12. Fatty acid composition of muscles in cattle and lamb

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Ruminant diets usually contain low levels (2-3%) of lipids and fatty acids (FA). Before absorption, dietary lipids undergo extensive modifications by ruminal micro-organisms. These processes and FA absorption are described in detail in Chapter 11. In the present chapter, the origins of muscle FA are summarised in Figure 12.1. Muscle medium chain FA are synthesised *de novo* from plasma acetate and β-hydroxybutyrate to generate C12:0, C14:0 and C16:0. Long chain muscle FA arise from modified dietary lipids via plasma lipoproteins (C16:0, C18:0, C18:1, C18:2 and C18:3) and are taken up through the action of the lipoprotein lipase (LPL). All saturated FA (SFA, mainly C14:0, C16:0, C18:0) and C18:1 t11 can be desaturated by the stearoyl-coenzyme A desaturase (Δ9 desaturase, SCD) to produce C14:1 c9, C16:1 c9, C18:1 c9 and C18:2 c9t11. Both C18:2 n-6 and C18:3 n-3 are elongated and desaturated to longer n-6 and n-3 polyunsaturated fatty acids (PUFA): C20:4 and C22:4 for the n-6 PUFA and C20:5, C22:5 and C22:6 for the n-3 PUFA.

This chapter presents the average FA profiles of muscles according to the main types of diets and the responses law of the muscle FA composition to dietary lipid or FA contents for both cattle and lamb. A similar study has not been performed on adipose tissue FA because there is too little data for

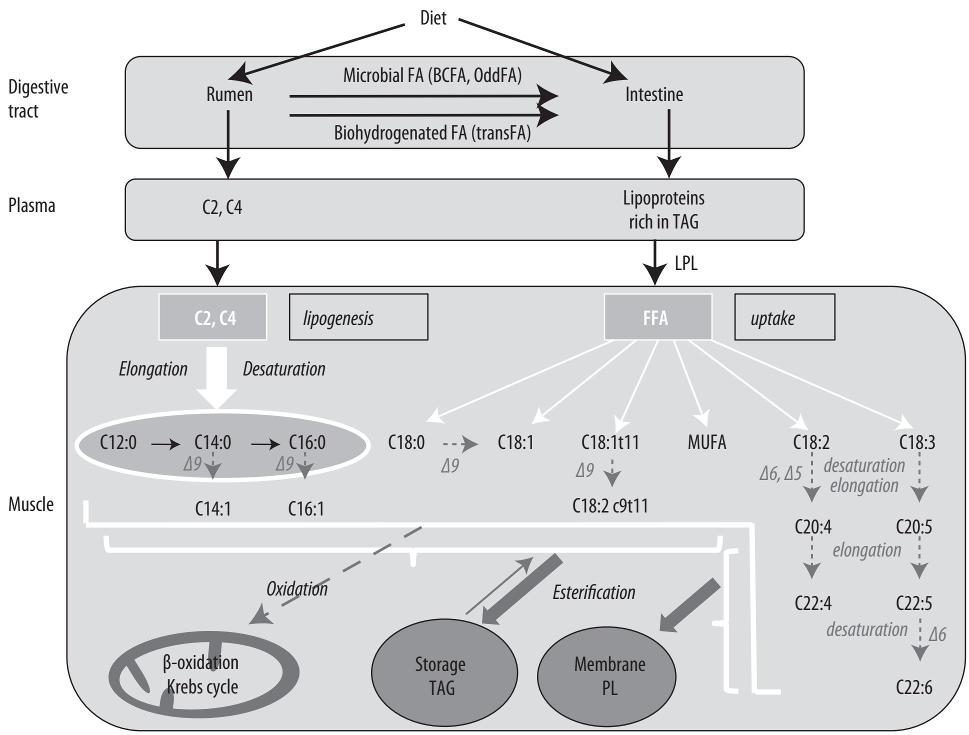

Figure 12.1. Fatty acids (FA) uptake and metabolism in muscle of fed ruminant. TAG = triacylglycerol; FFA = free fatty acids; PL = phospholipids; BCFA = branched chain fatty acids; OddFA = odd chain fatty acids; LPL = lipoprotein lipase; Δ9 = stearoyl-coenzymeA-desaturase (SCD) or Δ9 desaturase enzyme.

cattle. However, mean FA compositions of subcutaneous and perirenal adipose tissues of both cattle and lamb fed diets not supplemented with lipids are given in Table 12.1, to compare with muscle FA composition.

