Body tissue development in lambs of two genetic lines analysed by x-ray computer tomography

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Introduction

As observed internationally, the market for lamb meat shows an increased request for the more muscular cuts with a low proportion of fat. Increasing lean tissue deposition while decreasing fat entails breeding of genotypes that are genetically superior for lean tissue deposition. As sheep grow toward maturity, in absolute terms, body, carcass, bone, fat and muscle weights all increase without decreasing lean meat accretion. However, the different body tissues vary in development and is complex. A better understanding of the pattern of growth of different body tissue and within total body fat is needed for greater progress in carcass traits of lamb

Computer tomography (CT) allow development of body tissue within an animal to be examined, given the animals are CT scanned at two or more times during growth. The great advantage of CT scanning above dissection in analysis of growth in animals is that body tissues in the same animal can be accurate and immediate estimated at different stages during growth period.

This paper is giving preliminarily results of a CT experiment with lambs of two genetic lines, a meat-line (ML) and a conventional line (CL) with an aggregate breeding goal that was initiated in 2002. The aim was to i) describe the pattern of growth and development of body tissues in lambs from early age until weaning, and ii) investigate if there was any difference in the development and growth pattern of body tissue between the two genetic lines.

Material and methods

Data was recorded from a nucleus flock of sheep at the Agricultural University of Norway. At the initiation of the experiment, the research flock comprised 120 meatline (ML) ewes and 40 conventional bred (CL) ewes. A total of 30 (20 ML and 10 CL) and 31 (21 ML and 9 CL) male lambs were CT scanned in 2002 and 2003, respectively. Each lamb was CT scanned three times at an average age of 42 (CT1), 92 (CT2) and 119 (CT3) days. Male lambs born as twins were selected at random each year, balanced within sires.

The development of the ML, the breed composition, and the selection procedure performed within the line was presented and described by Vangen et al. (Rome, EAAP, 2003). In brief, ML is a composite breed of Norwegian White Sheep and Texel. Sires are selected in two stages, primarily for ultrasound muscledepth (BLUP1) at weaning and finally for CT lean weight (BLUP2). BLUP1 is the main criteria for replacement of ML ewes. CL animals originate from a previous selection experiment (Larsgaard and Kolstad, 2003) and are bred according to the National breeding Schedule including maternal, functional and carcass traits.

All ewes were managed together and given the same treatment. They were housed from November until the first week postpartum and were fed according to the Norwegian feeding standards (Havrevoll et al., 1992).

Ewes were mated from the beginning of November and lambed indoor from the end of April. Each lamb was weighed and tagged at birth and the dam identified. The lambs suckled their mothers from birth until they were weaned together in one day in the beginning of September.

CT scanning

Animals were scanned lying on their backs with their fore- and hindlimbs extended, retained to a cradle. They were fasted for about 4 hours prior to CT scanning. Cross sectional images were recorded from a fixed position from a point behind the rump cranial throughout the animal every 40 mm to the 1^{st} cervical vertebrae (Jopson et al., 1997) using a Siemens Somatom Emotion. An average of 18, 22 and 23 images were taken at CT1, CT2 and CT3, respectively. Image analysis was performed using AutoCAT (Jopson, et al., 1995) based on procedure reported by Kinghorn and Thompson (1992).

Weight of total carcass lean (LEAN), carcass fat (FAT), bone (BONE), subcutaneous fat (SFAT), intermuscular fat (IeFAT), non-carcass fat (NcFAT), non-carcass visceral tissue (NcVT), total CT weight (CTwt) and carcass weight (Ccwt) were estimated for each animal. Total CT weight was defined as the sum of all tissues from all original images recorded for each animal, including carcass and non-carcass components. Carcass weight was defined as the sum of LEAN, FAT and BONE in each animal. NcFAT was found from total fat estimated for CTwt subtracted FAT, and NcVT from total visceral tissues (carcass and non-carcass) estimated for CTwt subtracted from LEAN. Proportion (%) of LEAN, FAT, BONE, SFAT, IeFAT were all expressed as percentage of to total Ccwt. Ratio of LEAN:BONE and LEAN:FAT are defined as the weight of LEAN relative to the weight of BONE and FAT.

Statistic analysis

Initially, each individual lamb, for each scanning, was analysed for weights of each body tissues determined by CT. A GLM model was then fitted in SAS to identify appropriate class-, interactions and linear regression variables to test for differences in body tissue weights between the two genetic lines. Model 1 included class variables; line, dam age, scan event, year and their interactions, with age at CT1 as a covariate. Growth in body tissues based on the three repeated scan events was also analysed using an allometric growth function $Y=aX^b$ (model 2) including all the same variables as for model 1. Allometric growth coefficients were estimated within each animal for each tissue; body tissues relative to total CT weight, carcass tissues relative to total carcass weight, and carcass fat depots relative to total carcass fat.

