LEATHER PROPERTIES AS A FUNCTION OF CATTLE BREED

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Abstract. Since hundreds of years, tanners share the opinion that hides from different cattle breeds lead to varying leather characteristics. Especially European hides from the alpine region (e. g. Simmentaler or brown origin) are preferred by tanners. These leathers feature a higher thickness, a maximum utilisation induced by a minor thickness difference over the whole area and a lower tensile strength in contrast to leathers from other breeds. However, are these alpine hides better because of their breed affiliation or because they are kept in special regional conditions? It is known that, besides the breed, also other factors can influence the rawhide and leather quality like age, gender, nutrition and climate conditions. In addition, present dairy and beef cattle are high-performance cattle by breeding, which leads to more crossbreeds than 100 years ago. Our intention was to find out, whether leather characteristics nowadays are still a function of breed or not. For that purpose, 50 rawhides from four different cattle breeds (Angus, Charolais, Simmentaler, Limousin, Holstein) were collected from the Saxon region. For characterization, the physical parameters tensile strength, elongation at maximum force and stitch tear strength were detected for all breeds. In summary, only minor differences between leathers from different cattle breeds were found for the tensile strength, the elongation at maximum and the stitch tear strength. In addition, the intra-group variation within the breeds was constantly on a high level. Interestingly, we observed that older skin donors show a higher variance of the tensile strength and of the elongation at maximum force. Nevertheless, this tendency to equal leather properties between the breeds must be confirmed by a larger quantity of test individuals.

1 Introduction

It is an unwritten law for tanners, that hides from different cattle breeds lead to varying leather characteristics. Especially European hides from the alpine region (e. g. Simmentaler or brown origin, so called “south german raw hides”) are preferred by tanners. On the rawhide market, such raw hides achieve higher prices in contrast to hides from north German regions, where breeds such as Holstein prevail.

Leathers with south German origin should feature a higher thickness, a maximum utilisation induced by a minor thickness difference over the whole area and a lower tensile strength in contrast to leathers from other breeds (1). This tanners opinion is raised over hundreds of years but is only underlined by one scientific publication, which is over 60 years old. Since then, cattle breeds have extremely changed by genetic breeding programmes to raise their economic traits (e. g. milk yield, maternal ability, feed efficiency) (2). Additionally, present dairy and beef cattle are high-performance cattle, which leads to more crossbreeds than 100 years ago. However, there is the question whether these alpine hides are better because of their breed affiliation or because their regional husbandry conditions. It is known that, besides the breed, also other factors can influence the rawhide and leather properties like age, gender, nutrition and climate conditions (3,4).

We wonder if this deep-routed opinion from high-quality –leathers of alpine origin is still up-to-date. The intention of our study is to investigate if leather properties are still dependent on the cattle breed.

2 Materials and Methods

Collection of skin samples

Skins were collected from the following breeds: Simmentaler, Holstein, Angus (widespread occurrence in Germany), Limousin and Charolais.

All skins have their origin from small farms located in the Saxon region. Ten rawhides were collected from every breed. Preservation was achieved by salting. Table 1 shows the age and gender for all skins. For every breed, 5 skins of male and 5 skins of female individuals were collected. All individuals were younger than 4 years and 10 months. All female individuals were heifer, which means, that no female individual was pregnant during lifetime.

Table 1.

Breed	hide	Age (months)	gender	Breed	hide	Age (months)	gender
Angus	A1	20	♂	Limousin	L1	25	♂
	A2	24	♂		L2	30	♂
	A3	28	♀		L3	24	♂
	A4	23	♀		L4	30	♀
	A5	25	♂		L5	29	♀
	A6	12	♂		L6	46	♀
	A7	41	♀		L7	16	♂
	A8	27	♀		L8	34	♀
	A9	34	♂		L9	11	♀
	A10	41	♀		L10	12	♀
Charolais	C1	19	♀	Simmentaler	F1	24	♂
	C2	22	♀		F2	23	♂
	C3	19	♀		F3	21	♂
	C4	19	♀		F4	24	♂
	C5	21	♀		F5	17	♂
	C6	19	♂		F6	22	♀
	C7	19	♂		F7	24	♀
	C8	18	♂		F8	20	♀
	C9	16	♂		F9	22	♀
	C10	17	♂		F10	23	♀
Holstein	S1	56	♀				
	S2	36	♀				
	S3	13	♀				
	S4	25	♂				
	S5	13	♂				
	S6	17	♂				
	S7	39	♀				
	S8	17	♀				
	S9	15	♂				
	S10	15	♂				