To evaluate the average FA profiles of muscles according to the main types of diets and the responses law of the muscle FA composition to dietary lipid or FA contents for both cattle and lamb, 2 databases are used ('ω3Meat' and 'LambFAT' databases):

The 'ω3Meat' database is registered with the French digital creation and work authorship protection agency (key number IDDN.FR.001.370029.000.R.2011.000.10300). It contains bibliographic data from the year 2000 onwards related to the impact of cattle farming system parameters on beef FA composition. The 184 publications featured in this database, counting 680 treatments, span 28 cattlebreeds (pure-line and crosses) and 13 muscles, predominantly (66%) *longissimus thoracis* (LT).

The 'LambFAT' database contains an extensive compilation of data from studies assessing the effect of either the type of diet or the FA composition of the diet on the FA composition of lamb muscle and adipose tissue. All data had been published as peer-reviewed articles or conference proceedings. The 218 publications featured in this database, counting 1,823 treatments, cover adipose tissue (subcutaneous, intermuscular and internal) and intramuscular fat. For the purposes of this chapter only 125 publications and 584 treatments dealing with intramuscular fat are considered.

Data included in both databases are expressed as average per treatment. Studies on fish oil or algae supplementation were discarded from the 2 databases.

12.1 Effects of type of diet

The impact of the type of diet on muscle FA composition of cattle and lamb is only assessed on *longissimus* muscle. Thus, FA values presented in Tables 12.3 and 12.4 are muscle dependent and maybe different between muscles (leaner or fatter).

Table 12.1. Fatty acid (FA) composition (in % of total FA) of subcutaneous and internal adipose tissue (AT) of beef cattle and lamb fed non-lipid-supplemented diets.

		C14:0	C16:0	C16:1	C18:0	C18:1	C18:2 n-6	C18:3 n-3
Cattle[1]	Subcutaneous AT	3.8	27.2	6.1	13.7	41.8	1.6	0.8
	Internal AT[2]	3.7	27.0	2.3	29.4	31.2	1.7	0.6
Lamb[3]	Subcutaneous AT	6.4	24.6	3.3	14.9	36.9	4.5	1.6
	Internal AT[2]	5.7	22.1	1.8	26.2	32.0	3.4	1.7

[1] Bas and Sauvant (2001).

[2] Perirenal, omental and mesenteric adipose tissues.

[3] Extracted from the 'LambFAT' database.

12.1.1 Cattle

The impact of the type of diet on FA composition of LT muscle of cattle is derived from 46 selected publications representative of the four main types of diets of animals, i.e. concentrate (C)-, corn silage (CS)-, concentrate plus forage (CF)- and grass (G)-based diets (Table 12.2) and is evaluated without taking into account the experiment effect due to the structure of the meta-design. The cattle initial body weight (BW), BW at slaughter, age and average daily gain (ADG) according to the type of diet show the great variability of livestock data in the database.

The effect of the type of diet on intramuscular lipid content of cattle LT muscle and its FA composition is presented in Table 12.3. No significant effect of the type of diet is observed on the muscle lipid content despite a tendency towards fatter muscles with the C-based diet compared to others. The types of diet therefore differ mainly according to FA compositions. The SFA and c9-C18:1 contents are slightly higher with CS-based diet compared to the other diets without any change in t11-C18:1 content. With forage-based diets (CF and G diets), known to be rich in n-3 PUFA, the level of 18:2 n-6 in the muscle is lower compared to C and CS-based diets, in favour of muscle 18:3 n-3 content. The C20:5 n-3 and C22:5 n-3 contents, and to a lesser extent C22:6 n-3 content, are also higher with CF and G diets, indicating an enhanced synthesis of n-3 long chain PUFA with forage-based diets. However, these concentrations remain low and fall below the limit considered eligible by some authorities to be labelled a source of omega-3 PUFA. In the same way, forage-based diets result in higher muscle c9t11-conjugated linoleic acid (CLA) content compared to C-based diet. All these changes in n-3 PUFA contents cause a lowering of C18:2 n-6/C18:3 n-3 and n-6/n-3 nutritional ratios. All these results are in line with a recent review by Scollan *et al.* (2014) that focuses on dietary approaches to controlling intramuscular fat deposition to increase beneficial omega-3 PUFA and CLA contents and reduce SFA in beef.

