EFFECT OF DIET COMPOSITION, PHYSIOLOGICAL STATE AND AGE ON FIBRE TYPE PROPERTIES OF *m.Longissimus dorsi* IN SHEEP

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Background

The current trends in growing animals are addressed to deposition of more muscle tissue. The size and proportion of the different fibres types reflect on the formation of muscles and meat quality. Previous studies with lambs and hoggets (Marinova et al., 1992; Shindarska et al., 1992; Banskalieva et al., 1995; Ivanov et al., 1995; Marinova, 2000) showed that varying energy/protein density of diet, castration, or increasing age or live weight of animals, changed meat deposition and had some effect on physicochemical characteristics of *m.Longissimus dorsi*. However no information was received concerning fibre type properties of studied muscles.

Objectives.

The purpose of this study was to investigate the effect of the diet composition, physiological state and age on size and relative parts of oxidative, oxidative glycolytic and glycolytic fibres *of m.Longissimus dorsi* in sheep.

Methods

Two experiments, involving male lambs and hoggets of the semi-fleeced breed, were carried out. In Experiment I two groups of lambs (12 each) from weaning of at an age of 45 days to 165 days of age were fed with a diet of different energy and protein contents (Table 1, Diet 1 and Diet 2, Groups A1 and A2, respectively). In Experiment II eight animals, fed with Diet 1 were castrated at 10 months of age. Two groups (castrated and uncastrated hoggets) received Diet 3 for a period of 6 months (Table 1).

Table 1. Diet composition

Ingredients (g kg^{-1} diet)	Diets		
	D1	D2	D3
Corn	119	85	-
Barley	68	84	120
Wheat	90	200	115
Sunflower meal	90	255	-
Wheat bran	77	212	50
Urea	-	-	6
Vitamins, ADE	2	3	-
Trace elements mixture	1	2	2
Dicalcium phosphate	1	3	2
Limestone	1	3	2
Salt	1	3	3
Prairie hay	550	150	700
Net energy (MJ kg^{-1} diet)	4.2	6.0	4.1
Crude protein (g kg^{-1} diet)	130	200	130

Samples for histochemical analysis from *m. Longissimus dorsi* (LD) were taken 45 min after slaughter and frozen in liquid nitrogen until determinations. Histochemical analysis was carried out on cross serial cuts, 16 μm of thickness and coloured for succinatedehydrogenase (Nachlas et al. 1957), α-glycerophosphatdehydrogenase (Dubowitz and Brooke, 1973) and myofibrillar ATP-ase activity (Guth and Samaha, 1969). Muscle fibres were classified as slow oxidative (So), fast oxidative glycolitic (FoG) and fast glycolitic (FG) types, according the nomenclature of Peter et al. (1972).The diameters and proportions of fibres were the mean of measurements of each 100 of both FG and FoG types, and 50 of So type, of 5 fields of vision. For statistical evaluation of the results Student's *t*-test was used.

Results and discussion

With elevation of energy (Table 1, Diets, D1 and D2) no significant changes in length and weight of m.LD in lambs were observed (Table 2, Groups A1 and A2). The diameters of all three metabolic types of fibres increased but at different degree (So – with 5.9%; FoG – with 14.1%; FG – with 12%), accompanied by a slight change in proportions in each one. Despite of the tendency of decrease, the majority of FoG and FG fibres types determine the higher value (significant at $p < 0.05$) of cross sectional area of m.LD in animals from group A2, compared with group A1. The results suggest that the increase of cross sectional area of m.LD in that period of post-natal development of lambs was mainly due to greater increase of fibre diameters, similar to data of Suzuki (1991) for sheep. On the other hand, the variations in fibre type proportions suggest a change in muscle metabolism toward more oxidative, less glycolytic capacity, with increasing energy and protein density of diet. Oksbjerrg et al. (1994) however reported that the changes in fibre type distribution in m.LD in pigs, were independent of dietary protein content, in contrast to muscle anabolism. According to Vestergaard et al. (1994), the greater number of capillarities in contact with the smaller type So fibres compared with larger type FG fibres might explain the fibre differences in energy metabolism and function

