

INFLUENCE OF THE REARING SYSTEM AND SEX ON THE ADIPOCYTE SIZE AND DISTRIBUTION IN DIFFERENT FAT DEPOTS IN LAMBS

V. VASILEVA, P. MARINOVA and T. POPOVA
Institute of Animal Science, BG-2232 Kostinbrod, Bulgaria

Abstract

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The experiment was carried out with 30 lambs at the age of 75 days of the local Zapadnostaroplaninska sheep breed. The animals were divided in three groups according to the rearing system (indoors and on pasture) and the sex. 10 lambs were allowed to graze natural pasture, and additionally received concentrates of 250g/d/animal. The animals reared indoors received a commercial concentrate and hay.

The aim of the study was to compare the influence of the rearing system and sex on the adipocyte size and distribution in the perirenal fat and muscle tissue.

The rearing system led to a decrease of the content of the perirenal and intramuscular fat in the pastured lambs. Lower percentage of intramuscular fat content in m.Semimembranosus and the smaller proportion of adipocytes with average diameter were found in the male compared to the female lambs. Female unlike the male animals had a larger population of bigger cells within the range of 19-39 μm which is related to higher capacity for lipid synthesis.

The results obtained suggest that the changes in the lipid deposition and metabolism due to the rearing system and sex could lead to further improvement of the sensory traits and optimal composition of meat in relation to the human health and nutrition.

Key words: lambs, rearing systems, adipocytes

Introduction

The deposition of intramuscular fat or so called marbling of the meat is a quality trait which influences the consumer perception of taste, juiciness and tenderness (Platter et al., 2005). In the last decade many studies focus on the marbling of the meat. Still the results obtained do not fully clarify the mechanisms of

the changes in the development and composition of the adipose tissue as well as the adipocytes of the muscle tissue under the influence of different endogenous and exogenous factors (Azain, 2004; Yang et al., 2006).

The carcasses obtained from lambs reared on pasture are smaller, with less subcutaneous and internal fats which is reflected by their degree of fatness, evalu-

ated by the (S) EUROP system (Stankov et al., 2001; Ignatova et al., 2005). The adipose tissue of these animals has an optimized composition and decreased values of n-6/n-3 PUFA ratio which respond to the contemporary concepts for dietetic nutrition in relation to the prevention of the risk of cardio-vascular diseases, diabetes, obesity, etc. (Fisher et al., 2000; Schmidt et al., 2001; Aurousseau et al., 2007).

The present study is a part of a larger experiment on the quality of carcass and meat in lambs reared on pasture and indoors.

The object of the experiment was to study the influence of the rearing system and sex on the adipocyte size and distribution in muscles and perirenal adipose tissue in lambs.

Material and Methods

The experiment was carried out with 30 lambs from local Zapadnostaroplaninska sheep breed. The initial live weight of the animals averaged 13.4 kg (± 0.9) at the age of 75 days. The lambs were divided in three

groups according to the rearing system and sex. The first group consisted of 10 ram lambs which were reared on pasture in the Experimental unit of the Institute of Animal Science (Zlatusha region) where *Nardus Stricta* dominated. Additionally the animals received a commercial concentrate with crude protein content of 14.34 % and metabolizable energy value of 11.13 MJ/kg, at a rate of 250 g/d/animal. The other animals, divided in two groups according their sex, were housed indoors. They had *ad libitum* access to water, commercial concentrate (CP-17.43 %, ME-10.82 MJ/kg) and hay. The main diet composition is described in details elsewhere (Ignatova et al., 2005; Banskalieva et al., 2005).

The animals were slaughtered at the age of 135 d. The average weight of the carcass was 5.87 kg (± 0.28) and 8.61 kg (± 0.25) for the pastured and indoors reared lambs respectively.

Samples of 1 cm³ of periranal fat, *m. Longissimus dorsi* (m. LD), *m. Semimembranosus* (m. SM) and *m. Supraspinatus* (m. SP) were taken from five animals of each group. The microscopic cuts with

Table 1

Weight, fat content and average diameters of adipocytes in different fat depots in male and female lambs, reared on pasture and indoors

Items	Groups			Level of significance	
	On pasture, male	Indoor, male	Indoor, female	A	B
	$\bar{x} \pm S \bar{x}$	$\bar{x} \pm S \bar{x}$	$\bar{x} \pm S \bar{x}$		
Weight of perirenal fat, g	17.80 \pm 2.50	38.40 \pm 7.50	27.00 \pm 8.00	*	NS
Diameters of adipocytes in perirenal fat, μm	20.90 \pm 0.58	27.26 \pm 0.35	-	***	-
Fat content in m.LD, %	1.45 \pm 0.13	2.52 \pm 0.15	2.69 \pm 0.13	***	NS
Diameters of adipocytes in m.LD, μm	19.28 \pm 1.22	19.47 \pm 1.96	25.35 \pm 1.12	NS	*
Fat content in m.SM, %	2.03 \pm 0.21	2.24 \pm 0.15	2.44 \pm 0.11	NS	*
Diameters of adipocytes in m.SM, μm	18.28 \pm 1.42	18.51 \pm 1.86	25.69 \pm 0.41	NS	**
Fat content in m.SP, %	1.92 \pm 0.13	2.78 \pm 0.21	2.81 \pm 0.11	**	NS
Diameters of adipocytes in m.SP, μm	20.65 \pm 1.31	20.47 \pm 1.43	25.35 \pm 0.76	NS	**