12.1.2 Lamb

Twenty-five studies evaluating the effect of the type of diet on FA composition of *longissimus* muscle of lamb are selected. These represent 94 treatments which are classified into 5 groups. In two groups, lambs remained with their dams (M, maternal milk) and had, as complementary feed, concentrate (M+C) or were allowed to graze on pasture (M+Pa). In the other three groups, lambs were weaned and were fed dried grass forage and concentrates (F+C) or grazed on pasture with (Pa+C) or without

Table 12.2. Zootechnical parameters of beef cattle (mean, [min-max]) in 'ω3Meat' database according to the type of diet.

	Concentrate-based diet	Corn silage-based diet	Concentrate + Forage[1] diet	Grass-based diet[2]
Number of treatments (n)	111	29	160	132
Initial body weight (kg)	339 [121-642]	364 [213-531]	361 [122-620]	378 [176-569]
Body weight at slaughter (kg)	534 [231-789]	588 [445-720]	552 [208-772]	494 [185-718]
Age at slaughter (d)	585 [329-1741]	574 [330-1,701]	527 [310-941]	636 [240-2520]
Average daily gain (kg/d)	1.27 [0.69-1.97]	1.18 [0.91-1.56]	1.24 [0.6-2.05]	0.91 [0.24-2.02]

[1] Grass silage or hay.

[2] Grass silage-based diet + grazing.

Table 12.3. Lipid content and fatty acid (FA) composition of *Longissimus thoracis* muscle of beef cattle according to the type of diet.[1]

	Diet				RMSE	*P*-value
	Concentrate-based	Corn silage-based	Concentrate + forage	Grass-based[2]		
Total lipids (g/100 g fresh tissue)	3.58	2.50	2.67	2.92	1.72	0.055
FA composition[3] (% total FA)						
SFA[3]	44.2[c]	47.6[a]	45.8[ab]	44.8[bc]	3.98	0.001
C16:0	24.6[bc]	26.9[a]	25.5[ab]	24.4[c]	3.17	0.001
C18:0	14.7[b]	16.8[a]	15.8[ab]	15.8[ab]	2.80	0.003
MUFA[3]	42.0	42.4	42.9	41.0	5.76	0.116
c9-C18:1	34.3[bc]	37.4[ab]	36.5[a]	33.5[c]	5.22	0.001
t11-C18:1	2.41	1.58	1.72	2.19	1.45	0.166
PUFA[3]	12.0	8.90	10.0	9.80	7.10	0.046
PUFA n-6	8.50[a]	7.25[ab]	6.72[b]	6.06[b]	4.69	0.004
C18:2n-6	7.42[a]	5.84[ab]	5.64[b]	4.39[b]	3.82	0.001
C20:4 n-6	2.12[a]	1.63[ab]	1.42[b]	1.50[b]	4.41	0.003
PUFA n-3	1.18[b]	0.96[b]	1.66[b]	2.72[a]	1.34	0.001
C18:3 n-3	0.50[c]	0.52[bc]	0.81[b]	1.41[a]	0.70	0.001
C20:5 n-3	0.28[b]	0.18[b]	0.41[b]	0.64[a]	0.37	0.001
C22:5 n-3	0.58[bc]	0.33[c]	0.77[ab]	0.94[a]	0.59	0.001
C22:6 n-3	0.08[b]	0.10[ab]	0.14[ab]	0.17[a]	0.16	0.016
c9t11-CLA	0.28[c]	0.46[abc]	0.38[b]	0.54[a]	0.16	0.001
C18:2 n-6/C18:3 n-3	20.3[a]	13.3[abc]	12.3[b]	5.80[c]	15.3	0.001
n-6/n-3	10.0[a]	8.70[a]	5.80[b]	2.40[c]	4.20	0.001

[1] SFA = saturated FA = ∑(C14:0+C16:0+C18:0+C20:0); MUFA = mono-unsaturated FA = ∑(C14:1+C16:1+∑(C18:1)+C20:1); PUFA = poly-unsaturated FA = ∑(C18:2n-6+C18:3n-6+C20:4n-6+C22:4n-6+C18:3n-3+C20:5n-3+C22:5n-3+C22:6n-3).

[2] Different superscripts indicate significant differences using Bonferroni adjustments ($P<0.05$).

