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STRENGTH OF BRAZILIAN GOATSKIN LEATHERS IN RELATION TO SKIN AND ANIMAL CHARACTERISTICS

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Summary

There are clearly advantages in being able to understand how the characteristics of an animal's raw skin relate to the physical properties of the leather produced from it. For example, such knowledge will assist in the selection of those breeds which will yield the best leather for a given application. Although there have been a number of studies relating animal and skin characteristics to leather properties for bovine leather research on this topic appears less well developed for goatskins and leather. This paper therefore details some recent work on Brazilian goat skins which was concerned with the relationship between animal and skin characteristics and leather strength.

Goatskins covering a range of breed, age and sex were obtained from the Sobral experimental station in Brazil. The skins were subjected to a variety of chemical, biochemical, biophysical and histological analyses including measurement of collagen content, fat content, amount of glycosaminoglycan, relaxation of shrinkage stress and assessment of compactness of fibre weave. The skins were all processed together into leather and strength was assessed via tensile testing, tear testing and lastometer test. In addition, the apparent density of the leather was also measured.

Most of the skin and leather characteristics showed a well-defined trend with increasing animal age. Glycosaminoglycan content and relaxation of shrinkage tension decreased rapidly up to the age of ten months and thereafter more slowly. Collagen content increased more slowly up to age 20 months and thereafter levelled off. The weave of collagen fibre bundles became more compact with age.

The strength of the leathers was strongly associated with their apparent density which in turn could be related to the compactness of fibre bundle weave in the skin. Although animal age appeared to be the dominant factor, breed influences could also be discerned. Thus the Anglo–Nubiana breed gave a lower strength leather than the general trend would suggest: this was ascribed to the greater fat content of its skin.

It is concluded that assessments of goatskin characteristics can be directly related to leather strength. Such information is of considerable value in assessing which breeds are of most potential for leather production.

Introduction

There have in recent years been a number of publications[1–4] concerned with the influence of factors such as the breed, age at slaughter, sex and plane of nutrition of an animal on the properties of leather produced from its skin. The work referred to has exclusively involved bovine hides and it was reported that each of the factors mentioned above had an influence on the leather strength.

Although there have been previous studies of the strength of leather made from goatskins[5–8] there appear to be no published studies of the type mentioned above, in which the characteristics of the goat are related to the strength of leather produced from its skin. The work reported here forms part of an investigation of this topic and is specifically focused on the influence of the age and breed of Brazilian goats on the strength of leather produced from their skins.

In addition the results of investigations of the histological, biochemical and biophysical characteristics of the goat skins and how these factors are influenced by age and breed are also presented. Apart from its intrinsic value such information can be used to attempt to establish which properties of the skin are important in determining the strength of leather.

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Experimental

1) Raw Materials

Dried goatskins were obtained from the Sobral Experimental Station in northern Brazil (Centre Nacional de Pesquisa de Caprinos Sobral 62.100, Ceara, Brazil). The range of skins studied is indicated in Table I. As can be seen the skins covered two pure breeds and three cross breeds and were from animals whose age at slaughter ranged from 3 to 75 months. The skins were cut down the backbone and one half was processed into leather. (see Appendix). Samples (shaved) were taken from the official sampling area

TABLE I
Goatskins studied

Breed	Short code used in text	Age at slaughter (months)	Sex	Number of skins received
1/2 Anglo-Nubiana × 1/4 Parda-Alpina × 1/4 Moxoto	APM	3	M	
1/2 Parda-Alpina × 1/2 Moxoto	1/2 PM	3	M	
,,	,,	8	M	
,,	,,	24	F	
3/4 Parda-Alpina × 1/4 Moxoto	3/4 PM	12	M	
Anglo Nubiana	AN	47		
Moxoto	MOX	75	F	