Results

Mean CT body tissue weights estimated for all lambs are presented in figure 1. LEAN had the largest and BONE the smallest weight at all scan events ($P<0.05$). NcFAT was the largest fat depot, and IeFAT a larger carcass fat depot than SFAT for each period of scanning ($P<0.05$). Mean weight of SFAT was greater at CT3 than at CT2 ($P<0.05$), but similar for CT1 and CT2 ($P>0.05$).

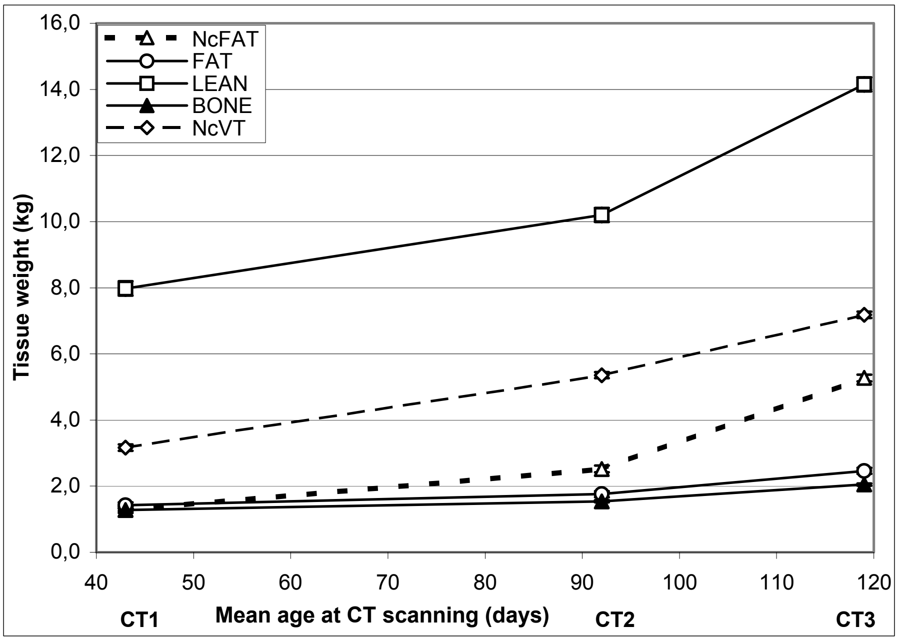

Figure 1. Mean weight and standard error of carcass lean (LEAN), FAT and BONE, and of non-carcass fat (NcFAT) and non-carcass visceral tissues (NcVT) of lambs CT scanned three times (CT1, CT2 and CT3) during growth.

Table 1 show least square mean weights estimated for lambs of the two genetic lines. CL had more NcFAT at CT3 (P=0.0128) than ML, but no significant (P>0.05) difference between the two lines was found for SFAT and IeFAT. ML showed a tendency to greater LEAN weight than CL at all scan events.

Table 1 Number of animals, mean age and least square mean CT weights[1)] and their standard errors of lamb of a meat (ML) and a conventional (CL) line of lamb CT scanned at three times during growth (CT1, CT2 and CT3) (model 1)

	CT1		CT2		CT3	
variable	CL	ML	CL	ML	CL	ML
animals (n)	19	42	19	42	19	42
age lamb (days)	41.1±9.0	44.1±6.9	90.1±9.0	93.1±6.9	117.2±7.9	119.9±7.6
LEAN	7.31±1.26	8.70±1.60	9.66±1.37	10.80±2.17	13.54±2.13	14.80±2.30
FAT	1.30±0.50	1.57±0.60	1.64±0.61	1.90±0.78	2.42±0.92	2.53±0.91
BONE	1.26±0.18	1.31±0.25	1.54±0.20	1.56±0.30	2.05±0.30	2.06±0.31
SFAT	0.51±0.22	0.66±0.28	0.65±0.29	0.79±0.36	1.07±0.50	1.12±0.46
IeFAT	0.79±0.29	0.92±0.33	0.99±0.33	1.11±0.43	1.36±0.44	1.40±0.47
NcFAT	1.17±0.37	1.35±0.45	2.50±0.84	2.48±0.90	5.48±1.16	5.00±1.14
NcVT	3.07±0.21	3.28±0.14	5.26±0.21	5.48±0.21	7.18±0.21	7.20±0.14
CTwt	14.12±2.70	16.24±3.23	20.60±3.14	22.23±4.72	30.69±4.73	31.58±4.77

[1)]LEAN=total carcass lean, FAT=total carcass fat, BONE=total carcass bone, SFAT=subcutaneous fat, IeFAT=intermuscular fat, NcFAT=non-carcass fat, Ccwt=carcass weight, NcVT=non-carcass visceral tissue, CTwt=total CT weight

Proportion of bone relative to total carcass weight was larger for CL than ML for all scan events (P<0.05) (Table 2). Ratio of LEAN/BONE was greater for ML than CL for all scan events (P<0.01). ML showed also a tendency of a higher LEAN:FAT ratio than CL at CT3. Differences between lines in proportion of LEAN from CT1 to CT3 just failed to reach significance (P=0.0592).

