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Chemical and physical characteristics of lamb meat related to crossbreeding of Romanov ewes with Suffolk and Charollais sires

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ABSTRACT

The aim was to evaluate the effects of crossbreeding Romanov (RO) ewes with Suffolk (SF) and Charollais (CH) sires on the chemicophysical characteristics and FA profile of the *Quadriceps femoris* muscle (QFM) in lambs fattened under organic conditions. The experimental animals were male lamb twins of two different crossbreds; CH 50 RO 50 and SF 50 RO 50. Lambs were slaughtered at an average live weight of 31 kg. CH 50 RO 50 displayed higher contents of dry matter and intramuscular fat of the QFM. A lower pH value of CH 50 RO 50 was reflected in an increase of WHC. Meat of SF 50 RO 50 lambs had more lightness (L*) and yellowness (b*). The CH 50 RO 50 genotype showed a significantly higher proportion of C18:3n−3cis and n−3 PUFA than the SF 50 RO 50 genotype. The genotype also affected the Δ^9-desaturase (16) index.

1. Introduction

Most sheep farms on mountainous areas in the Czech Republic (CR) raise mainly meat type breeds (Suffolk, Charollais and Oxford down) and selected dual and multi-purpose type breeds (Romney March, Šumavská breed and Merinolandschaf). However, recently the number of Romanov sheep has increased.

The Romanov breed (RO) is renowned worldwide for its early sexual maturity, long breeding season and high prolificacy (Stanford, Wallins, Jones, & Price, 1998). Furthermore, within the prolific type sheep Shrestha, Boylan, and Rempel (2008b) found that the RO breed achieved higher prolificacy and fecundity, heavier ewe weight, favourable lamb survival and heavier total lamb weights. On the other hand, a typical feature of this breed is a relatively low growth rate and poor carcass quality compared to traditional meat type breeds. The fastest and the simplest way of improving the growth and carcass quality in RO lambs consists of using commercial crossing with the meat type breeds (Stanford et al., 1998). In this regard the Romanov ewes are the most frequently crossed with Suffolk (SF) sires in the CR (Zapletal, Kuchtík, & Dobeš, 2010) and also relatively frequently with Charollais (CH) sires.

Today's consumers are currently searching for healthier foods, with lower fat and cholesterol contents (Costa et al., 2009). The profile of fatty acids in the human diet has received increased attention due to their impact on human health. Lamb fat deposition and composition of fatty acids (FA) can be influenced by many factors including breed, gender, age/body weight, fatness, depot site, environmental conditions, diet, and rearing management (Diaz et al., 2005). The effect of crossbreeding on the FA composition of lamb meat has been confirmed by Salvatori et al. (2004). There are only a few studies evaluating the nutritional quality of lamb meat fattened under organic farming conditions (Angood et al., 2008; Nurnberg et al., 2006; Zapletal et al., 2010), and there is little or no information about the FA composition of lamb meat in crossbreeding Suffolk × Romanov or Charollais × Romanov.

The aim of this study was to evaluate the effects of crossbreeding Romanov ewes with Suffolk and Charollais sires on the chemicophysical characteristics and fatty acid profile of the *Quadriceps femoris* muscle in lambs fattened under organic conditions.

2. Materials and methods

2.1. Animals and experimental design

The experiment was carried out at an organic sheep farm in Kuklík, located in the Vysočina region of the Czech Republic (the farm is situated at 680 m above sea level with an average annual temperature of 6.8 °C and precipitation of 965 mm). The experimental animals were male

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lamb twins of two different crossbreds of Romanov breed; Charollais–Romanov (CH 50 RO 50, n = 10) and Suffolk–Romanov (SF 50 RO 50, n = 10). All lambs were born indoors during March 2009. From their birth to May 3 all lambs were housed indoors with their mothers.

The daily feeding ration (DFR) of the ewes in the period from parturition until the May 3 consisted of haylage (2.5 kg/ewe), meadow hay (ad libitum) and organic mineral lick (ad libitum). The DFR of the lambs during the same period consisted of mother's milk (ad libitum) and organic mineral lick (ad libitum); the lambs had also free access to the feedstuff of their mothers.

On May 4 the ewes with their lambs were placed on permanent pasture, where the DFR of ewes consisted of medium quality grass (ad libitum) and organic mineral lick (ad libitum). The DFR of lambs till slaughter, consisted of mother's milk (ad libitum), medium quality grass (ad libitum) and organic mineral lick (ad libitum). The weaning of lambs was carried out just before slaughter. During the experiment, all of the lambs were reared in one flock under identical conditions without any discernible differences in nutrition or management.

The lambs of both genotypes were slaughtered at similar average live weights of 31 kg (31.79 kg for CH 50 RO 50 and 31.22 kg for SF 50 RO 50); they were slaughtered according to EU laws. Procedures were conducted according to the guidelines of the Council Directive 86/609/EEC on the protection of animals used for experimental and other scientific purposes. The meat production characteristics, such as live weight (LWS), age at slaughter and average daily gain (ADG) were evaluated on the day of slaughter. On the following day, after a chilling period of approximately 24 h, the cold carcass weight (CCW), dressing percentage and the kidney fat weight were evaluated. On the same day the samples of *Quadriceps femoris* muscle (QFM) were collected for subsequent chemical and physical analyses.