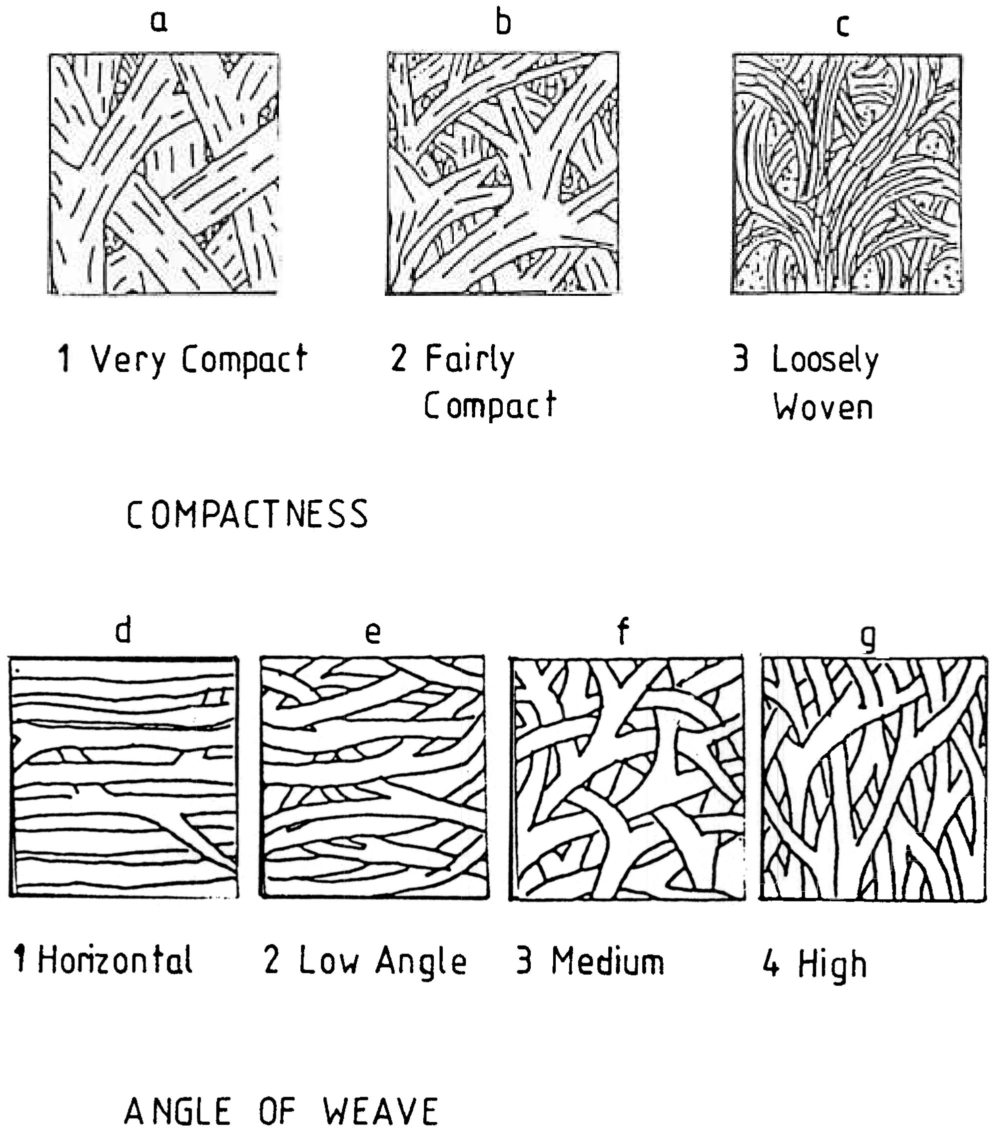

Figure 1. Histological assessment of the corium.

(IUP/2) of the other, unprocessed half and used in the various tests noted below.

2) Biochemical Analysis

All the following were calculated on the basis of moisture free skin

(*a*) *Fat Content*
Fat content was determined via solvent extraction (SLC4, 1966)

(*b*) *Collagen Content*
Hydroxyproline content was determined via the procedure detailed by Lollar.[9] Collagen content was calculated on the basis that the hydroxyproline was 14% by weight of the collagen.

