Effect of age at slaughter on carcass characteristics and carcass composition in lambs of mountain Greek breeds

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ABSTRACT: Forty male lambs of the mountain Greek breed were used to evaluate the effect of age at slaughter on carcass characteristics and composition. The slaughter of lambs was carried out at the age of 30, 45, 60, 75 and 90 days. The slaughter procedure, carcass dissection and carcass composition were realized according to the standard method of CIHEAM-AGRIMED programme. The results of this work showed that the lambs of different age groups did not differ in dressing percentage significantly. The proportion of muscles showed a tendency of increase with the increasing slaughter age but the differences were not significant. The proportion of total fat in carcass increased with the increasing slaughter age from 20.84 to 23.59% for the age group of 30 and 90 days, respectively ($P < 0.05$). On the contrary, as the age at slaughter increased, the proportion of bones decreased ($P < 0.05$). Subcutaneous, intermuscular, perinephric and pelvic fats increased with the slaughter age, but only the subcutaneous fat was influenced significantly ($P < 0.05$). Among the different commercial cuts proportions of long leg, first 5 ribs and shoulder decreased, while those of last 8 ribs-loin and breast-flank increased ($P < 0.05$). The overall results suggest that the slaughter age of lambs of the mountain Greek breed should be increased from the present ~45 days to more advanced age of 75 or 90 days in order to improve the farmers' profits without serious negative effects on the quality of carcasses or meat of lambs.

Keywords: lamb; age at slaughter; carcass characteristics; carcass composition; commercial cuts

The total sheep population in Greece currently numbers about 9 million animals producing annually 670 000 tons of milk and 82 000 tons of meat (Faostat, 2004). The sheep meat accounts for 18% of the total meat production of the country and 7.8% of that of EU. The sheep meat consumption per capita is the highest in the EU countries (~14 kg).

All the Greek local sheep are dual-purpose (milk and meat) animals. The milk-fed lamb carcasses (light lambs) are dominant (65–70%) in the total sheep meat production. Every year about 6 million young lambs are slaughtered, immediately after weaning, at the age of 30–60 days. So the carcass weight, like in the other Mediterranean countries of Europe, is much lower (6–10 kg) in comparison with that of the countries of Central and Northern Europe. The low slaughter weight is due above all to the traditional preference of consumers for meat of young animals considering it to be of better quality (Bernabeu et al., 2005). This choice also tends to be favoured by the traditional farming systems where the farmers often prefer to get rid of lambs as soon as possible considering lamb production as a by-product of lactation (Arsenos and Zygoyiannis, 2005). On the other hand, there are objective reasons for this situation that are related with the higher proportion of fat in the heavier lamb carcasses which characterizes the unimproved dual-purpose sheep breeds (Tzalis et al., 1994). The fat in these carcasses is more saturated at the same time (Cifuni et al., 2000).

The production of heavier carcasses with acceptable quality for consumers could undoubtedly be advantageous for producers by providing higher

profits from meat sales and for consumers by supplying more mature meat with better flavour. But the commercial success of systematic lamb fattening is related with the carcass characteristics and composition (Croston et al., 1987; Kemster et al., 1987a; Taylor et al., 1989). Substantial improvements are therefore needed if lamb is to retain its position in the Greek diet.

In recent studies on the production of heavier lamb carcasses (> 13 kg) from local Greek breeds (Karagouniko, Serres and Butsiko), a possibility of the production of heavier carcasses was confirmed by using different nutritional treatments (Zygoyiannis et al., 1999). This product was more preferable when offered in standard commercial cuts to the consumers who were informed about its nutritional value (Katsaounis et al., 1996). In other studies carried out with the breeds Chios, Atikis, Serron and Karagouniko it was observed that produced carcasses had satisfactory quality at certain slaughter weights but their crosses with imported breeds (East-Friesian, Ile de France, Suffolk, Texel, Charmoise) gave heavier carcasses of higher quality (Skapetas, 1999).