Leathers and test samples

All skins were halved from neck to tail along the backbone and were prepared equally. The leather was produced by using conventional processes: First, the skins were subjected to a lime-sulfide liming, followed by a mechanical flesh removing, a formic and sulphuric acid pickling and chrome tanning. Skins from one breed were tanned in one lot. The skins were then fatliquored, dyed and dried.

The samples for the physical measurements were cut from the same area along the backbone in the lower third, which is the official testing side for leathers or so called DIN-area.

Tensile strength and elongation at maximum force

Measurements of tensile strength and elongation at maximum force were performed according to standard methods (DIN EN ISO 3376) on a LLOYD Instrument (Erichsen Prüftechnik Wuppertal). The thickness of the rawhides was measured with the same instrument. The tensile strength and the elongation at maximum force were normalized for thickness of the leathers. For every individual, two leather samples from the DIN-area was taken from the right and left hide. Six samples were taken from each hide sample for the measurements, respectively. Every individual leather contributes with 12 data values to the overall of data set.

Stitch tear strength

Measurements of stitch tear strength were performed according to standard methods (DIN EN ISO 23910) and normalized for leather thickness. For each leather, three test samples were cut parallely and perpendicularly to the backbone, respectively. Therefore, one leather contributes with 12 data values (left and right hide) to the overall data set.

All parallel and perpendicular measurements of one leather were averaged for the stitch tear strength. Because the stitch tear strength depends mainly on the orientation of the collagen fibrils (5), an adjusted stitch tear strength (ATS) is introduced. The ATS is the quotient between the stitch tear strength parallel to the backbone and the strength perpendicular to the backbone. An ATS of 1 indicates the same force is needed to tear the leather parallelly and perpendicularly to the backbone. An ATS over 1.0 indicates that a higher force is needed to tear the leather parallelly than perpendicularly to the backbone. Moreover, an ASR under 1.0 indicates lower forces for leather rupture parallel in contrast to perpendicular to the backbone are needed.

Data analysis

Data were submitted to analysis of variance using R (6) and mean values were compared by Tukey's test (7) at 5 % level of significance.

3 Results and Discussion

The collected 50 rawhides have their origin in the saxon region. The thickness of these rawhides was compared to get a first overview over the hide samples. Figure 1 shows the thickness of all sampled hides grouped by breed or gender.

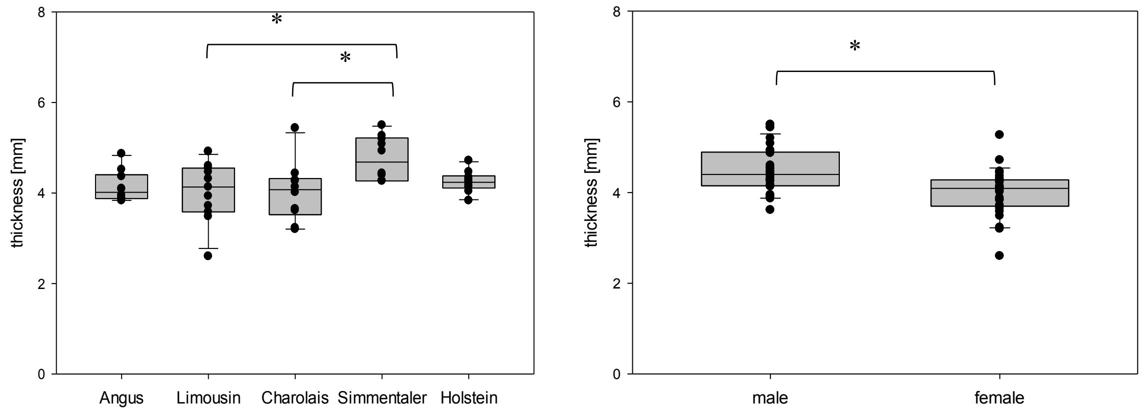

Figure 1. Thickness of all sampled hides (left: grouped by breed, right: grouped by gender, Significance code: '*' 0.05.) Every point is a mean value of 12 data values for one hide.