[3] Grass silage-based diet + grazing.

concentrate supplementation (Pa). The M+C type of diet is not well represented in the database (only 3 treatments) compared to the other diets. The lamb initial BW, age and BW at slaughter as well as their ADG according to the type of diet are given in Table 12.4. In this database, lambs of the Pa system have significantly lower ADG than lambs of the M+Pa and F+C systems (P=0.003); they are also slaughtered at a later age than the F+C lambs (P=0.01). An important characteristic of the F+C type of diet is the high percentage of concentrate (79%) in these diets.

The effect of the type of diet on intramuscular FA content and composition of lamb *longissimus* muscles is presented in Table 12.5 and is evaluated taking into account the experiment effect. Grazing lambs on pasture (Pa) have lower muscle FA content compared to lambs on the other diets; they also have lower C16:0 and higher C18:0 proportions compared to F+C lambs. Grazing lambs on pasture alone (Pa) or associated with their dam (M+Pa) have a lower proportion of c9-C18:1 and mono-unsaturated (MUFA) proportion compared to those on the F+C system. In contrast to cattle, muscle proportion of C18:2 n-6, C20:4 n-6 and PUFA n-6 are similar between types of diet. In agreement with Popova *et al.* (2015) and in line with the grass richness in C18:3 n-3, grazing lambs on pasture alone (Pa) or associated with their dam (M+Pa) have higher proportions of C18:3 n-3 and of C20:5 n-3, C22:6 n-3

Table 12.4. Zootechnical parameters of lambs and percentage of concentrate in their diets (mean [min – max]) in 'LambFAT' database according to the type of diet.[1]

	M+C	M+Pa	Pa	Pa+C	F+C
Number of treatments	3	10	26	22	33
Duration of the experiment (d)	44 [na]	62 [na]	90 [56-156]	69 [42-98]	84 [29-173]
Initial body weight (kg)	12.6 [11.2-14.2]	16.2 [13.8-24.0]	18.5 [11.1-30.0]	22.5 [14.3-36.0]	17.8 [11.1-37.1]
Body weight at slaughter (kg)	26.1 [21.0-30.0]	30.6 [22.9-40.0]	32.8 [15.7-42.0]	34.8 [25.5-45.0]	33.4 [20.6-48.0]
Age at slaughter (d)	104 [82-120]	115 [66-134]	179 [132-245]	159 [91-245]	127 [69-245]
Average daily gain (g/d)	248 [244-253]	266 [189-331]	150 [30-237]	207 [71-286]	247 [71-446]
Concentrates in the diet (g/g)	na	0	0	0.37 [0.15-0.85]	0.79 [0.60-1.00]

[1] M+C = maternal milk with concentrates supplementation; M+Pa = maternal milk and pasture; Pa = pasture; Pa+C = pasture with concentrates supplementation; F+C = dried forage and concentrates supplementation. na = not available.

Table 12.5. Lipid content and fatty acid (FA) composition of *longissimus* muscles of lamb according to the type of diet.[1,2]

	n	nexp	M+C	M+Pa	Pa	Pa+C	F+C	RMSE	*P*-value
FA content (g/100 g fresh tissue)	74	20	2.54^{ab}	2.52^{ab}	1.83^{b}	2.53^{a}	2.53^{a}	0.48	0.002
FA composition (% total FA)									
SFA[3]	85	24	46.8	46.1	44.8	45.7	45.4	2.0	0.66
C16:0	73	21	24.1^{ab}	22.5^{abc}	20.9^{c}	22.2^{bc}	23.7^{a}	1.3	0.0001
C18:0	73	21	15.8^{bc}	16.2^{bc}	18.8^{a}	17.6^{ab}	15.9^{c}	1.2	0.0001
MUFA[3]	74	21	37.2^{abc}	35.6^{bc}	36.5^{c}	39.3^{ab}	39.9^{a}	2.0	0.0001
c9-C18:1	44	13	31.6^{ab}	29.4^{b}	30.5^{b}	33.1^{ab}	34.0^{a}	1.9	0.001
PUFA[3]	91	24	12.6^{ab}	13.6^{ab}	15.3^{a}	12.3^{b}	12.4^{b}	2.1	0.001
PUFA n-6	80	22	9.32	9.25	10.07	8.64	10.22	1.82	0.17
C18:2 n-6	81	23	6.25	5.84	6.11	6.42	6.96	1.26	0.20
C20:4 n-6	67	20	2.52	2.71	3.02	2.51	2.80	0.68	0.64
PUFA n-3	80	22	3.14^{ab}	4.31^{a}	4.65^{a}	2.56^{b}	1.98^{b}	0.69	0.0001
C18:3 n-3	81	23	1.56^{ab}	2.08^{a}	2.33^{a}	1.34^{b}	0.88^{b}	0.43	0.0001
C20:5 n-3	48	15	0.96^{ab}	1.30^{a}	1.14^{a}	0.65^{ab}	0.56^{b}	0.30	0.0001
C22:5 n-3	26	8	1.26	1.55	1.24	0.85	0.92	0.38	0.13
C22:6 n-3	35	12	0.54^{ab}	0.64^{a}	0.58^{a}	0.25^{b}	0.30^{b}	0.13	0.001
∑ CLA	34	11	0.79^{ab}	1.33^{a}	1.41^{a}	1.13^{a}	0.67^{b}	0.18	0.0001
C18:2 n-6/C18:3 n-3	81	23	3.82^{ab}	1.94^{b}	3.70^{b}	7.31^{ab}	11.05^{a}	4.18	0.0001
n-6/n-3	84	23	4.91^{ab}	3.90^{b}	2.66^{b}	4.76^{b}	7.71^{a}	2.47	0.0001