In the last years an increase in the mean slaughter weight of lambs has been noted but it is not a general tendency. The researchers suggest that dairy breeds of sheep may produce leaner carcasses at higher weights on the basis of understanding the effects of genotype, environment and their interactions on the growth and production of such breeds (Butler-Hogg et al., 1986; Zygoyiannis et al., 1990).

The aim of the present study was to evaluate the effect of slaughter age of lambs of the mountain Greek breed on their carcass characteristics and composition.

MATERIAL AND METHODS

Experimental design and animal management

The experiment was carried out in the period March–May 1997 at Vlasti's Animal Husbandry Research and Training Centre in West Macedonia, Greece. Forty single-born male lambs of the mountain Greek breed of sheep were used to evaluate their carcass characteristics and composition. Thirty-two of the above-mentioned animals were weaned at the age of 45 days while the other 8 were slaughtered at the age of 30 days. The slaughter of the animals was realized at the age of 30, 45, 60, 75 and 90 days (eight lambs for each slaughter age). The above age groups were balanced for the lambing date and the birth weight. The last four age groups were balanced for the weaning weight of the animals.

The lambs were kept indoors during the whole experimental period. After weaning the lambs of the four age groups (45, 60, 75 and 90 days) were allotted into adjacent pens (groups of 8 animals) and had a free access to water. During the suckling period (45 days) the lambs were fed supplementary unchopped lucerne hay *ad libitum* (180 g CP/kg DM and 8.6 MJ ME/kg DM) and concentrated mixture (145 g CP/kg DM and 12.3 MJ ME/kg DM). After weaning the lambs were fed *ad libitum* unchopped lucerne hay of good quality and concentrated mixture (pellets, 123 g CP/kg DM and 10.6 MJ ME/kg DM).

Slaughter procedure

For the evaluation of the quantitative and qualitative characteristics of lamb carcasses the standard method of CIHEAM and AGRIMED programme was used (Colomer-Rocher, 1986). The animals were slaughtered after a 24-h fasting period. Initial, final and fasted weight was recorded individually. Blood, skin, head, feet, heart, stomach, liver, hot and cold carcass weight was also recorded. The full and empty digestive tract was weighed. Carcass weight was defined as body weight minus head, feet, skin, digestive tract and internal organs except kidneys and kidney fat. The skinned tail, thymus gland, lateral portion of the diaphragm, perinephric and pelvic fat and testes were retained in the dressed carcass (Colomer-Rocher, 1986).

Carcasses were hung in a cold room of the abattoir at 4°C for 24 h by a standard gambrel of 14 cm through each hock (tarsus), without hind legs being crossed. Shoulders were hung freely with fore legs not tied to the neck. Cold carcasses were weighed and dissected by sawing down the centre of the vertebral column. The two sides were as symmetrical as possible with each other containing one kidney and the perinephric and pelvic fat. The tail was removed and weighed separately. The six anatomical cuts (long leg, shoulder, first 5 ribs, last 8 ribs-loin, breast-flank and neck) were separated from the left side as described by Colomer-Rocher (1986). The six anatomical joints from each lamb

Table 1. Dressing percentage in hot and cold carcasses and carcass composition of lambs