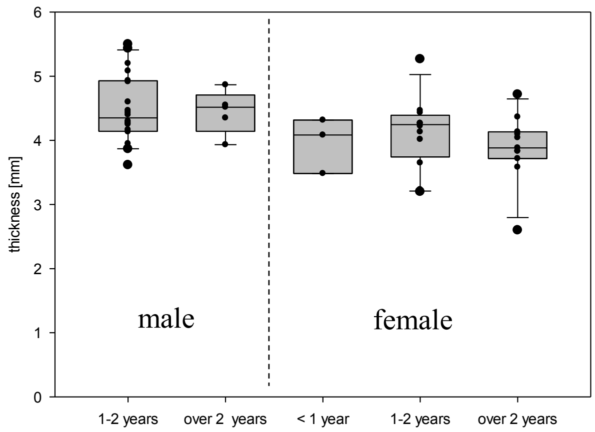

Figure 2. Thickness of the rawhides in dependence of the age of the donor (Every point is a mean value of 12 data values for one hide).

Simmentaler rawhides show the highest thickness compared to the other tested breeds. This is in accordance to the measurements of the workgroup of Hausam from 1952 (1), who also showed, that breeds with south german origin (such as Simmentaler) have a higher thickness in contrast to other breeds.

For Holstein rawhides, the variance was the smallest (Figure 1, left), which means that Holstein individuals deliver hides of mostly constant thickness independent from gender or age (age variance 13 months up to 56 month, see table 1). Except from Holstein, male and female rawhides differ significantly in thickness (Figure 2). However, the age of the donor did not affect the thickness (Figure 2). In summary, the thickness of the rawhides depends on breed and gender.

All rawhides were tanned equally, because any change in the leather manufacture process influences derma structure and the final properties of leather (8). The produced leathers were subjected to tensile strength measurements. Figure 3 and 4 show the resulting values for the tensile strength in dependence of breed, gender or age.

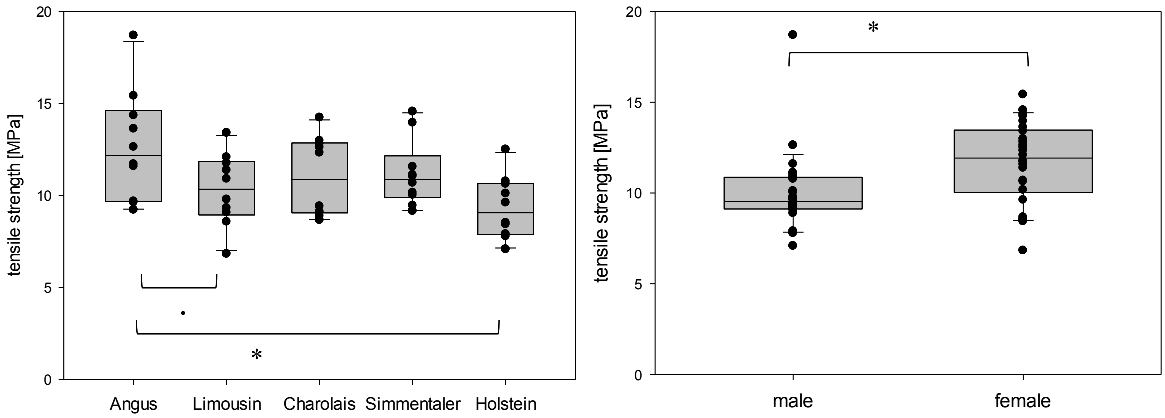

Figure 3. Tensile strength in dependence of breed (left) and gender (right) (Significance codes: '.' 0.1, '*' 0.05). Every point is a mean value of 12 data values for one leather.