[1] Different superscripts indicate significant differences using Bonferroni adjustments (P<0.05).

[2] M+C = maternal milk with concentrates supplementation; M+Pa = maternal milk and pasture; Pa = pasture; Pa+C = pasture with concentrates supplementation; F+C = dried forage and concentrates supplementation.

[3] SFA = saturated FA = ∑(C14:0+C16:0+C18:0+C20:0); MUFA = mono-unsaturated FA = ∑(C14:1+C16:1+∑(C18:1)+C20:1); PUFA = poly-unsaturated FA = ∑(C18:2n-6+C18:3n-6+C20:4n-6+C22:4n-6+C18:3n-3+C20:5n-3+C22:5n-3 +C22:6n-3).

and PUFA n-3 in muscle compared to concentrate supplemented systems (F+C and Pa+C) lambs, indicating, as in cattle, an enhanced synthesis of n-3 long chain PUFA with grass diets. Moreover, with all grass types of diet, lambs have a higher proportion of CLA compared to F+C lambs due to the biohydrogenation of C18:3 n-3 to 11t-C18:1 in the rumen and the c9t11-CLA synthesis in the muscle via the Δ9 desaturase (SCD). All these increases in muscle n-3 FA contents and the decreases in the C18:2 n-6/C18:3 n-3 and n-6/n-3 nutritional ratios with weaned or unweaned grazing lambs compared to F+C lambs indicate an expected improvement in meat dietetic quality with access to pasture.

Thus, for both cattle and lamb, forage-based diets promote the deposition of n-3 PUFA (C18:3 n-3, C20:5 n-3, C22:5 n-3 but also C22:6 n-3) in the muscles of animals with higher proportions of these FA in lamb *longissimus* muscle compared to cattle.

12.2 Response laws to dietary fatty acids

12.2.1 Cattle

The response law of the cattle muscle FA composition to dietary lipid or FA contents is derived from 36 studies including 86 experiments assessing the effect of the FA composition of the diet on the FA composition of cattle muscle.

C18:3 n-3 and n-3 long-chain PUFA (LC-PUFA)

The proportion of C18:3 n-3 present in cattle muscle is directly proportional to its percentage in the diet and/or to the fat content of the diet (Table 12.6). However, the slopes of the regressions are low because of ruminal lipolysis and biohydrogenation which limit the ability to improve beef lipids. The proportion of n-3 LC-PUFA such as C20:5 n-3, C22:5 n-3 and C22:6 n-3 is also linearly dependent of the proportion of C18:3 n-3 in the diet indicating a possible synthesis of these specific FA in cattle. Nevertheless, the slope of the relationship decreases with the elongation and the desaturation of the FA in accordance with the limited ability of the cattle to synthesise C22:6 n-3 (Scollan *et al.*, 2014).

Table 12.6. Intra-experiment relationships between the proportion of C18:3 n-3 (C18:3 n-3 %FA) and the fat content (ether extract, EE) in the diet, and the proportion of n-3 poly-unsaturated fatty acids (PUFA) in the *longissimus thoracis* muscle of beef cattle.

