Mechanical quality of leather in Texel lambs and their crossbreds

Mechanická kvalita kůže jehňat plemene Texel a jejich kříženců

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Abstract

High quality leather of small ruminants is a valuable raw material for various industrial sectors. Sheep breeding system was significantly re-oriented and focused on meat breeds in the Czech Republic during last 15 years. Therefore, the objective of work was to evaluate effect of Texel genetic portion and body part on selected quality traits of sheep leather as an additional product of its breeding. A total of 10 leathers of purebred Texel lambs (T100) and 10 leathers of Merino x Texel crossbred (T50) were analysed. The basic indicators of leather quality namely leather thickness (LT, mm), yield strength (YS, μm), tensile strength (TS, MPa), and breaking point (BP, μm) were measured and evaluated in relation to selected factors. LT of crossbreds with 50% of Texel genetic portion was by 0.1616 ($P < 0.001$) mm thicker than in pure-bred Texel lambs. Body part of leather significantly ($P < 0.05$-0.01) affected all characteristics evaluated except BP. Results documented necessity of more detailed further research focusing on leather quality of meat breeds of sheep.

Keywords: breaking point, mechanical properties of leather, tensile strength, Texel sheep, thickness

Abstract in native language

Vysoce kvalitní kůže z malých přežvýkavců je cennou surovinou pro různá průmyslová odvětví. Systém chovu ovcí v České republice v průběhu posledních 15 let byl značně pře-orientován a zaměřen na masná plemena. Cílem práce bylo proto vyhodnotit vliv podílu krve ovcí plemene Texel a tělesné partie na vybrané ukazatelé kvality ovčích kůží jako dalšího produktu z chovu. Celkem bylo analyzováno 10 kůží od čistokrevných jehňat Texel (T100) a 10 kůží od kříženců Merino x Texel (T50). Základní ukazatele kvality usní, a to tloušťka kůže (LT, mm), mez kluzu (YS, μm), pevnost v tahu (TS, MPa), a bod zlomu (BP, μm) byly měřeny a hodnoceny ve vztahu k vybraným faktorům. Hodnota LT kříženců T50 byla o 0,16 mm ($P < 0{,}01$) vyšší než u čistokrevných jehňat Texel. Statisticky průkazné rozdíly ($P < 0{,}05$ – $0{,}01$) v závislosti na tělesné partii byly pozorovány u všech analyzovaných ukazatelů kvality kůží, kromě BP. Počáteční výsledky dokumentují nutnost podrobnějšího výzkumu zaměřeného na kvalitu usní masných plemen ovcí.

Introduction

In relation to small ruminants, high quality leather is a valuable raw material for various industrial sectors. The farming of meat breeds of sheep has become much more widespread in the Czech Republic recently, not only due to efforts to produce high quality meat on a commercial basis. Indeed, meat breeds of sheep are also used for landscape management as well as for controlled grazing in protected landscape areas. The characteristics of these breeds include a good fleece that must be clipped, especially in the summer, to ensure the welfare of the animal. Sheep skin – leather should provide to sheep farmers an alternative product to compensate for lack of demand for wool, whilst also presenting a good quality and cheap domestic material for the garment industry. In fact, leather products are being more widely utilised as a part of today’s modern lifestyle, whether they find a use in furniture, shoe-making and automotive or other industries, but especially in clothing. Clothes made from natural leather possess typical attributes: softness, plasticity, strength and formability. Being clothed in "skin" actually dates back to the very beginnings of mankind. The production of leather garments most widely employs the leathers of sheepskin (including lambskin) and goatskin. The former is largely imported from Africa, where furry breeds of sheep are bred, the hide proving to be a very good raw material for the garment industry.

The quality of the leathers in question is uneven throughout the area of the hide due to the inherently different structure. Indeed, the leathers from the hides of animals of the same species differ from each another. Other factors as animal’s age, sex or diet exhibited different characteristics for different body parts as well.