Variables	Age (days) at slaughter				
	30	45	60	75	90
	($\bar{x}$ ± s.e.)	($\bar{x}$ ± s.e.)	($\bar{x}$ ± s.e.)	($\bar{x}$ ± s.e.)	($\bar{x}$ ± s.e.)
Slaughter weight (kg)	11.91 ± 0.63^{a}	15.45 ± 0.46^{b}	18.51 ± 0.78^{c}	21.75 ± 0.95^{d}	24.2 ± 1.21^{e}
Empty slaughter weight (kg)	11.61 ± 0.56^{a}	15.31 ± 0.38^{b}	18.40 ± 0.65^{c}	21.60 ± 0.85^{d}	23.9 ± 0.98^{e}
Hot carcass weight (kg)	6.56 ± 0.33^{a}	8.64 ± 0.33^{b}	9.87 ± 0.60^{c}	11.86 ± 0.65^{cd}	13.3 ± 0.73^{d}
Cold carcass weight (kg)	6.43 ± 0.32^{a}	8.37 ± 0.32^{b}	9.63 ± 0.59^{c}	11.58 ± 0.56^{d}	13.03 ± 0.62^{d}
Dressing percentage in hot carcass (%)	56.50 ± 1.32^{a}	56.41 ± 0.71^{a}	53.64 ± 1.07^{b}	54.90 ± 1.46^{ab}	55.69 ± 1.53^{a}
Dressing percentage in cold carcass (%)	53.98 ± 1.07^{a}	54.17 ± 0.89^{a}	52.03 ± 1.02	53.24 ± 1.38b^{ab}	53.84 ± 1.47^{a}
Carcass muscles (%)	54.65 ± 0.53^{a}	54.98 ± 0.57^{a}	55.31 ± 1.30^{a}	55.26 ± 0.41^{a}	54.89 ± 0.44^{a}
Carcass visible fat (%)	20.84 ± 1.10^{a}	22.96 ± 1.2^{b}	22.43 ± 0.79^{b}	22.87 ± 0.68^{b}	23.59 ± 0.75^{b}
Carcass bones (%)	19.67 ± 0.46^{a}	18.32 ± 0.50^{ab}	18.24 ± 0.56^{ab}	18.20 ± 0.56^{ab}	17.36 ± 0.37^{b}
Carcass remains (%)	3.70 ± 0.32^{a}	3.30 ± 0.22^{a}	3.20 ± 0.16^{a}	3.46 ± 0.20^{a}	3.48 ± 0.26^{a}
Entrails (%)	8.53 ± 0.29^{a}	8.88 ± 0.28^{ab}	9.09 ± 0.18^{ab}	9.55 ± 0.31^{b}	9.67 ± 0.42^{b}
Stomach weight (%)	2.51 ± 0.10^{a}	3.56 ± 0.19^{ab}	3.68 ± 0.49^{b}	6.22 ± 0.58^{c}	6.64 ± 0.28^{c}
Cuts of first grade (%)	55.77 ± 1.06^{a}	53.00 ± 1.18^{a}	51.99 ± 0.90^{a}	52.48 ± 1.20^{a}	52.40 ± 1.06^{a}

^{abcde}within lines, the means not sharing a common superscript differ significantly ($P < 0.05$)

were weighed and were chilled at 0°C. At an opportune time the meat of each cut was dissected into separate tissues (muscles, fat and bones).

In all the experimental lambs the empty body weight was calculated by subtracting the weight of the stomach content from the fasted live weight.

The dressing percentage in hot carcass (true carcass yield) was calculated by the ratio (hot carcass weight/empty body weight) × 100, while the dressing percentage in cold carcass (commercial carcass yield) was calculated by the ratio (cold carcass weight/fasted live weight) × 100.

Statistical analysis

All the measured variables were compared by one-factor ANOVA (SAS, 1995) in order to evaluate the effect of age at slaughter on carcass characteristics and composition of lambs. The mathematical model included fixed effect due to slaughter age and residual error. Multiple mean comparisons were made using Duncan's multiple range test.

RESULTS AND DISCUSSION

In Table 1 the mean values of dressing percentage in hot and cold carcass, of carcass composition (muscles, fat, bone, remains), the percentage of cuts of the first category (pistol) and the proportion of entrails and of empty stomach on the basis of corrected fasted slaughter weight are shown.