Y = PUFA[1]	Regression[2]	n	nexp	RMSE
C18:3 n-3_mu	$Y = 0.416 + 22.20\times10^{-3} \times$ C18:3 n-3 %FA	79	29	0.27
	$Y = 0.109 + 25.22\times10^{-3} \times$ C18:3 n-3 %FA $+ 4.19\cdot10^{-3} \times$ EE	45	18	0.21
C20:5 n-3_mu	$Y = 0.203 + 4.90\times10^{-3} \times$ C18:3 n-3 %FA	66	22	0.07
C22:5 n-3_mu	$Y = 0.443 + 5.22\times10^{-3} \times$ C18:3 n-3 %FA	59	20	0.09
C22:6 n-3_mu	$Y = 0.496 + 1.05\times10^{-3} \times$ C18:3 n-3 %FA	46	18	0.02

[1] C18:3 n-3_mu (0.75±0.62, min = 0.05, max = 2.7% of FA), C20:5 n-3_mu (0.27±0.20, min = 0.001, max = 0.82% of FA), C22:5 n-3_mu (0.49±0.30, min = 0.04, max = 1.5% of FA), C22:6 n-3 _mu (0.07±0.04, min = 0.01, max = 0.2% of FA) are the proportion of C18:3 n-3, C20:5 n-3, C22:5 n-3, C22:6 n-3 in the muscle (% of total FA).

[2] C18:3 n-3 %FA (21.1±20.2, min = 0.7, max = 64.8% of FA) and EE (47.8±21.9, min = 12.5, max = 100 g/kg DM) are respectively the proportion of C18:3 n-3 and the fat content of the diet.

C18:2 n-6

The C18:2 n-6 proportion in cattle muscle FA depends linearly on fat content of diets (ether extract, EE) as part of the database 'ω3Meat' that contains many lipid supplemented diets.

$$C18:2\ n\text{-}6\_mu = 4.44 + 0.011 \times EE \qquad (12.1)$$
(n=60, nexp = 24, RMSE = 0.62)

where C18:2 n-6_mu (4.7±3.2, min = 1.2, max = 16.5% of FA) is the proportion of C18:2 n-6 in the muscle total FA and EE (47.3±21.9, min = 12.5, max = 100 g/kg DM) is the fat content of the diet. However, no relationships are obtained from dietary fat or FA contents to predict C18:2 n-6 elongation/desaturation products in muscle such as C20:4 n-6 or C22:4 n-6.

Trans fatty acids

The number of publications reporting the levels of *trans* FA in the muscles of cattle is low. Thus, in 'ω3Meat' database, data on t11-C18:1 and ∑CLA are available in only 11 studies; information about other isomers is not sufficient to be used. The proportion of t11-C18:1 in muscle FA depends linearly on the fat content of the diet:

$$t11\text{-}C18:1\_mu = 1.44 + 0.027 \times EE \qquad (12.2)$$
(n=28, nexp = 11, RMSE = 0.36)

where t11-C18:1_mu (2.4±1.3, min = 0.6, max = 6.5% of FA) is the proportion of t11-C18:1 in the muscle total FA and EE (47.3±21.9, min = 12.5, max = 100 g/kg DM) is the fat content of the diet. Similarly, the proportion of ∑CLA in the cattle muscle FA is linearly related to the fat content of the diet:

$$\sum CLA\_mu = 0.04 + 0.008 \times EE \qquad (12.3)$$
(n=27, nexp = 11, RMSE = 0.20)

where ∑CLA_mu (0.41±0.32, min = 0.04, max = 1.3% of FA) is the proportion of ∑CLA in the muscle total FA and EE (47.3±21.9, min = 12.5, max = 100 g/kg DM) is the fat content of the diet.

12.2.2 Lamb

To investigate the responses law of the muscle FA composition to dietary FA content of diets, 100 studies assessing the effect of the FA composition of the concentrate or the diet on the FA composition of lamb muscle are used. It includes 47 experiments studying the effect of dietary lipid supplementation on muscle FA composition.

C18:3 n-3 and LC-PUFA n-3

The proportion of C18:3 n-3 in the muscle depended linearly on the proportion of C18:3 in the diet. However, as the slopes of the within-experiment regression are different between lipid- and non-lipid-supplemented diets, two equations are proposed in Table 12.7. The lipid-supplemented diet equation will be used when oil seed, oil seed cake or oil are added to the concentrate of lambs. The higher slope for lambs fed lipid-supplemented diets is expected as they have higher C18:3n-3 content in their diet.