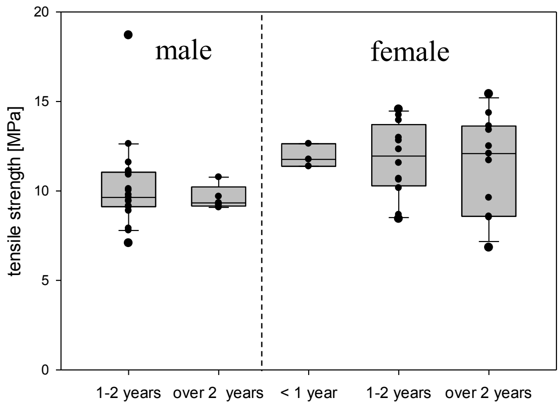

Figure 4. Tensile strength in dependence of the age of the donor. Every point is a mean value of 12 data values for one leather.

The major skin component is the protein collagen, which is therefore responsible for many properties of the skin and also of the leather such as flexibility and strength (9).The stability of leather and therefore its tensile strength depends mainly on the produced crosslinks by tanning (10) and on the collagen matrix of the rawhide. Leathers with Limousin or Holstein origin feature the lowest tensile strength (in dependence of the chosen tanning procedure) (Figure 3, left). This is not in accordance with fewer results, because as described by Hausam (1), the breeds with south German origin (e. g. Simmentaler) should have the lowest tensile strength. In our study, leathers with Angus origin showed the highest tensile strength when compared to Limousin or Holstein. However, the variation within the breeds are mostly higher than between the breeds.

In addition, there is a significant difference of the tensile strength between leathers with male and female origin (Figure 3, right). Leathers with female origin show higher tensile strengths than leathers with male origin. But this result must regard with caution, because of the existing sub-grouping by breed in the male and female group.

Figure 4 shows the dependence of the tensile strength in dependence of different age categories. No significant differences were found between the different groups, but leathers with female origin show the more variation, the older they are. Obviously, external influences on the skin stability, such as nutrition and husbandry conditions, increase over time. This effect is not confirmed in the groups of male leathers, but here only 5 individuals account to the group of leathers from over- 2- years- old individuals.

For the produced leathers, also the elongation at maximum force was measured. The elongation of maximum force was normalized for thickness because of local thickness changes between the leathers. Of course, the elongation at maximum force depends not only on the thickness. The elongation at maximum force is mainly a function of the density because of the heterogeneity of the leather material. However, the existing data were plotted against thickness, and under the given conditions, the elongation at maximum force became a linear function of the thickness (in the range of 1.3 mm to 2.2 mm) [data not shown]. Therefore, the normalization for thickness is a good approximation for interpretation of the existing data. Figure 5 and 6 show the normalized data in dependence of breed, gender or age.