Changed physiological state (castration of hoggets – Experiment II) did not induce marked changes in the properties of the three types of muscle fibres (Table 2, Group B1 and B2). The tendency of an increase of proportion of the glycolytic type fibres (FG) reflects on the value of cross sectional area of m.LD, being higher in castrated animals (25.2 sm^2 vs. 21.6 sm^2). Presumably, regardless of complex changes which occurred in hormonal status immediately after castration, the late age of castration, when muscles types were formed and long-term rearing afterwards (6 months) induces a certain metabolic adaptation by the organism, where muscle fibre types are not so significant.

Of interest are results from animals (lambs and hoggets; Groups A1 and B1) fed diets similar in energy and protein (4.1 MJ kg^{-1} and 130 g^{-1} diet, respectively), but with some changes in ingredient composition (Table 1, Diets D1 and D3). In the first case, roughage/concentrates feed ratio was 55:45 and the diet conformed to intensive growth of animals in the age of 1.5 to 5.5 months. In the second case, roughage/concentrate feed ratio was 70:30 for animals completing their growth. A marked age effect on the relative parts of the different fibre types was observed. In older animals (group B1) the proportion of glycolytic type fibres (FG) increased ($p < 0.01$), accompanied by a reduction of oxidative glycolytic fibre type ($p < 0.01$). The increased cross sectional area of m LD in hoggets (group B1), compared with that of lambs (group A1), is due to higher relative part of fibres with bigger diameters (FoG and FG), despite of elevation of oxidative type fibres. Similar changes (transformation of FoG to FG) were established in post-natal development of sheep (wool type) between 45 and 360 days of age (Marinova, 2000). Maltin et al. (1990) showed that an increase of size and proportion of fast-twitch muscle fibres correlates well with an apparent increased capacity to metabolise glycogen. However, Vestergaard et al. (1994) found an increase of muscle oxidative potential, with elevation of live weight of bulls, but not changes in glycolytic.

In conclusion, the results of the present study demonstrate that age and physiological state of animals exert their effect on properties of m.LD by changes in proportions of the different metabolic types of fibres, whereas the effect of protein/energy density of diet, was not only on the relative parts of the three fibre types, but also on their size. The biochemical mechanisms, controlling formation of muscle fibres types and their conversions are still unclear and need further investigations.

Table 2. Influence of diet composition, physiological state and age on fibre type properties of *m.Longissimus dorsi* in sheep

Parameters	Experiments									
	I. Lambs					II. Hoggets				
	Groups					Groups				
	A1		A2			B1		B2		
	Mean	Sx	Mean	Sx		Mean	Sx	Mean	Sx	
Cross sectional area 12th rib, cm^2	17.2	0.5^a	20.6	0.9	*	21.6	1.5^b	25.2	1.0	NS
Length, cm	35.2	1.8	37.7	1.9	NS	39.0	1.1	35.9	1.3	NS
Weight, g	473	35.1	424	36.6	NS	538	47	568	33	NS
Fibre types,										
- diameters, μ m										
So	35.9	1.59	38.0	0.31	NS	33.7	2.7	36.6	2.1	NS
FoG	36.3	0.71	41.4	1.05	NS	37.2	1.7	37.5	0.9	NS
FG	37.5	0.87	42.0	0.40	NS	37.8	0.9	37.7	1.2	NS
- proportions, %										
So	9.2	0.63	14.5	1.93	NS	12.5	1.7	10.3	1.4	NS
FoG	61.8	0.62^a	59.0	3.46	NS	49.0	1.6^b	47.5	4.5	NS
FG	29.0	1.22^a	26.5	1,93	NS	38.5	1.6^b	42.2	4.8	NS

NS – non-significant;
* $p < 0.05$, Significance of difference between groups A1 and A2;
a,b $p < 0.01$, Significance of difference between groups A1 and B1.

Pertinent literature

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