Table 2. Least square mean percentage of carcass LEAN, FAT and BONE, and subcutaneous fat (SFAT) and intermuscular fat (IeFAT), and ratio of LEAN/BONE and LEAN/FAT of a meat line (ML) and conventional (CL) line of lambs at three scan events (CT1, CT2 and CT3) (model 1)

	CT1		CT2		CT3	
Variable	CL	ML	CL	ML	CL	ML
%LEAN	74.04	75.31	75.23	75.90	75.20	76.50
%FAT	13.31	13.34	12.97	13.08	13.50	12.90
%BONE	12.66	11.39[b]	11.89	10.99[a]	11.31	10.65[a]
%SFAT	5.26	5.51	5.16	5.41	5.92	5.71
%IeFAT	8.05	7.83	7.81	7.67	7.58	7.19
LEAN/BONE	5.85	6.61[c]	6.32	6.90[b]	6.65	7.18[b]
LEAN/FAT	5.56	5.65	5.80	5.80	5.57	5.93

[abc)]line means within scan events are significant different, [a)]$P<0.05$, [b)]$P<0.01$, [c)]$P<0.001$

*Data were analysed by the least-squares method using LM procedure, LSMeans adjusted for covariate age at first scanning

Table 3 Estimates of allometric growth parameters (b) and standard error of body components[1)] relative to total CT weight (*CTwt*), carcass fat tissues relative to total carcass fat (*FAT*), and carcass tissue relative to total carcass weight (*Ccwt*) of a meat (ML) and conventional (CL) line of lambs (model 2). No b-value differed between the two genetic lines (P>0.05) (model 2)

Variable	ML	CL
Ccwt		
FAT	0.99±0.115	1.00±0.082
LEAN	1.03±0.015	1.02±0.011
BONE	0.83±0.036	0.88±0.026
FAT		
SFAT	1.18±0.047	1.20±0.034
IeFAT	0.89±0.035	0.87±0.023
CTwt		
LEAN	0.79±0.017	0.79±0.012
FAT	0.79±0.097	0.77±0.069
BONE	0.64±0.022	0.68±0.016
SFAT	0.89±0.119	0.89±0.085
IeFAT	0.73±0.082	0.67±0.055
NcFAT	2.02±0.089	1.97±0.063
NcVT	1.22±0.051	1.19±0.036

[1)]LEAN=total carcass lean, FAT=total carcass fat, BONE=total BONE, SFAT=subcutaneous fat, IeFAT=intermuscular fat, NcFAT=non-carcass fat, NcVT=non-visceral tissues

Estimates of allometric growth coefficients (Table 3) showed that carcass tissues had a lower growth rate or matured earlier than non-carcass tissues for the period studied. All carcass tissues had a growth value less than 1 in contrast to NcFAT with a value close to 2 and NcVT with a mean value of 1.21. Hence, the growth in NcFAT and NcVT was greater than the sum of all body tissues (CTwt) (P<0.05). The growth coefficient of the two carcass tissues relative to total carcass fat was greater for SFAT than IeFAT (P<0.05).

Discussion and preliminarily conclusion

The large absolute weight of non-carcass fat and the high growth coefficient for this depot suggests that non-carcass fat is an early maturing depot and hence, the most important fat depot in young lambs. In contrast, the lower growth coefficient and the small absolute weight of carcass fat, especially in the first growth period, indicate that deposition of carcass fat starts at later stages in the growth period of lambs than non-carcass fat. The weight of SFAT was lower than that of IeFAT at all scan events suggesting that IeFAT is an earlier maturing carcass tissue compared to SFAT, as SFAT is found to be the largest carcass tissue in older animals (Lambe et al., 2003). Further, lambs seems to have a great potential for growth in LEAN from a mean age of 92 days considering the great change in absolute weight of LEAN from CT2 to CT3.

The greater LEAN:BONE ratio and the tendency of a higher LEAN:FAT ratio suggest that ML will produce a more efficient and higher quality carcass as regards to the level of muscle and fat in the carcass. The difference between the two genetic lines in mean tissue weights implies that selection for CT lean weight at weaning could have altered the growth curves for LEAN, FAT and BONE in the carcass. Alternatively, this could be a combined effect of selection and the introduction of Texel because of the relative strong genetic relationship between growth rate and mature size.

The overall aim of the project is to develop a meatline for use as a sire line for commercial production of high quality slaughterlamb. Until date, semen from the top ML sires are distributed to members of the Norwegian Meat Cooperation. A specific breeding system is recommended for crossbreeding. The interest for the ML among Norwegian farmers' is increasing, partly as a result of the meat companies' greater focus on carcass traits and the differentiation in price according to the weight and quality of the carcass.

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