When the FA contents of the diet were available in the studies, a linear within-experiment relationship between the dietary C18:3n-3 content (i.e. expressed in g/kg DM) and its proportion in the muscle FA is observed (Figure 12.2). As elongation and desaturation of C18:3 n-3 to C20:5 n-3, C22:5 n-3 and C22:6 n-3 has been evidenced in the muscle, special attention is paid to the within-experiment regression between the proportion of C18:3n-3 in the dietary FA and the proportion of these LC-PUFAn-3 in the muscle FA. Linear relationships are observed between the proportion of C18:3 n-3 in the dietary FA and the proportion of C20:5 n-3, C22:5 n-3 and C22:6 n-3 (Table 12.7) in the muscle FA. As expected and observed in cattle, the slopes decrease with elongation and desaturation steps indicating decreased efficiencies in these LC-PUFA syntheses.

C18:2 n-6 and LC-PUFAn-6

In lamb, the proportion of C18:2 n-6 in the muscle FA depends linearly on the proportion of C18:2 n-6 in the dietary FA only for the diet with lipid supplementation (Table 12.7). Elongation and desaturation of C18:2 n-6 to 20:4 n-6 and 22:4 n-6 occurs in muscle. No relationship is observed between the C20:4 n-6 proportion in muscle FA and the proportion of C18:2 n-6 in the dietary FA. This is not surprising as the proportion of C20:4 n-6 in muscle FA decreases curvilinearly with muscle fat content. Nevertheless, the proportion of C22:4 n-6 in the muscle FA depends linearly on the proportion of C18:2 n-6 (Table 12.7) in the dietary FA.

Trans fatty acids

In the 'LambFAT' database, data on ∑t-C18:1 are available in 18 studies but proportions of the different isomers are not sufficiently numerous to be used. The proportion of ∑t-C18:1 in muscle FA depends linearly on the C18:2 n-6 and C18:3 n-3 dietary content:

$$\sum t\text{-C18:1\_mu} = 1.973 + 0.073 \times \text{C18:2n-6} + 0.128 \times \text{C18:3n-3} \quad (12.4)$$

(n=51, nexp = 20, RMSE = 0.71)

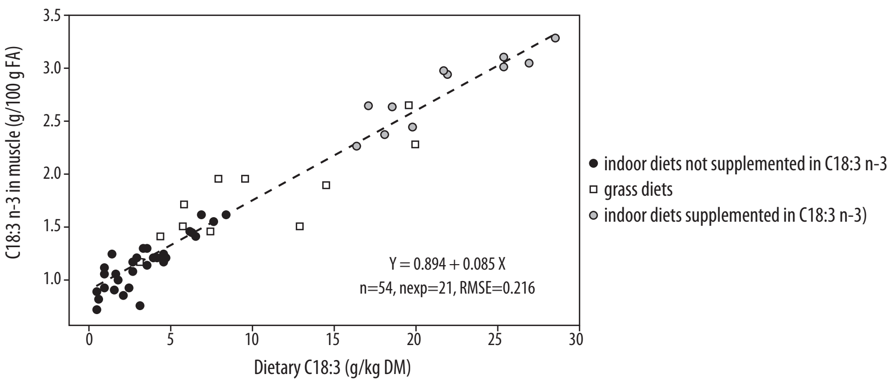

Figure 12.2. Intra-experiment relationship between the quantity of C18:3 n-3 in the diet and the proportion of C18:3 n-3 in the fatty acids (FA) of lamb muscle.

Table 12.7. Intra-experiment relationships between the proportion of C18:3 n-3 (C18:3 n-3 %FA) or C18:2 n-6 (C18:2 n-6 %FA) in the diet, and the proportion of the n-3 or n-6 poly-unsaturated fatty acids (PUFA, in % of total FA) in the *longissimus* muscle of lambs.

Y = PUFA	Regression	n	nexp	RMSE
C18:3 n-3_mu[1]	*Without lipid supplementation*	70	20	0.16
	$Y = 0.79 + 24\times10^{-3} \times$ C18:3 n-3 %FA			
C18:3 n-3_mu[2]	*With lipid supplementation*	63	27	0.35
	$Y = 0.464 + 54\times10^{-3} \times$ C18:3 n-3 %FA			
C20:5 n-3_mu[3]	$Y = 0.464 + 7.3\times10^{-3} \times$ C18:3 n-3 %FA	94	34	0.13
C22:5 n-3_mu[4]	$Y = 0.661 + 3.6\times10^{-3} \times$ C18:3 n-3 %FA	82	29	0.11
C22:6 n-3_mu[5]	$Y = 0.235 + 2.3\times10^{-3} \times$ C18:3 n-3 %FA	93	33	0.05
C18:2 n-6_mu[6]	*With lipid supplementation*	63	27	1.05
	$Y = 5.628 + 44\times10^{-3} \times$ C18:2 n-6 %FA			
C22:4 n-6_mu[7]	$Y = 0.153 + 0.2\times10^{-3} \times$ C18:2 n-6 %FA	47	16	0.05