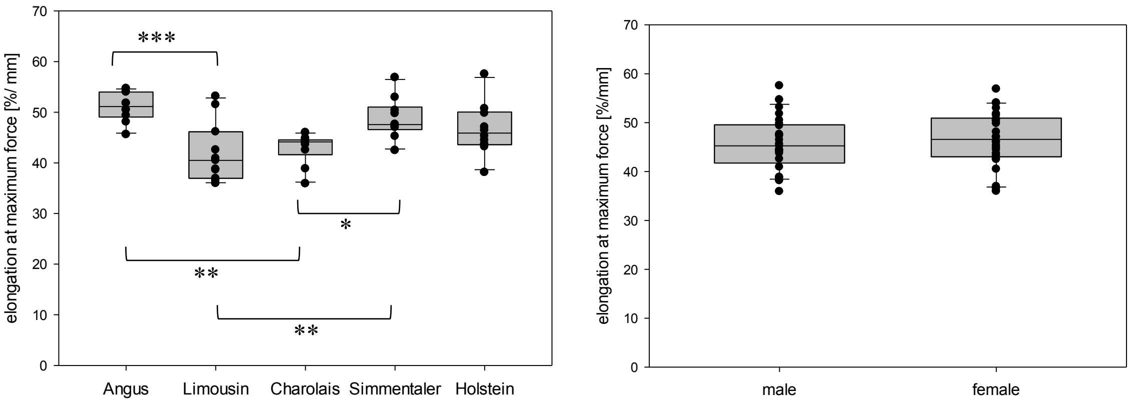

Figure 5. Elongation at maximum force in dependence of breed (left) and gender (right).
(Significance codes: '.' 0.1, '*' 0.05, '**' 0.01, '***' 0.001). Every point is a mean value of 12 data values for one leather.

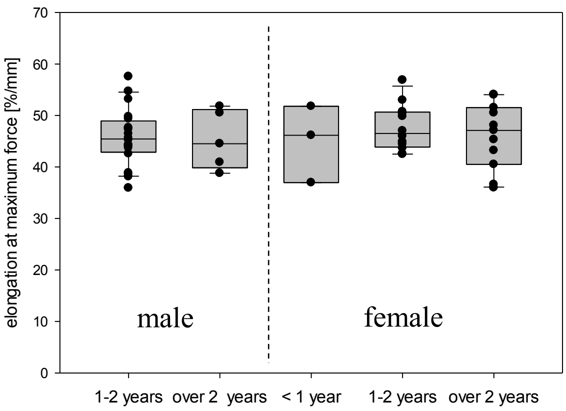

Figure 6. Elongation at maximum force in dependence of the age of the donor. Every point is a mean value of 12 data values for one leather.

Leathers with Limousin and Charolais origin feature the lowest elongation at maximum force (Figure 5, left). Although, the variation within the breeds are quiet high, significant differences of both breeds compared to Angus and Simmentaler could be observed.

There is no significant difference between leathers with male or female origin (Figure 5, right). But the male and female group are also structured, which means that differences between breeds could be balanced out by each other. Therefore the male and female group must be divided in breed- dependent sub-groups, which is handicapped by the low number of individuals.

Figure 6 shows that the elongation at maximum force has the lowest variation in 1- 2 years- old individuals. Similar to the tensile strength, the variation of the elongation is higher in older donors. Females younger than one year are not considered because of the low number of samples.

Finally, besides tensile strength and elongation at maximum force, the stitch tear strength was analysed. Figure 7 and 8 show the stitch tear strength in dependence of breed, gender or age.

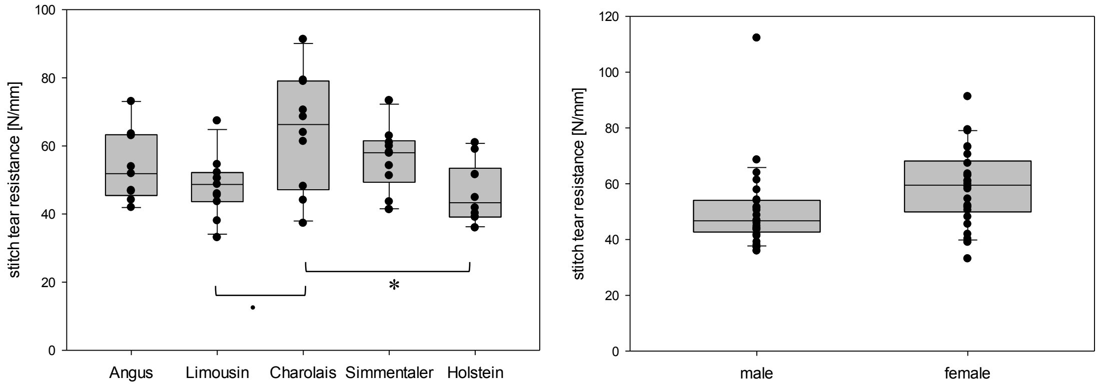

Figure 7. Stitch tear strength in dependence of breed (left) and gender (right).
(Significance codes: '.' 0.1, '*' 0.05, '**' 0.01, '***' 0.001). Every point is a mean value of 12 data values for one leather.