(*c*) *Glycosaminoglycan (GAGS) content*
Following papain digestion of the skin the amount of glycosaminoglycan was assessed via a quantitative measurement of the Alcian Blue-Glycosaminoglycan complex.[10]

3) Biophysical Analysis

Relaxation of Isometric Tension

The approach used followed Haines and Shirley.[11] A strip of rehydrated skin was held at constant strain at 70°C and the force exerted by the sample was measured as a function of time. The percentage relaxation (R_{10}) of the force after ten minutes was calculated as:

$$R_{10}(\%) = \frac{F_0 - F_{10}}{F_0} \times 100$$

where F_0 = Maximum Force developed
F_{10} = Force exerted ten minutes after maximum

4) Histological Analysis

Formalin fixed samples of rehydrated skin were cut into 20μ thick sections along the plane of hair follicles. These thin sections were stained with Haematoxylin and Eosin and examined by optical microscopy. Grain to corium ratio was measured and both the angle of weave and compactness of weave of collagen fibres in the corium was assessed. The procedure used to arrive at a numerical value of these latter two variables was based on an approach described in the publication "Leather under the Microscope",[12] and Fig. 1 is based on some diagrams in that publication. In the case of compactness, microscope images were compared to Fig. 1(a)–(c) and a numerical value of 1,2 or 3 was assigned on the basis of which figure most closely resembled the microscope image. A similar procedure was used for angle of weave using Figs 1(d)–(g). For any one skin observations from six serial sections were used. The average values of these six results were then used to calculate a mean value for that skin type.

5) Physical Testing of Leather

All material was kept in a standard atmosphere (temperature 20±2%, humidity 65±2% RH) for 48 hours prior to testing. Tensile and tear tests were carried out using an Instron 1122 testing machine. Samples were cut from (or close to) the official sampling area (SLP2).

(*a*) *Apparent Density*
A standard procedure (SLP5) was used

(*b*) *Tensile Strength (SLP6)*
The middle sized test sample was used and four samples were tested perpendicular and parallel to the back bone.

(*c*) *Tear Strength*
The procedure described in SLP7 was used for each skin. Two samples were tested, one perpendicular and one parallel to the backbone.

The tear strength (T) was calculated as:

$$T=\frac{F}{t}$$

where F=Maximum force during tearing
t=sample thickness

(*d*) *Load at Grain crack and Grain burst*
These parameters were assessed via the standard ball burst test (SLP9)

For all the procedures described above a mean and standard deviation for a given skin type was calculated from the results for each individual skin.

Results

1) Skin Characteristics

Fig. 2 a,b,c and 3 a,b,c show plots of the various skin characteristics against the age of the animal at slaughter. The results shown in Figure 2a are consistent with a general trend of collagen content increasing from 59% at age 3 months up to 70% at ages greater than 20 months. The collagen content for breed 3/4 PM (see Table I) appears to fall below the general trend line. Figure 2b indicates that the relaxation of isometric tension (R_{10}) is large for the skin of the three month old animals but that it falls rapidly with age up to around 10 months, after which it decreases only slowly. A similar trend is observed for GAGS content (Fig. 2c).

There is some suggestion that the proportion of grain layer falls between 3 months and 24 months (Fig. 3a). A tentative trend line has been drawn which if valid would indicate that breeds 1/2 PM (age 3 months) and 3/4 PM (see Table I) have a lower proportion of grain layer than might be expected. Fat content appears to fall as animal age increases from 3 to 12 months (Fig. 3b). The general trend appears to be that for animals of 12 months and over fat content becomes invariant with age. The result for breed AN is not consistent with this and suggests that this breed has a higher skin fat content than the other breeds studied. The compactness of corium fibre weave falls over the first 24 months of an animals' life (ie the fibre weave becomes more compact) but thereafter remains constant (Fig. 3c). Results for angle of corium fibre weave have not been presented graphically since this parameter showed no discernable trend with age and results for all skins were consistently low (1.3–1.9)