2.2. Chemical, physical and fatty acids analysis

The content of dry matter was determined in homogenised meat samples mixed with dry sea sand; the samples were pre-dried at 60 °C for 2 h and then dried at 105 °C for 6 h. The protein content was calculated as the percentage of nitrogen multiplied by 6.25. Collagen content was determined by the AOAC (Association of Official Analytical Chemists) (1996) method. Myoglobin (Mb) concentration was measured as described by Hornsey (1956) and expressed as mg Mb/g of fresh meat. The ash content was determined by burning in a laboratory furnace at 550 °C for 8 h. The content of fat was determined by extraction with diethyl ether in the Soxhlet extractor for 6 h; the extraction was performed without acid hydrolysis.

PH value (pH 24) was measured on freshly cut surfaces of the *Quadriceps femoris* muscle by direct probe using a pH 340/SET-1 WTW (Germany). Water-holding capacity (WHC) was determined in duplicate in fresh meat (5 g) following the method of Grau and Hamm (1953) and then expressed as a percentage of expelled water. Meat colour was assessed by the L* a* b* system (Centre Internationale de l'Eclairage, 1976) using a Konica Minolta CM-2600d spectrophotometer (Minolta Camera Co., Ltd, Osaka, Japan), utilising an integrated specular component, a D_{65} illuminator, and a 10° observer. The sample thickness was at least 12 mm. The samples were not covered and analysis was made at the laboratory temperature. Every sample was measured five times and the average value was calculated.

Duplicate samples of the extracted fat (40–60 mg) were dissolved in isooctane and homogenised in a sonication bath. After the addition of sodium methanolate, the mixture was heated for 5 min using a reflux condenser. After the addition of BF_3, the CH_3ONa not used in the reaction was neutralised and if there still were any free FA, they were esterified in the acid environment. The mixture was heated again for 5 min using the reflux condenser. Isooctane was added to the hot mixture of reagents, which was shaken and left to stand for 1 min. After that, saturated water solution of NaCl was added and FAMEs were shortly shaken out to get to the isooctane phase. The organic and water phase were separated and FAMEs were analysed via capillary gas chromatography. The analysis of fatty acids was performed by a gas chromatograph HP 4890D (Hewlett Packard) with a flame ionisation detector (GC-FID). The separation was carried out using a capillary column DB-23 (60 m × 0.25 mm × 0.25 μm) with the following temperature programme: 100 °C for 3 min then 10 °C/min to 170 °C then 4 °C/min to 230 °C, held for 8 min then 5 °C/min to 250 °C, held for 15 min; the injector temperature was 270 °C, and the detector temperature was 280 °C. The injection volume was 2 μl and the carrier gas was nitrogen. Final chromatograms were processed via the programme Chromatography Workstation (ver. 1.7, Apex Data, CZ). The result is the content (%) of FA. Atherogenic and thrombogenic indices were calculated according to Ulbricht and Southgate (1991) as:

$$\text{Atherogenic index (AI)} = \frac{C12:0 + 4 \times C14:0 + C16:0}{\Sigma MUFA + \Sigma PUFA(n-6) \text{ and } (n-3)}$$

$$\text{Thrombogenic index (TI)} = \frac{C14:0 + C16:0 + C18:0}{0.5\,\Sigma MUFA + 0.5\,\Sigma PUFA(n-6) + 3\,\Sigma PUFA(n-3) + (n-3)/(n-6).}$$

2.3. Statistical analysis

Statistical analyses were performed using STATISTICA CZ version 6 (StatSoft, Inc, 2001). ANOVA analysis was used to study the differences in the birth weight (BW), LWS, age at slaughter, ADG, carcass traits, chemical and physical characteristics, and FA composition and ratios of the *Quadriceps femoris* muscle as two independent groups of genotypes. When the analysis of variance showed significant differences between the groups, Tukey's test was used. The differences were considered significant if $P<0.05$.

3. Results and discussion

3.1. Growth rate and carcass characteristics

The birth and slaughter weights, age at slaughter, average daily gain, carcass traits (weight of cold carcass and kidney fat) are summarised in Table 1. CH 50 RO 50 lambs were significantly younger at slaughter with higher ADG in the period from birth to slaughter. The effect of genotype on the growth rate of lambs has been reported by Burke, Apple, Roberts, Boger, and Kegley (2003) and Costa et al. (2009). The growth rate of both genotypes was higher than reported by Costa et al. (2009) and Scerra et al. (2010) in relatively intensively fattened lambs. By contrast, the ADG of the Suffolk crossbreds was low compared to the results for these crossbreds published by Snowder and Duckett (2003) and Shrestha, Boylan, and Rempel (2008a). Nevertheless the ADG of the Suffolk crossbreds in the present study is in

Table 1
Mean values of live weights, age, gain and carcass quality traits.

Traits	Genotype				Sign.
	CH 50 RO 50		SF 50 RO 50		
	x	s.e.m	x	s.e.m	
Birth weight (kg)	3.38	0.08	3.27	0.11	ns
LWS (kg)	31.79	0.71	31.22	0.60	ns
Age at slaughter (day)	129.4	4.49	146.8	1.44	*
ADG (g)	221.3	7.28	190.4	3.91	**
CCW (kg)	13.74	0.32	13.21	0.24	ns
Dressing percentage (%)	43.26	0.67	42.33	0.28	ns
Kidney fat (kg)	0.19	0.02	0.09	0.01	**

x: mean; s.e.m.: standard error of the mean; ns: non-significant; **: ($P<0.01$); *: ($P<0.05$).
LWS: live weight at slaughter; ADG: average daily gain; CCW: cold carcass weight.