These data indicated that dressing percentage reached its highest value at the slaughter age of 45 days and this is explained by the fact that in this age group the growth rate was on the highest level (data not shown). At the slaughter age of 60 days the dressing percentage tends to decrease, and it increased in the age groups of 75 and 90 days. The tendency of dressing percentage decrease 15 days

after weaning can be explained by weaning stress (usually a decrease in weight gains is observed). At the slaughter age of 90 days (at slaughter weight of 24 kg) the dressing percentage was on a similar level to that of 45 days without significant differences. These results are in agreement with those found by Cifuni et al. (2000) in Apulian lambs. They also found that the higher dressing percentage was obtained at the slaughter age of 45 days versus that of 90 days. In other similar studies on Karagouniko and Serres lambs an increase in dressing percentage was noted with the increase in slaughter weight from 24 to 34 kg (Matsoukas et al., 1987). A higher carcass yield was also observed in Chios and Kimis lambs at the slaughter weight of 26 and 30 kg in comparison with that at the slaughter age of 50 days (Gablilides et al., 1993; Papadopoulos et al., 1993). In Serres lambs Tzalis et al. (1994) found the highest dressing percentage at the slaughter age of 42 days (weaning) in comparison with higher ages at the slaughter weight of 25 and 30 kg.

The proportion of muscles in the whole carcass showed an increasing tendency with the increase of slaughter age (Table 1). However, no significant differences were found between the different age groups. It is well known that the muscle tissue is "maturated" earlier in relation to the body weight of lambs. Researchers found a decrease in the lean percentage when the slaughter weight reached 40–76% of the mature weight of sheep (Taylor et al., 1989; Zygoyiannis et al., 1990). In Karagouniko and Kimis lambs a decrease in the muscle percentage was also noted with the increase in the slaughter weight from 26 to 30 kg (Matsoukas et al., 1991; Papadopoulos et al., 1993).

Total fat percentage increased constantly with the increase of slaughter age from 30 (20.84%) to 90 days (23.59%, $P < 0.01$). A relative decrease in this variable was seen in lambs of slaughter age of 60 days because of weaning stress. However, after this age the increasing tendency continued. Regarding the fat content our findings are in agreement with those reported for Serres, Chios and Kimis lambs for the same stage of "maturity" (Matsoukas et al., 1991; Gabrilides et al., 1993; Papadopoulos et al., 1993; Tzalis et al., 1994). From the above, and also from other studies, fat seems to grow at a lower rate in the first stage of lambs' life. But after several weeks the growth rate of this tissue is intensified in comparison with body weight increase. So researchers found that for the same stage of "maturity" (e.g. 40% of adult animals' body

Table 2. Fat partitioning of lamb carcasses

Variables	Age (days) at slaughter						Significance	
	30	45	60	75	90		slaughter age	C.V. (%)
	($\bar{x}$ ± s.e.)	($\bar{x}$ ± s.e.)	($\bar{x}$ ± s.e.)	($\bar{x}$ ± s.e.)	($\bar{x}$ ± s.e.)			
Total fat (%)	20.80 ± 1.10^{a}	23.0 ± 1.2^{b}	22.4 ± 0.79^{b}	22.9 ± 0.68^{b}	23.6 ± 0.75^{b}		***	16.2
Perinephric fat (g)	45.5 ± 0.83^{a}	57.0 ± 0.71^{b}	65.2 ± 1.27^{b}	82.5 ± 0.76^{c}	91.3 ± 0.79^{c}		**	32.6
Perinephric fat (%)	1.3 ± 0.025^{a}	1.4 ± 0.03^{ab}	1.4 ± 0.03^{ab}	1.4 ± 0.03^{b}	1.4 ± 0.04^{b}		**	11.4
Pelvic fat (%)	0.4 ± 0.02^{a}	0.5 ± 0.03^{a}	0.4 ± 0.025^{a}	0.5 ± 0.02^{b}	0.5 ± 0.022^{b}		**	7.5
Subcutaneous fat (mm)	1.7 ± 0.88^{a}	2.3 ± 0.26^{a}	2.2 ± 0.39^{a}	2.6 ± 0.39^{b}	2.8 ± 0.43^{b}		**	29.0
Subcutaneous fat (%)	8.2 ± 0.69^{a}	8.5 ± 0.71^{a}	8.6 ± 0.80^{a}	8.4 ± 0.91^{a}	9.2 ± 0.90^{b}		**	12.6
Intermuscular fat (%)	10.9 ± 1.05^{a}	12.9 ± 0.92^{b}	12.4 ± 0.84^{b}	12.4 ± 0.86^{b}	12.4 ± 0.91^{b}		**	19.6