The quality of the leather is determined primarily by its density, which can be identified through efforts to bend the leather or stretch it in different directions. For leather, the more even it is and the more resistance it exhibits, the better the quality assigned to it (Fischer, 2011). Generally speaking, the denser the fibrous structure, the stronger and stouter the leather, whilst the thinner the fibrous structure, the softer and more ductile the leather is. These features and the varied levels of ductility and strength in the different parts of a piece of leather have to be respected for the individual final products (Jůva, 1983). Leather quality is assessed in its appearance and mechanical and chemical properties. Sensory evaluation involves cleanliness, lustre, colour, the pattern and overall appearance of the grain, softness and the plasticity of the leather. Objective testing comprises weight (per dm^2), area (in dm^2), tensile strength (in MPa), water content (in %), grain strength, permanent elongation (%), water absorption (%), permeability (in ml of water that permeates through the area of 1 cm^2 of leather per hour), heat resistance and ash content. According to current industrial criteria, leather is classified by the raw material used (cowhide leather, calf leather, goat leather, pigskin leather, horse leather, sheepskin leather, deerskin leather and reptile leather), by tanning method (vegetable tanned leather, leather tanned by synthetic/combined tanning agents or chrome salts, tawed leather, chamois leather), by leather finish (natural grain leather, patented leather, corrected grain leather, embossed leather), and by processing method (shoemaker’s leather, garment leather, glove leather, saddle leather, upholstery leather, bag leather, belt leather and technical leather) (Floriánová, 2005).

Oliveira et al. (2007) focused in their study on the influence of genotype on the physico-mechanical properties of goat and sheep skins. This involved local breeds in Brazil, where kids. Jacinto et al. (2004) discussed the structure of sheep wool as well as the skins of local breeds and the relations of these to the physico-mechanical properties of the skin from the respective body parts. De Brito et al. (2002) studied the process of tanning goat skins for shoemaking based on trivalent chromium and subsequent aldehyde tanning, which requires a detailed study of the physico-mechanical properties. Using a randomly different percentage of chromium, i.e. 1.5%, 3% and 4.5%, they concluded that the already low percentage of chromium affected the cracks and tension of heavy leather. Superior softness and fineness of grain is achieved through combining aldehydes and chromium salts in the tanning of goat skins for the shoemaking industry. Global environmental regulations in the sphere of skin processing have also undergone change recently. For example, Thanikavelan et al. (2004) concerned themselves with studying new biotechnological methods for leather processing using enzymes that are environmentally friendly. The physical and mechanical properties of leather largely relate to its structure as well as the orientation and mobility of fibre bundles and the size of the interfibrous space. There are differences in stiffness even throughout the area of a piece of leather. In the ligament regions, leather is usually stiffer than in the underbelly and abdomen of the animal. Referred to as the topographic characteristics of leather, these features should be taken into account when handling sections of garment products, as indicated by Štachová (2005).

Based on the information mentioned above and very poor information in this area, necessity of evaluation of leather quality in meat breeds of sheep bred in the Czech Republic is definitely obvious. Consequently, it is possible to hypothesize, that breed and body part affect the quality features of sheep leather as a raw material for manufacturing industry. Therefore, the objective of work was to evaluate effect of Texel genetic portion and body part on selected quality traits of sheep leather.

Materials and Methods

A total of 10 leathers of purebred Texel lambs (T100) and 10 leathers of Merino x Texel crossbred (T50) were included in the trial performed during 2011. The lambs - all males born in April 2011 were bred in one flock with the same nutrition, stable and handling conditions with total number of 1200 ewes. Lambs were slaughtered in 7 months of age during November 2011, clipped prior to slaughter and the skin was subsequently treated with salt. The skins were tanned using chromium in a standard manner (Jůva, 1983). After tanning, samples were taken from the respective body parts, i.e. the front limbs, the hind limbs and the back. The basic indicators of leather quality in four variables were objectively measured, namely **leather thickness** (**LT**, mm), **yield strength** (**YS**, μm), **tensile strength** (**TS**, MPa), and **breaking point** (**BP**, μm). Each measurement was repeated twice in the individual body part. The evaluation of measured characteristics was performed in relation to group of Texel genetic portion and the individual body part measured.