[1] C18:3 n-3 %FA = 18.9±21.6% (min = 1.7%; max = 67.8%); C18:3 n-3_mu = 1.1±0.8% (min = 0.01%; max = 2.8%).
[2] C18:3 n-3 %FA = 18.6±15.9% (min = 1.7%; max = 66.1%); C18:3 n-3_mu = 1.5±1.0% (min = 0.2%; max = 3.6%).
[3] C18:3 n-3 %FA = 21.9±18.9% (min = 1.7%; max = 67.8%); C20:5 n-3_mu = 0.58±0.46% (min = 0.04%; max = 2.03%).
[4] C18:3 n-3 %FA = 20.8±17.2% (min = 1.9%; max = 66.4%); C22:5 n-3_mu (0.69±0.39%; min = 0.7%; max = 2.4%).
[5] C18:3 n-3 %FA = 21.2±18.2% (min = 1.7%; max = 67.8%); C22:6 n-3_mu (0.26±0.20%; min = 0.04%; max = 1.36%).
[6] C18:2 n-6 %FA = 33.4±11.9% (min = 11.9%; max = 68.5%); C18:2 n-6_mu (7.2±2.8%; min = 2.9%; max = 14.8%).
[7] C18:2 n-6 %FA = 32.5±11.9% (min = 10.0%; max = 57.1%); C22:4 n-6_mu = (0.115±0.113% (min = 0.005%; max = 0.580%).

where $\sum$t-C18:1_mu is the proportion of $\sum$t-C18:1 in the muscle FA (4.0±2.2%; min = 1.1%; max = 9.8% of total FA) and C18:2 n-6 (11.9±6.7; min = 0.94; max = 28.4) and C18:3 n-3 (10.0±8.4; min = 0.5; max = 31.9) are the C18:2 n-6 and C18:3 n-3 dietary content (g/kg DM). The proportion of c9t11-CLA in the muscle FA depends linearly on the C18:3 n-3 dietary content and quadratically on the C18:2 n-6 dietary content:

$$\text{c9t11-CLA\_mu} = 0.831 + 0.027 \times \text{C18:3n-3} - 0.056 \times \text{C18:2n-6} + 0.002 \times \text{C18:2n-6}^2 \quad (12.5)$$

(n=52, nexp = 20, RMSE = 0.12)

where c9t11-CLA_mu (0.69±0.45%; min = 0.05%; max = 1.90% of total FA) is the proportion of c9t11-CLA in the muscle FA and C18:2 n-6 (13.0±7.6; min = 0.94; max = 31.9) and C18:3 n-3 (9.8±8.6; min = 0.5; max = 31.9) are the C18:2 n-6 and C18:3 n-3 dietary content (g/kg DM).

12.3 Conclusions

Numerous experiments have studied the impact of types of diet on ruminant meat FA composition, but no quantitative synthesis of these studies is currently available. In this chapter, special attention was paid to FA which are most important for the quality of products and human health (PUFA n-3, PUFA n-6, CLA and *trans* C18:1). For both cattle and lamb, forage-based diets promote the deposition of n-3 PUFA (C18:3 n-3, C20:5 n-3, C22:5 n-3 but also C22:6 n-3) in the muscles of animals. Likewise, the muscle proportion of n-3 PUFA is mainly modulated by the dietary proportion (or concentration) of C18:3 n-3. Cattle and lamb are capable to synthesise C22:6 n-3, albeit in a limited way. For PUFA n-6, results between lamb and cattle differ as relationships between dietary C18:2 n-6 and the muscle proportion of C18:2 n-6 for lipid-supplemented diet and of C22:4 n-6 was observed for lamb but not for cattle. This discrepancy may be because the n-6 LC-PUFA data are poorly represented in the 'ω3Meat' database. In addition, EE seems to be the most important factor of variation of n-6 PUFA and *trans* FA for cattle whereas for lamb, muscle *trans* FA proportions can be estimated with C18:2 n-6 and C18:3 n-3 dietary content.