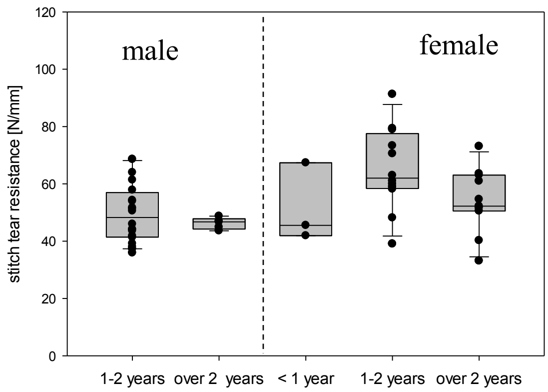

Figure 8. Stitch tear strength in dependence of the age of the donor.
(Significance codes: '.' 0.1, '*' 0.05, '**' 0.01, '***' 0.001). Every point is a mean value of 12 data values for one leather.

Leathers with Charolais origin feature the highest stitch tear strength, but also the highest in- group- variation (figure 7, left). The lowest stitch tear strength was measured in the Limousin and Holstein group. However, the variation within the breeds are again mostly higher than between the breeds. There is no significant difference between leathers with male or female origin (Figure 7, right) for the stitch tear strength. The high variance of older donor individuals was not present here (see Figure 8). However, the stitch tear strength is higher for female leather in the age category 1- 2- years- old donor individuals than for male leathers of the same age category.

Because the stitch tear strength depends mainly on the orientation of the collagen fibrils (5), measurements parallel and perpendicular to the backbone were performed and the ATS was calculated for every breed (Figure 9).

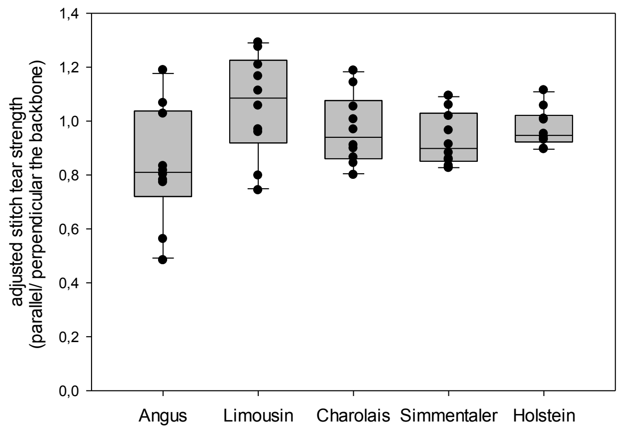

Figure 9. Adjusted stitch tear strength (ATS) in dependence of cattle breed.

The average ATS for all leathers except for leathers with Limousin origin showed values below 1.0, that means a lower force is needed to tear the leathers parallel than perpendicular to the backbone. Why Limousine leathers have a different behaviour compared to the other breeds is unknown. Maybe a different collagen fibril orientation is present. But more analyses are needed to verify this assumption (e. g. small angle X-ray scattering studies, SAXS(5,11)).

4 Conclusions

In summary, the results indicate, that the over- hundreds- of- years- raised tanners opinion can be partially disproved. Simmentaler rawhides have the highest thickness, but differences in physical tests are mostly negate when transformed to leathers. The tensile strength, the elongation at maximum force and the stitch tear strength of different leathers showed only minor differences between the cattle breeds. The variation within the breeds were mostly higher than between the breeds. However, this evaluation is based only on 10 individuals per breed, and the measured tendency must be confirmed by a larger quantity of test individuals. For this purpose, an analysis is planned with 100 individuals from different breeds and crossbreeds.

5 Acknowledgements

The project no. 19368BR of the research association “Leder und Kunststoffbahnen, Meißner Ring 1, 09599 Freiberg” was funded on behalf of the Federal Ministry of Economics and Technology by the AiF in the framework of the program “Industrielle Gemeinschaftsforschung” (IGF) based on a resolution of German Bundestag. We would like to thank for the support granted.

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