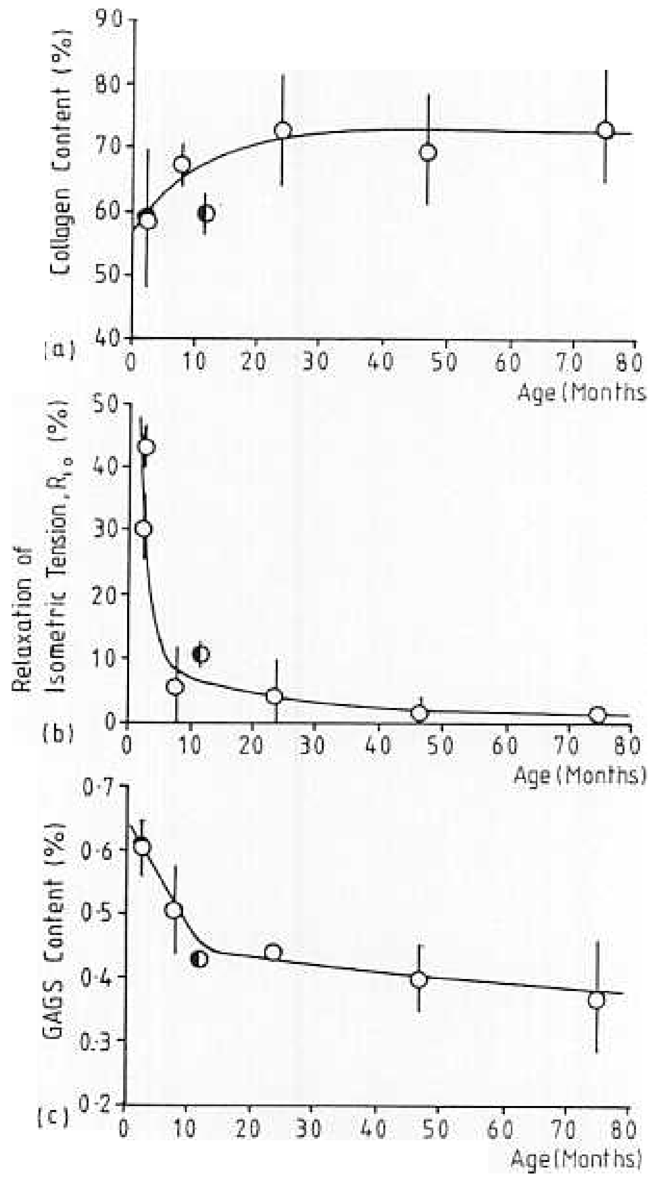

Figure 2. Skin characteristics plotted against age.
◐ 3/4 Parda-Alpina x 1/4 Moxoto

2) Physical Properties of Goatskin Leathers

The results for the physical properties of the goatskin leathers are plotted as a function of animal age at slaughter in Figs. 4a,b,c and 5a. The apparent density tended to increase with age (Fig. 4a) and a smooth trend line could be drawn through all but one point. The exception was the AN (see Table I) breed which had a lower apparent density than might have been expected.

Tensile strength parallel to the backbone showed a 50% increase between ages 3 and 24 months thereafter changing little. (Fig. 4b) When a trend line was drawn there was a suggestion that the result for breed 3/4 PM was lower than might have been expected. A similar but less pronounced influence of age was found for tensile strength perpendicular to the backbone: in this case the result for breed AN fell below the trend line (Fig. 4b) Tear strength showed a strong sensitivity to animal age (Fig. 4c) nearly doubling in value between