^{abc}within lines, the means not sharing a common superscript differ significantly ($P < 0.05$)
$^{**}P < 0.01$; $^{***}P < 0.001$

Table 3. Proportions of carcass commercial cuts at different slaughter ages of lambs

Variables	Age (days) at slaughter					Significance	
	30 ($\bar{x}$ ± s.e.)	45 ($\bar{x}$ ± s.e.)	60 ($\bar{x}$ ± s.e.)	75 ($\bar{x}$ ± s.e.)	90 ($\bar{x}$ ± s.e.)	slaughter age	C.V. (%)
Long leg (%)	34.20 ± 0.29^{a}	33.23 ± 0.32^{ab}	32.30 ± 0.66^{b}	32.59 ± 0.46^{b}	31.82 ± 0.34^{b}	**	3.71
First 5 ribs (%)	6.56 ± 0.21^{a}	6.65 ± 0.25^{a}	6.41 ± 0.29^{a}	6.34 ± 0.27^{ab}	6.0 ± 0.20^{b}	*	11.00
Last 8 ribs-loin (%)	18.57 ± 0.26^{a}	19.77 ± 0.51^{ab}	19.7 ± 0.56^{ab}	19.89 ± 0.49^{ab}	20.58 ± 0.56^{b}	**	6.92
Shoulder (%)	20.94 ± 0.35^{a}	19.81 ± 0.24^{b}	19.76 ± 0.24^{b}	19.63 ± 0.41^{b}	19.12 ± 0.40^{b}	**	4.91
Neck (%)	8.33 ± 0.37^{a}	8.41 ± 0.14^{a}	8.31 ± 0.21^{a}	8.77 ± 0.44^{a}	8.53 ± 0.39^{a}	NS	9.83
Breast-flank (%)	11.44 ± 0.25^{a}	11.94 ± 0.28^{ab}	12.87 ± 0.46^{b}	12.88 ± 0.59^{b}	13.80 ± 0.48^{c}	***	8.95

^{ab}within lines, the means not sharing a common superscript differ significantly ($P < 0.05$)

NS = not significant difference; *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

weight) the fat percentage reached 22–24% of carcass weight in dairy-type and 19–20% in meat-type breeds of sheep (Taylor et al., 1989).

The bone proportion in the whole carcass decreased with the increase of age at slaughter (19.67% in lambs slaughtered at 30 days and 17.36% in those of 90 days, $P < 0.05$). This tendency was also noted in lambs of other sheep breeds showing that bones have earlier growth in comparison with muscles and fat (Kemster et al., 1987b; Papadimitriou et al., 1989; Taylor et al., 1989; Tzalis et al., 1994). This phenomenon can be explained by a change in the priority of the blood nutrient use by the body tissues of animals during the different stages of their life.

It can be said that the carcass composition influences the commercial value of lamb meat significantly. On the other hand, the age at slaughter or the maturity stage of lambs is one of the most important factors that determine the carcass composition.

The meat-to-bone ratio of the whole carcass was found to be 1:0.36, 1:0.33, 1:0.329, 1:0.329 and 1:0.32 for the slaughter age of 30, 45, 60, 75 and 90 days, respectively. It was shown clearly that as the age at slaughter increased, the meat-to-bone ratio tended to be improved. This ratio is an important factor of lamb carcass quality because it defines the amount of edible meat in cuts which are largely sold bone-in. Papadimitriou et al. (1989) found the meat-to-bone ratio 1:0.39 in Karagouniko and Chios lambs slaughtered at 30 kg. In the lambs of meat-type breeds researchers found a better meat-to-bone ratio that ranged from 1:0.22 to 1:0.30 (Croston et al., 1987).