Breaking force test

The test was carried out using DEFORM 2 (PEMAR, Ltd.; Czech Republic). The device is connected to a computer installed with measurement data processing software TRHEY (Department of Physics, Faculty of Engineering, Czech University of Life Sciences Prague; Czech Republic). DEFORM 2 is a deformation device that is also termed a *tearing device*. The machine has adjustable jaws, into which the sample of leather is inserted, with the then entered into the TRHEY software. Subsequently, **leather thickness** is measured in millimetres, with water content and air temperature at the instance of measurement indicated automatically. Before each measurement, the system is calibrated to 0. The measuring speed was 100 mm per minute until breakage. The measured data are entered into the program automatically.

Yield strength or proportionality limit refers to the point where the leather exhibits a "flowing" quality, with subsequent irreversible deformation occurring once this limit has been exceeded, leading to eventual breakage. Yield strength is computed using the equations below, where D_o^2 is leather thickness in mm, l_o is the initial length of the leather at the instance of measurement and Δ_l is the elongation of the leather. **Tensile strength** (MPa) is the force that operated at the point referred to as the yield strength. **Breaking point** or breaking strength refers to the limit at which the leather is so elongated that it tears. It is computed using two modified equations:

$$S = \frac{\pi * D_o^2 * l_o}{4.000.000 * \dfrac{(l_o + \Delta_l)}{1.000}} \rightarrow \sigma = \frac{F}{S}$$

where D_o^2 is the fibre diameter in microns, l_o is the initial length of the leather at the instance of measurement and Δ_l is the elongation of the leather. **F** is the force that worked at the breaking point, which is usually labelled σ. Whereas, MPa is used very often as a tension unit.

Using Excel, the values of strength and elongation generate a linear trendline, through which the regression and reliability equation is obtained. The regression equation $y = a + b_x$ produces the value b_x, which equals the force that would be developed by the leather if elongated by 1 metre, whilst the other value of the regression equation (*a*) is the force that equals zero deformation. The confidence equation yields a value that indicates the percentage of confidence to which the linear trendline is accurate.

The SAS 9.1 (SAS/STAT® 9.1., 2004) program was used for evaluating the respective indicators based on the measured values, which more specifically involved the general linear model (GLM) procedure for calculating basic statistical data and the GLM procedure for calculating the relationship between dependent and independent variables. The following equation was used:

$Y_{ijk} = \mu + TEX_i + PART_j + e_{ijk}$,

where:

Y_{ijk} = observed value of the dependent variable (leather thickness in mm; yield strength in μm; tensile strength in MPa; and breaking point in μm),

μ = average value of the dependent variable,

TEX_i = fixed effect of the i^{th} group of TEXEL genetic portion (i=100%, n=10; 50%, n=10) back, n=20),

e_{ijk} = residual effects.

Results and Discussion

It is necessary mentioned generally poor information sources focusing the leather detailed quality in sheep, all the more so for meat breeds of sheep. So, comparison and discussion of results achieved is very complicated. Table 1 shows the basic statistical indicators for leather thickness (LT), yield strength (YS), tensile strength (TS), and breaking point (BP) variables calculated in the GLM procedure.

Table 1 Basic statistical indicators of evaluated leather characteristics

Tab. 1 Základní statistické ukazatele hodnocení charakteristik kůže

Variable	n	$\bar{x}$	s_d	min	max
LT (mm)	120	1.04	0.174	0.73	1.46
YS (μm)	120	40.25	9.992	23.67	67.48
TS (MPa)	120	6.02	5.391	0.20	22.80
BP (μm)	120	48.21	9.593	31.94	74.94

LT - leather thickness, YS - yield strength, TS - tensile strength, BP - breaking point.

The most balanced measurement was that concerning leather thickness, achieving an average value of 1.04 mm, the standard deviation equalling 0.174. The average value of yield strength was 40.25 μm when standard deviation was 9.992. The average value for measurement of tensile strength achieved 6.02 MPa. Closing leather have to achieve tensile strength before subsequent tearing on the level 20 N x m^{-2} in minimum (Štachová, 2005), therefore it is possible to conclude this requirement was completely passed. The breaking point reached an average of 48.21 μm, the standard deviation being 9.593, which is slightly lower compared to that of yield strength. Table 2 contains the basic statistical characteristics of the linear model applied in the GLM procedure of SAS.