P<0.05*; P<0.01**; P<0.001***, NS - Non significant (P > 0.05)

A - level of significance of difference between male lambs reared on pasture and indoors

B - level of significance of difference between male and female indoor reared lambs

thickness of 16 μm for the perirenal and 10 μm for the muscles were made by microtome Cryo-Cut. The coloration of the adipocytes was made by Sudan III and after that the average diameter was determined in 3-5 visible fields in 100 cells per sample using an eyepiece micrometer. The size of the adipocytes population in the histograms is showed in percent.

Statistical evaluation of the results was made by t-criterion of Student at the level of significance $P < 0.05$ - *; $P < 0.01$ - **; $P < 0.001$ - ***.

Results and Discussion

The results for the weight of the perirenal and the extracted intramuscular lipids from m.LD and m.SP showed significant influence of the rearing system on these traits (Table 1). The higher weight of the perirenal fats in the ram lambs reared indoors was proved at lower level of significance ($P < 0.05$) which is due to the larger variation of this trait. However the adipocyte diameter of this fat depot was significantly larger ($P < 0.001$) in the ram lambs housed indoors which corresponded to the higher amount of deposited fat. No significant differences were observed in the average diameter of adipocytes in the muscles between pastured and indoors reared ram lambs, but the latter had higher amounts of extracted lipids in

m.LD ($P < 0.001$) and m.SP ($P < 0.01$). According to Owens et al. (1993) tissues have different growth rates during the post natal development which is related to the incorporation of the lipids in the fat depots and muscles by increasing of the number (hyperplasia) and the size (hypertrophy) of the adipocytes. In this study the higher amount of the perirenal fat could be linked to the larger size of the adipocytes, because this fat depot develops earlier after birth (Eginoa et al., 2003).

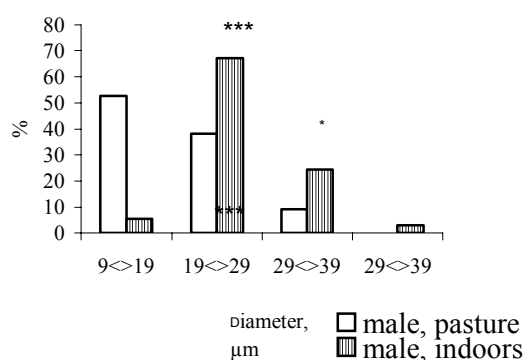
Similar trend was observed in the intramuscular lipids as well, because the larger adipocyte diameter in m.LD and m.SP corresponded to the higher amount of the extracted lipids (Marinova, 2000; Mourot et al., 1999).

The sex of the lambs reared indoors did not affect significantly the amount of the perirenal fat and intramuscular lipids in m.LD and m.SP. The female lambs had higher amount ($P < 0.05$) of intramuscular fat in m.SM compared to the ram lambs. The adipocyte diameters in the three muscles studied were significantly smaller ($P < 0.05$, $P < 0.01$) in the male lambs which corresponded to the lower amount of fat in these animals in comparison to the females.

The results obtained in this study were confirmed by Eginoa et al. (2003) and Hansen et al. (1995), whose research showed higher capacity for lipid synthesis in female ruminants as well as larger adipocytes.

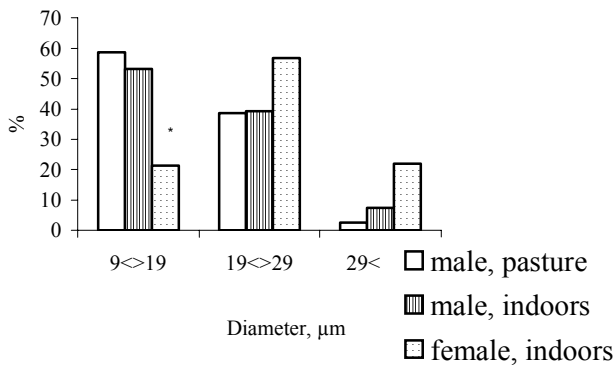
The smaller average diameter of the adipocytes in the perirenal fat (Figure 1) in the pastured animals was formed by a significant relative proportion of adipocytes with size up to 29 μm (90.8%), while in the animals reared indoors the relative part of the adipocytes with such size is 72.6%. The differences in each interval are proved at different level of significance.