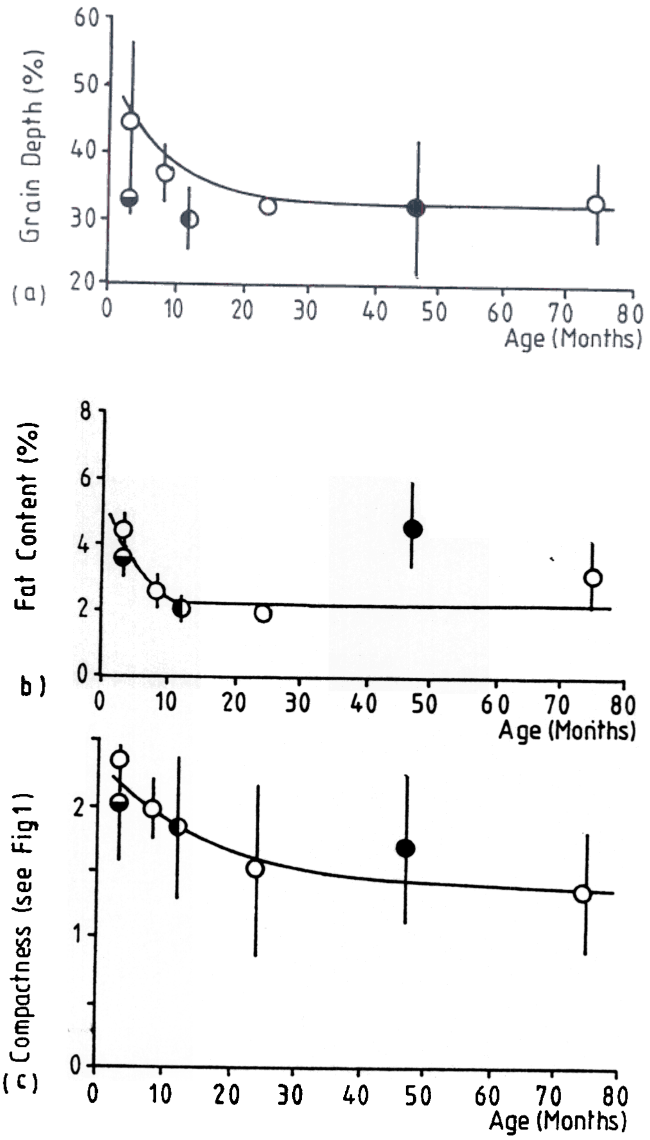

Figure 3. Skin characteristics plotted against age.
● Anglo-Nubiana ◐ 3/4 Parda-Alpina × 1/4 Moxoto ◒ 1/2 Parda-Alpina × 1/2 Moxoto

