.58	6.17	7.05
O	2.44	3.62	4.50	5.09	5.68	6.27	7.16
P	2.54	3.72	4.61	5.20	5.79	6.38	7.26

a) Model: fat trim = 1.11 - 0.104 C15 + 0.295 Sfe + 0.0181 CW

Table 6.23 Total percentage fat trim across the classification grid for a carcass weight of 23.7 kg (mean +1 SD) in lambs using the whole data[a]

Conformation class	Fat class						
	1	2	3L	3H	4L	4H	5
E	2.20	3.38	4.26	4.85	5.44	6.03	6.92
U	2.30	3.48	4.37	4.96	5.55	6.14	7.02
R	2.41	3.59	4.47	5.06	5.65	6.24	7.13
O	2.51	3.69	4.58	5.17	5.76	6.35	7.23
P	2.61	3.79	4.68	5.27	5.86	6.45	7.33

a) Model: fat trim = 1.11 - 0.104 C15 + 0.295 Sfe + 0.0181 CW

Table 6.24 Total percentage fat trim across the classification grid for a carcass weight of 15.6 kg (mean -1 SD) in lambs using the whole data[a]

Conformation class	Fat class						
	1	2	3L	3H	4L	4H	5
E	2.05	3.23	4.12	4.71	5.30	5.89	6.77
U	2.16	3.34	4.22	4.81	5.40	5.99	6.88
R	2.26	3.44	4.33	4.92	5.51	6.10	6.98
O	2.36	3.54	4.43	5.02	5.61	6.20	7.08
P	2.47	3.65	4.53	5.12	5.71	6.30	7.19

a) Model: fat trim = 1.11 - 0.104 C15 + 0.295 Sfe + 0.0181 CW

6.2.2 *Sex effect on fat trim in lambs*

The differences between the sexes in level of fat trim were depending on conformation class. In conformation class E, the male lambs showed on average of all fat classes a 0.44% point higher fat trim than females (Table 6.25 vs. Table 6.28). This difference reduced gradually with lower conformation classes and even changed in higher fat trim of females at an average of 0.72% in conformation class P. The increase in fat trim from fat class 1 to 5 was similar in both sexes at about 4.6%.

Table 6.25 Total percentage fat trim across the classification grid for a carcass weight of 19.9 kg in male lambs[a]

Conformation class	Fat class						
	1	2	3L	3H	4L	4H	5
E	2.25	3.42	4.30	4.88	5.46	6.05	6.92
U	2.29	3.46	4.33	4.92	5.50	6.08	6.96
R	2.33	3.49	4.37	4.95	5.54	6.12	7.00
O	2.36	3.53	4.41	4.99	5.57	6.16	7.03
P	2.40	3.57	4.44	5.03	5.61	6.20	7.07

[a)] Model: fat trim =1.05 - 0.0370 C15 + 0.292 Sfe + 0.0110 CW

Table 6.26 Total percentage fat trim across the classification grid for a carcass weight of 23.8 kg (mean +1 SD) in male lambs[a]

Conformation class	Fat class						
	1	2	3L	3H	4L	4H	5
E	2.29	3.46	4.34	4.92	5.51	6.09	6.97
U	2.33	3.50	4.38	4.96	5.54	6.13	7.00
R	2.37	3.54	4.41	5.00	5.58	6.16	7.04
O	2.41	3.57	4.45	5.03	5.62	6.20	7.08
P	2.44	3.61	4.49	5.07	5.65	6.24	7.11

[a)] Model: fat trim =1.05 - 0.0370 C15 + 0.292 Sfe + 0.0110 CW

Table 6.27 Total percentage fat trim across the classification grid for a carcass weight of 16.0kg (mean -1 SD) in male lambs[a]

Conformation class	Fat class						
	1	2	3L	3H	4L	4H	5
E	2.21	3.38	4.25	4.84	5.42	6.01	6.88
U	2.25	3.41	4.29	4.87	5.46	6.04	6.92
R	2.28	3.45	4.33	4.91	5.50	6.08	6.96
O	2.32	3.49	4.36	4.95	5.53	6.12	6.99
P	2.36	3.53	4.40	4.99	5.57	6.15	7.03

[a)] Model: fat trim =1.05 - 0.0370 C15 + 0.292 Sfe + 0.0110 CW

Table 6.28 Total percentage fat trim across the classification grid for a carcass weight of 19.2 kg in female lambs[a]

Conformation class	Fat class						
	1	2	3L	3H	4L	4H	5
E	1.87	3.01	3.87	4.44	5.01	5.58	6.43
U	2.20	3.34	4.20	4.77	5.34	5.91	6.76
R	2.53	3.67	4.52	5.09	5.66	6.23	7.09
O	2.85	3.99	4.85	5.42	5.99	6.56	7.41
P	3.18	4.32	5.17	5.74	6.31	6.88	7.74

a) Model: fat trim = 1.45 - 0.326 C15 + 0.285 Sfe + 0.0476 CW

Table 6.29 Total percentage fat trim across the classification grid for a carcass weight of 23.4 kg (mean +1 SD) in female lambs[a]