The results of the histograms (Figures 2, 3 and 4) concerning the adipocyte size distribution in m.LD, m.SM and m.SP showed the absence of significant differences in the relative proportion of the adipocytes between the animals reared on pasture and indoors. The data for the lower part of the adipocytes with diameter up to 19 μm showed significant differences between sexes ($P < 0.05$, $P < 0.01$). In the ram lambs the part of the cells with a size 19-39 μm was smaller,



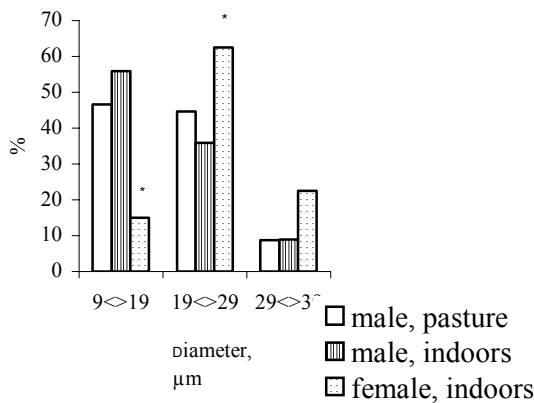
$P < 0.05$ - *; $P < 0.001$ - ***, level of significance of difference between male in pasture and male indoor reared lambs

Fig. 1. Adipocyte size distribution in perirenal fat



P<0.05*, level of significance of difference between male and female indoor reared lambs

Fig. 2. Adipocyte size distribution in m.LD in lambs



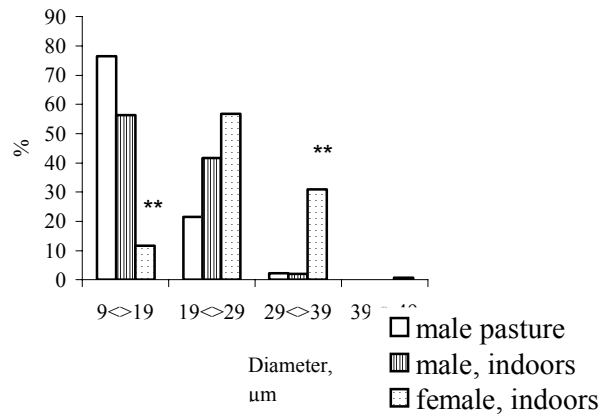
P<0.05*, level of significance of difference between male and female indoor reared lambs

Fig. 4. Adipocyte size distribution in m.SP in lambs

proved at different intervals for m.SM and m. SP. These results showed that the larger average diameter of the adipocytes in the female lambs was formed by a higher relative part of the population of cells with a size of 19-39 μm .

The decreased content of perirenal and extracted intramuscular lipids as well as the smaller average size of the adipocytes in the pastured animals was accompanied by improved ratio 18:2/18:3 in these animals (Banskalieva et al., 2005; Popova et al., 2007).

Comparing the results concerning the content of oleic acid at the same experimental design (Popova,



P<0.01**, level of significance of difference between male and female indoor reared lambs

Fig. 3. Adipocyte size distribution in m.SM in lambs

2007) it might be suggested that the larger relative part of the adipocytes with smaller size corresponded to the lower amount of oleic acid in m.LD and m.SM in the pastured animals. The fatty acid composition of the depots with different anatomical location is related to the different levels of acetyl CoA carboxilase and stearoyl CoA desaturase. These enzymes affect specifically the size of the adipocytes in the fat depots. The amounts of stearoyl CoA desaturase are also related to the percentage of the oleic acids in the muscle adipocytes (Barber et al., 2000; Daniel et al., 2004).

In their research Raclot et al. (1997), Perez-Matute et al. (2005) and Liu et al. (2005) suggested that the adipocyte size was related to the percentage and the composition of the polyunsaturated fatty acids which inhibit the display of the adipocyte determination and this of the genes responsible for the fatty acid synthesis. This effect could be related in particular with the concentration of the eicosapentaenoic acid as its elevation decreases lipogenesis and increases the lipolysis. In this study the larger associations of muscle adipocytes of smaller size in the pastured animals corresponded to the higher content of eicosapentaenoic acid (Popova et al., 2007). Perhaps the influence of the eicosapentaenoic acid is mediated through its leptin inducing effect on adipocytes and leptin is known to inhibit lipogenesis and stimulate lipolysis in adipose tissues (Shirai et al., 2004; Caro et al., 1996).

Conclusion

The average adipocyte diameter in the perirenal fat was smaller in the pastured animals which was related to the earlier postnatal development of this fat depot compared to the muscles. A tendency toward increased average diameter in the early developing muscles (m.LD, m.SP) was observed.

The diversities in the intramuscular lipid in m.SM and the average adipocyte diameter in the three muscles between the two sexes were significant. The larger average diameter in the female animals was formed by a larger relative proportion of the population of cells with size of 19-39 μm , which was related to higher capacity for lipid synthesis.

It could be suggested that the changes in the lipid deposition and metabolism due to the rearing system and sex which are reflected from the results in this study may lead to better sensory traits and optimal composition of meat in relation to the human health and nutrition.

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