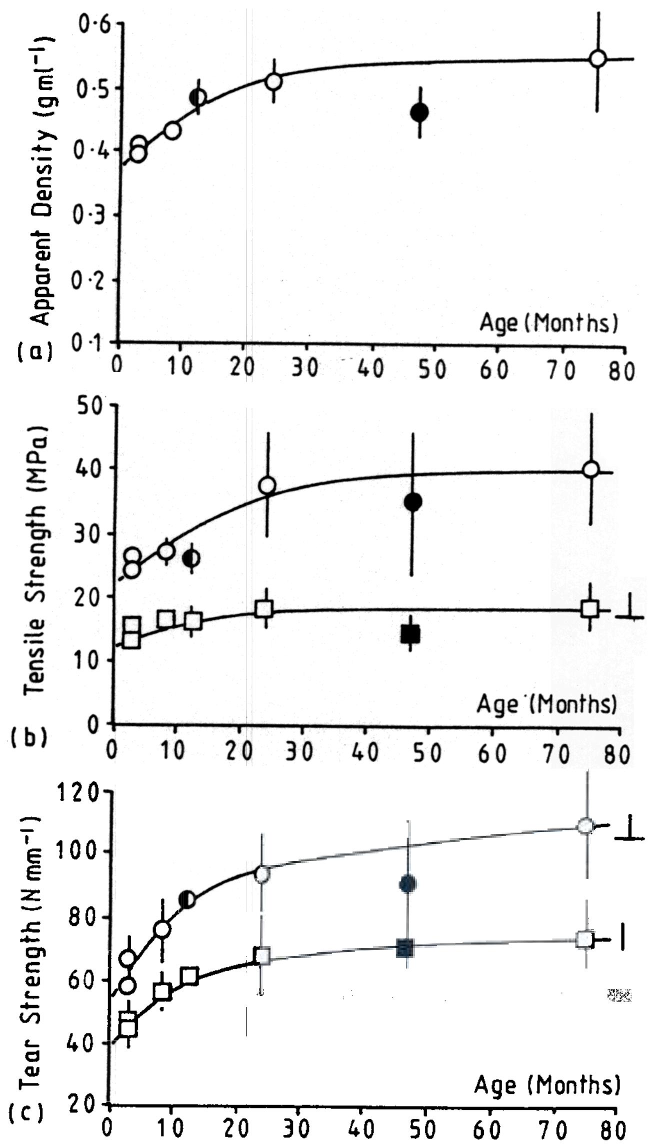

Figure 4. Physical properties of leather vs. age.
● ■ Anglo-Nubiana ◐ 3/4 PM

the ages of 3 months and 75 months with much of this increase occurring over the first 24 months.

Both load at grain crack and load at grain burst showed large (up to 165%) increases with increasing animal age (Fig. 5a). All of this increase appeared to occur between the ages of 3 and 24 months. A smooth trend line could be drawn through each set of results with the exception of breed AN which fell considerably below the general trend.

Discussion

It has been seen that the characteristics of the goat skins and the various measures of the strength of the leather produced from them all change in a regular way with increasing animal age. This has meant that when these properties have been plotted against animal age it has been possible to draw a smooth line through most of the data points. When data did not fall on this line this was assigned to the influence of the goat's particular breed. In making this assignment it must be born in mind that the goatskins received from Sobral represented both sexes and so it might be argued that a result off the trend line may be due to an influence of the goat's sex rather than its breed. However, we do not believe that this is the case since between ages 3 and 12 months all the animals were male allowing a single sex trend line to be established in this age range and similarly between 24 and 75 months where all animals were female (Table I).

Although as noted in the introduction there appear to have been no previous published studies of this nature for goat skins it is interesting to compare the results with those found for other animals. Studies of the changes in relaxation of isometric tension with age for sheep have been reported by Alexander *et al*[13] who found a rapid fall between 3 months and 7 months with a more gradual decrease thereafter. These authors point out that the decrease in relaxation of isometric tension is associated with the increasing degree of natural crosslinking within the collagen fibres which occurs on ageing. Studies of the collagen content of sheepskins have also been published[14] and indicate an initial increase with age with a levelling off occurring around six months.

As far as leather strength is concerned, Russell *et al*[4] have reported that, for the bovine leathers studied, strength characteristics tended to fall with age due to a number of changes in the histological characteristics of the hide including an increasing angle of weave and an increasing grain–corium ratio.

In the present study angle of weave was invariant with age and so cannot have been the cause of the changes in strength. Surprisingly it would also appear that the proportion of grain is not a major factor in determining the strength of these goatskin leathers since two of the younger examples (1/2 PM, aged 3 months and 3/4 PM aged 12 months) have a similar percentage of grain layer as the older animals (Fig. 3a) yet leather produced from their skins is markedly weaker (Fig. 4b, c and 5a).

In attempting to understand which of the remaining skin characteristics were related to leather strength an important clue was that there was a strong dependence of the various measures of strength on the apparent density of the leather (Fig. 5b, and 6a, b). This is not unreasonable since the apparent density reflects the concentration of loadbearing collagen fibres. In turn the apparent density of the leather can be related to the values assigned to the compactness of collagen fibre weave in the skin (Fig. 6c). The role of apparent density is also highlighted in the results for breed AN which has lower values of load at grain crack and grain burst than might be expected (Fig. 5a) (other measures of the strength of breed AN also tend to fall below the trend line (Figs. 4b,c) although less noticeably). The association of this lower strength with apparent density is supported by the observation that the apparent density of breed A/N also falls markedly below the general trend line with age (Fig. 4a). The low apparent density for breed AN may be associated with the slightly high value of compactness of fibre weave in its skin (Fig. 3c) but it is also apparent that this breed has an unusually high fat content for its age (Fig. 3b) which could also account for the low apparent density.