Conformation class	Fat class						
	1	2	3L	3H	4L	4H	5
E	2.07	3.21	4.07	4.64	5.21	5.78	6.63
U	2.40	3.54	4.39	4.96	5.53	6.10	6.96
R	2.72	3.86	4.72	5.29	5.86	6.43	7.28
O	3.05	4.19	5.05	5.62	6.19	6.76	7.61
P	3.38	4.52	5.37	5.94	6.51	7.08	7.94

a) Model: fat trim = 1.45 - 0.326 C15 + 0.285 Sfe + 0.0476 CW

Table 6.30 Total percentage fat trim across the classification grid for an carcass weight of 15.1 kg (mean -1 SD) in female lambs[a]

Conformation Class	Fat class						
	1	2	3L	3H	4L	4H	5
E	1.68	2.82	3.67	4.24	4.81	5.38	6.24
U	2.00	3.14	4.00	4.57	5.14	5.71	6.56
R	2.33	3.47	4.32	4.89	5.46	6.03	6.89
O	2.65	3.79	4.65	5.22	5.79	6.36	7.21
P	2.98	4.12	4.98	5.55	6.12	6.69	7.54

a) Model: fat trim = 1.45 - 0.326 C15 + 0.285 Sfe + 0.0476 CW

7. Carcass fat processing

In beef cattle the time spent dressing a whole carcass in the slaughter line is about 3 minutes. The costs involved in disposing of the fat from beef carcasses removed at the slaughter line are about £1.15 per carcass. Further trimming of about 25 minutes per whole carcass occurs in the cutting plant. The fat is sent by vacuum to the fat rendering plants. There, the fat is minced, melted and processed for human consumption and/or tallow.

McNaughton (2012) describes the market value of fat and bones as follows:

- Soft fats out of the slaughter (gut fat, kidney suet, etc) are sent for rendering into tallow. This tallow can be used to create soaps/gels or processed into other chemicals. Poorer quality tallow will end up as fuel or is converted into biofuels.

- Most hard fat ex boning go for render into tallow. But some of the best/cleanest may be sold for incorporation into sausages and other manufacturing products. Fat prices in January 2012 are approximately 25-30p/kg.

- Bones also go to the rendering companies. If they are from cattle under 30 months, the bone meal can be used for pet feed. Other bone meal would need to be used for burning/land fill. Bone prices in January 2012 are around 3p/kg.

- Using 11% fat trim value at 35p/kg, 20% bones valued at 3p/kg and 340 p/kg, the low values of 31% of fat trim and bones means that the remaining saleable meat has an effective purchase price of 486 p/kg, before taking into account cost of slaughter, butchering, etc.

Generally abattoirs do not trim lamb carcasses on the slaughter line. In the cutting plant, the time spent trimming is about 2.2 minutes per carcass.

8. Potential cost benefit

Considering an annual UK production of 898,000 T dressed beef and veal (Defra, 2010) and assuming 10% trimming, this production results in 99,700 T fat trim. At a producer value of £3.40 per kg dead-weight, this represents £339m paid for fat trim to the farmers. This represents rather an upper level of the benefit of avoiding excess fat during processing, because it is assumed that fat trim has no retail value, which is expected to be higher than the costs for trimming a carcass and the costs involved in disposing of fat.

Considering an annual UK production of 287,000 T dressed sheep and mutton (Defra, 2010), and assuming 5% trimming, this production results in 15,100 T fat trim. At a producer value of £4.40 per kg dead weight, this represents £66m paid for fat trim to the farmers. Again, this represents rather an upper level of the benefit of avoiding excess fat during processing because it is assumed that fat trim has no retail value.

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Annex1

Table A1. Total saleable yield (%), total fat trim (%) and total bone and waste (%) depending on breed, sex and growing-finishing management using data of the beef yield project of EBLEX (2011)

Breed	Sex	Feeding	Number of animals	Age		Side carcass weight (kg)		Total saleable yield (%)		Total fat trim (%)		Total bone and waste (%)	
				Mean	STD	Mean	STD	Mean	STD	Mean	STD	Mean	STD
All	All	All	149	746.6	145.7	144.6	14.6	70.3	3.0	9.6	3.0	19.6	1.9
Charolais	All	All	16	771.3	96.4	140.1	13.9	71.4	2.0	8.9	2.4	19.2	1.22
Hereford	All	All	16	757.3	114.3	143.3	16.9	67.4	1.8	12.5	2.3	19.6	1.1
All	Heifer	All	92	753.6	130.6	142.5	13.7	70.3	3.2	10.3	2.9	18.9	1.7
All	Steers	All	46	779.0	129.7	147.5	16.3	70.4	2.7	8.5	3.0	20.7	1.6
All	All	Intensive	26	530.0	118.8	144.7	14.9	70.8	3.5	8.7	3.3	19.9	1.9
All	All	Extensive	26	875.4	42.9	145.3	15.1	70.7	3.3	9.5	3.1	19.4	1.6

Table A2. Total saleable yield (%), total fat trim (%) and total bone and waste (%) depending on sex in sheep lamb using data of the VIA trial by EBLEX et al. (2007)

Sex	Number of animals	Carcass weight (kg)		Total saleable yield (%)		Total fat trim (%)		Total bone and waste (%)	
		Mean	STD	Mean	STD	Mean	STD	Mean	STD
All	495	19.7	4.0	77.6	2.1	4.9	1.9	17.5	2.0
Male	304	19.9	3.9	77.6	2.2	4.6	1.9	17.8	2.0
Female	191	19.3	4.2	77.7	2.1	5.4	1.8	16.9	1.7