Table 2 Basic statistical characteristics of the linear model applied

Tab. 2 Základní statistiky charakterizující použitý lineární model

Variable	Model		Breed	Body part
	P	r^2	*P*	*P*
LT (mm)	<0.001	0.3510	<0.001	<0.001
YS (μm)	0.1219	0.0498	0.3035	0.0927
TS (MPa)	0.0146	0.0949	0.8100	0.0056
BP (μm)	0.2759	0.0335	0.9442	0.1459

LT - leather thickness, YS - yield strength, TS - tensile strength, BP - breaking point.

The table shows statistically significant evidence for leather thickness with a significance sample was obtained. The whole model explained 35.10 % of biological variability of leather thickness. Secondly, significance (P<0.05) effect of model applied was documented in relation to tensile strength. Mainly effect of sampled body part was determined (P<0.01). However, only 9.49% of biological variability was described by linear model used. Table 3 reflects the influence of the breed on the respective characteristics of leather quality using the GLM procedure of SAS.

Table 3 The influence of breed on the characteristics of leather quality

Tab. 3 Vliv plemene na charakteristiky kvality kůže

Variable		T100 (n=20)	T50 (n=20)
LT (mm)	*LSM*	0.96^{A}	1.12^{B}
	SE	0.019	0.019
YS (μm)	*LSM*	41.19	39.30
	SE	1.285	1.296
TS (MPa)	*LSM*	5.90	6.14
	SE	0.715	0.695
BP (μm)	*LSM*	48.27	48.15
	SE	1.244	1.255

T100 - purebred Texel lambs, T50 - Merino x Texel crossbreds, LT - leather thickness, YS - yield strength, TS - tensile strength, BP - breaking point, LSM – least square mean, SE – standard error of LSM, A,B – different upper script letters means significance P<0.01.

As it is evident from the results, the thickness of the leather from crossbreds with 50% of Texel genetic portion was by 0.16 (P<0.01) mm thicker than in pure-bred Texel lambs. This fact documents significant influence of breed, respectively Texel genetic portion on leather thickness and it means on leather suitability for subsequent processing. Table 4 shows the influence of the respective body part observed on the characteristics of leather quality.

Tab. 4 Vliv části těla na charakteristiky kvality kůže

Variable		front limb (n=40)	hind limb (n=40)	back (n=40)
LT (mm)	*LSM*	0.96^{A}	1.10^{B}	1.06^{B}
	SE	0.023	0.023	0.023
YS (µm)	*LSM*	42.64^{a}	40.39^{ab}	37.72^{b}
	SE	1.580	1.580	1.580
TS (MPa)	*LSM*	5.02^{A}	4.69^{A}	8.35^{B}
	SE	0.844	0.879	0.867
BP (µm)	*LSM*	49.84	49.01	45.79
	SE	1.530	1.530	1.530

LT - leather thickness, YS - yield strength, TS - tensile strength, BP - breaking point, LSM – least square mean, SE – standard error of LSM, A,B; resp. a,b – different upper script letters means significance P<0.01; respectively P<0.05.

The results in the table mentioned above correspond to those presented in Table 2. A highly significant difference (P <0.01) was found in the thickness of leather, such a difference - as regards the thickness of the leather between the front and hind limb as well as between the front limb and back. Leather from back presented tensile strength higher by +3.33 MPa compared to front limb, respectively +3.66 MPa in comparison with hind limb. Significant differences in leather thickness indicate the leather from individual body parts should be suitable for processing of different products and the possibility more detailed sorting to leather quality grades. Statistical significance (P<0.05) was found as regards the difference in the yield strength between the front limb and the back, when the back leather achieved lower level by -4.92 µm. A statistically significant relationship was demonstrated between leather tensile strength in relation to the body part, the significance level being P<0.01. This concerns a difference in tensile strength between samples from the front and hind limbs and the back. As regards the breaking point indicator in any of the three body parts, statistical significance was not shown.

Conclusion

In accordance with the assumptions of the authors, it can be definitely concluded on the basis of the results obtained that there are significant differences in leather thickness between the purebreds and crossbreds of Texel sheep. The hypothesis that the properties of leather concerning physical indicators are not uniform throughout a piece of leather was confirmed. Further investigation on continuing and more detailed mapping of qualitative indicators of leathers from the individual meat breeds of sheep bred in the Czech Republic is necessary, from the perspectives of requirements of the leather processing industry.

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