Although it has been argued that apparent density is an important factor in determining the strength of the goat leathers of this study it seems clear that it is not the only factor involved. This is apparent from an inspection of Fig. 6a where it can be seen that the result for breed 3/4 PM does not fit the general pattern (i.e. it is considerably weaker than its apparent density

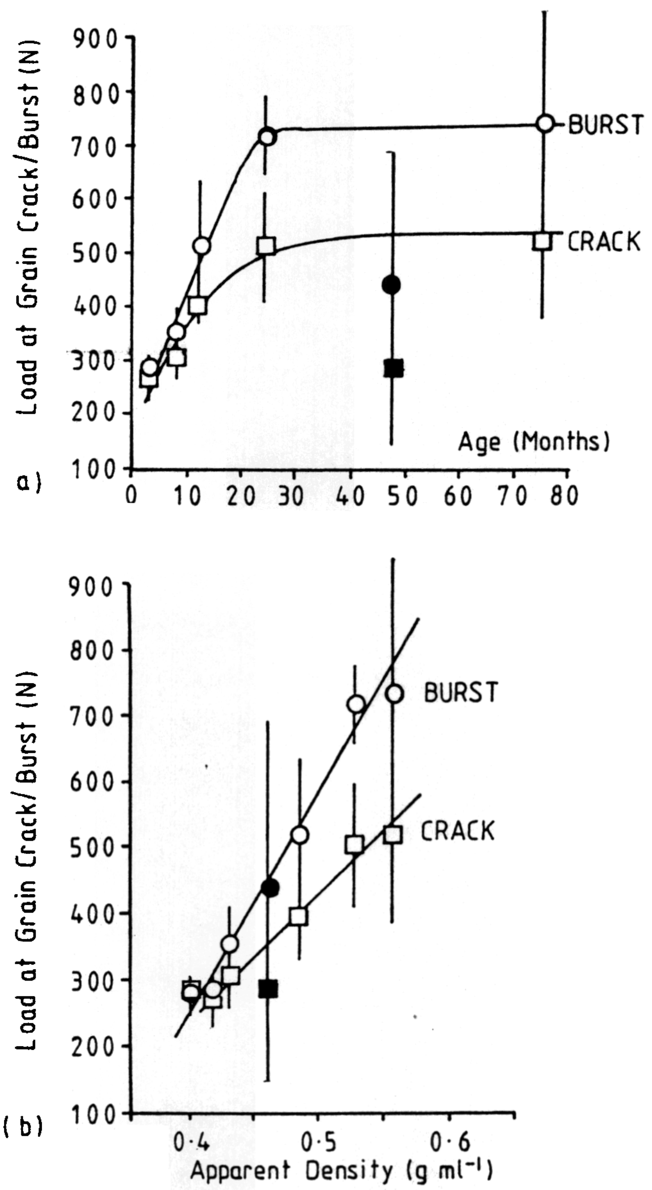

Figure 5. Load at grain crack/burst plotted against (a) age (b) Apparent Density.
● ■ Anglo-Nubiana