The proportion of the first grade wholesale cuts (long leg, last 8 ribs-loin) ranged from 53.0% in lambs slaughtered at 45 days of age to 52.4% at those slaughtered at the age of 90 days. This variable remained at a similar level for the 5 age groups of the experiment and was not significantly affected by the age at slaughter. Similar results were obtained by other researchers in lambs of Karagouniko, Chios and Serres breeds (Matsoukas et al., 1991; Gabrilides et al., 1993; Tzalis et al., 1994). In English meat-type lambs the percentage of the first grade cuts was not found to be influenced by the age or slaughter weight of lambs (Kemster et al., 1987a).

The empty stomach percentage in corrected slaughter weight increased rapidly between the age of 30 and 90 days from 2.51 to 6.64% ($P < 0.001$). These significant differences are explained by the

intensive functional changes in the digestive tract of lambs that took place with the age increase. As it has been shown, at the age of 60 days the complex stomach of lambs achieves its normal development and after that age the proportion of different compartments is the same as in adult animals. A tendency of significant increase was also noted for the percentage of entrails with the increase of slaughter age ($P < 0.05$) after the age of 60 days.

The fat partitioning among different fat depots in the whole carcass is shown in Table 2. A gradual increase on perinephric fat was noted either in absolute values (g/half-carcass) or in percentage ($P < 0.05$) with the increase of age at slaughter. Pelvic fat (%) followed the same patterns with statistically significant differences at slaughter ages of 75 and 90 days in comparison with the other slaughter ages ($P < 0.01$). The depth of subcutaneous fat (mm) also increased significantly at the slaughter ages of 75 and 90 days ($P < 0.01$). The increase in perinephric and pelvic fat (g and %) and the depth of subcutaneous fat with the advancement of slaughter age of lambs is explained by the increase of total carcass fat versus the muscle and bone tissues after a certain slaughter age of animals (Matsoukas et al., 1987; Taylor et al., 1989).

In other works it was shown that the perinephric and pelvic fat in dairy and dual-purpose breeds was highly correlated with the total carcass fat. For this reason their percentage is considered as an important index of carcass composition (Taylor et al., 1989). In lambs slaughtered at 45 days the intermuscular fat accounts for 12.60%, the subcutaneous for 8.5%, the perinephric for 1.36% and the pelvic fat for 0.45% of the total visible carcass fat.

In Table 3 the average values of commercial cut percentages in lamb carcasses are given. The data document that the proportions of long-leg ($P < 0.01$) and shoulder ($P < 0.01$) gradually decreased from the slaughter age of 30 to that of 90 days. The percentage of the last 8 ribs-loin increased from 11.44% (30 days) to 13.8% (90 days, $P < 0.01$), while the percentage of the first 5-ribs decreased from 30 to 90 days of slaughter age ($P < 0.05$). Our data are in line with those obtained by other researchers as regards the proportions of different carcass commercial cuts (Buterfield et al., 1984; Tzalis et al., 1994). In suckling lambs of Manchega breed Diaz et al. (2005) found that the individual carcass cuts were not affected by the slaughter weight except for loin-rib which had a higher proportion in heavier lambs compared to lighter ones.

The changes in the proportions of lamb carcass commercial cuts with the increase of age at slaughter are due to differences in the growth of body tissues (muscles, fat and bones) of animals in relation to body weight in the different regions of their body (Butterfield et al., 1984; Teixeira et al., 1996).

CONCLUSION

The results reported here show that the carcasses of lambs of the mountain Greek breed slaughtered at different slaughter ages (30, 45, 60, 75 and 90 days) did not differ significantly in dressing percentage and proportion of the first grade cuts and muscles. The proportion of the total carcass fat increased while that of bones decreased. As regards the different commercial cuts, the proportion of the last 8 ribs-loin and that of breast-flank increased while that of long leg, first 5 ribs and shoulder decreased. It was confirmed that the slaughter of lambs might be carried out at higher ages (75 or 90 days) in order to produce heavier carcasses that are acceptable for consumers.

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