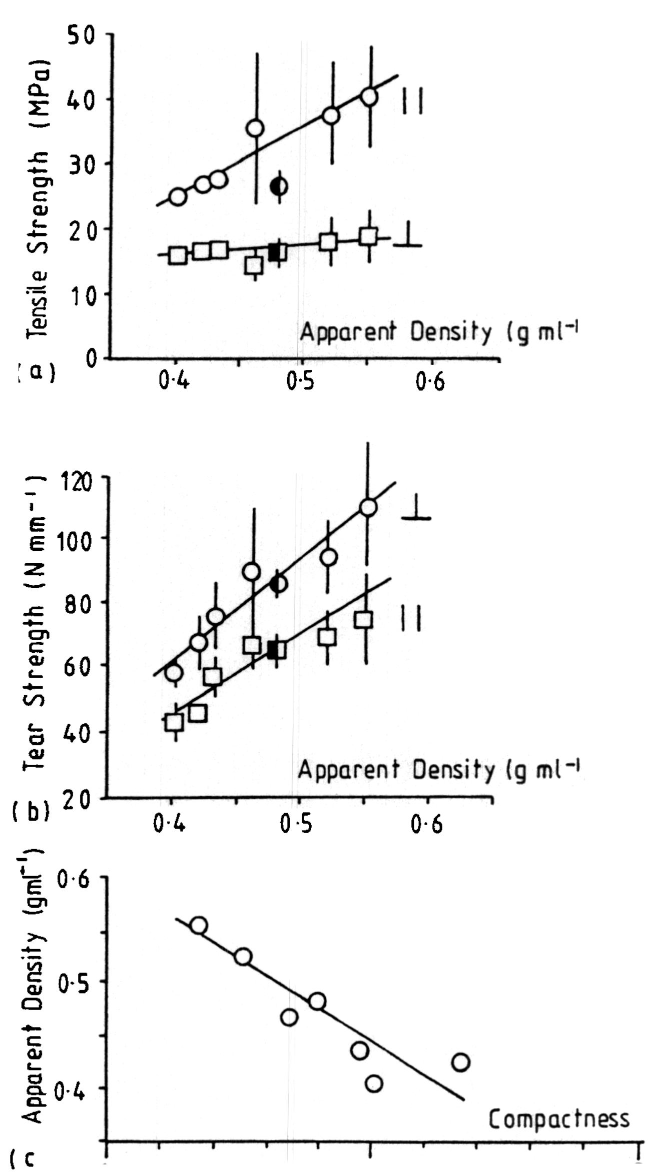

Figure 6. (a) Tensile Strength and (b) Tear Strength plotted against Apparent Density, (c) Apparent Density vs. Compactness.
◐ ◧ 3/4 Parda-Alpina × 1/4 Moxoto

would suggest). This observation would seem to be associated with the fact that breed 3/4 PM has a lower collagen content than expected for its age (Fig. 2a) and possibly a greater relaxation of isometric tension (Fig. 2b).

Conclusions

It is concluded that animal age at slaughter markedly influences the biochemical, biophysical and histological characteristics of goatskins and the strength of leather subsequently produced from them. The compactness of corium fibre weave is the principal skin characteristic influencing leather strength by virtue if its control over the apparent density of the leather. However, other skin characteristics were seen to be important for strength. Thus the breed Anglo–Nubiana has a lower strength due to the high fat content of its skin and the cross breed 3/4 Parda Alpina × 1/4 Moxoto has a lower tensile strength due to its lower collagen content.

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Appendix 1

Brief details of leather making process used for all goatskins.

Soak back 72 hours in 0.5 g l^{-1} sodium sulphide solution.
Degrease 1% Degreasing agent, 4 hours.
Paint with unhairing slurry (150 g l^{-1} sodium sulphide).
Leave for 12 hours, unhair.
Liming (2% Lime, 1% Sodium Sulphide) 48 hours.
Flesh.
Delime (2% ammonium chloride).
Bate (1% pancreatic bate).
Pickle (1% Sulphuric Acid 10% Sodium Chloride).
Tan (5% Chrome 42% Basicity).
Basify (1.5% Sodium Bicarbonate).
Horse up for 2 days.
Wash followed by neutralisation (1% Sodium Bicarbonate, 1% Sodium Formate).
Fatliquor (4% sulphited synthetic ester).
Sam, toggle dry, hand stake.