Skin and leather characteristics of hair-type goats reared in a hot-humid region

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Abstract Skin and leather characteristics of hair-type goats were studied in relation to their sex and age, using 100 randomly-selected skin from goats reared in east west Iran. Mean weights of skin and leather were 859.2±35.2 and 357.4±16.2 g, and the length and width of leather ranged from 60 to 121 and 41 to 87 cm, respectively. Age had a significant effect on the weight and area of skin and leather. Male goats had larger skins and leather weights and areas as well as thicker skins and leathers over shoulder and ribs compared to females. Age also had a significant effect on skin thickness and tensile properties from different parts of the body. Skin on the hip, back and shoulder was thicker than on the ribs and belt. Samples taken parallel and perpendicularly to the backbone from shoulder, hip and ribs parts showed significant differences in the mean value of breakage force, tensile strength and extensionat break. The leathers had a wide range of breakage force, tensile strength and percentage extension, being 6.7 to 58 kg.f, 94 to 448 kg.f/cm^2; and 33 to 93%, respectively. The results showed that there were significant differences in quantitative and qualitative characteristics of skin and leather between different goats of different genders and ages.

Keywords: skin, goat, leather, tensile properties

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Introduction

Due to skin structure, leather's tensile and elasticity properties will be affected by the type of animal and environmental factors. The origin, age at slaughter, temperature and humidity are important factors affecting leather quality (Passman and Sumner, 1987; Urbanija and Gersak, 2004.)

The typical structure of goat skin allows it to be processed into a wide variety of leather products, ranging from relatively firmer types such as the classical glazed kid to the rather softer types such as shoe upper leather as fashionable leather goods (Sarkar, 1982). So goat leather has received increasing attention and there has been an increasing demand, especially in the field of upper leather with classical mellow handle from the buyers (Felsner and Schmél, 2002). By looking at these trends, one can understand that attention not only should be paid to the type of raw material such as the skin, but also to the leather technology (FAO, 1998; Ørskov, 2011).

Determination of the characteristics of skin produced by native goats can help organize the grading and sorting of these products and improve this production systems that is different from other species and also between goats. Several research works have been published in this regard. Andersen et al. (1991) demonstrated that, skin weight, skin area and skin thickness increased with age. Snyman and Jackson-Moss (2000) showed very little breed difference in skin physical tanning properties among ten South African woolen, mutton and dual purpose sheep breeds, with the exception of Merino skin. This might also be the case for skins from goats of various skin covers.

Limited data are available in goats reared in tropical regions, including Iran, where some 5 to 6 thousand tons of goat crust (non-finished leather) is exported every year, making it a considerable income. Therefore, the main aim of the present research was to determine the effect of age and sex on qualitative and quantitative characteristics of skin and leather in a hair-type goat breed that has been adapted and reared in the hot and humid climate of Khuzestan province with a population of some 1.8 million goats.

Materials and methods

Selection of animals

One hundred (100) native hair-type goats, reared in Khuzestan province, comprised of 40 kids and 60 adult

goats, with a sex ratio of 40 males to 60 females, were randomly selected. Khuzestan is in the southwest of Iran (31° 19′ N, 48° 41′ E), bordering Iraq and the Persian Gulf. The climate of Khuzestan is generally hot and occasionally humid, particularly in the south, while winters are much more pleasant and dry. Temperature routinely exceeds 50 degrees Celsius in summer and drop to subzero temperatures during winter months (IPRD, 2013).

The goats were purchased from commercial flocks. The goats are grazed in different regions throughout the spring, summer and autumn, but in winter, they receive a limited amount of supplementary forage and grain and are housed at night. The average weight of male and female kids and adults were 22.0, 18.0 and 35.0, 30.0 kg, respectively. The goats were slaughtered and their skins cured by salting. The salted hides were placed in the shade (15 ºC and 50 % humidity) for 1 month to get dried.

Sample collection and measurements

Skin weight was recorded after removal of salt. The skin thickness at of shoulder, back, hip, rip and belt was measured using a manual thickness gauge. The skins were then transported to a tannery house. The chrome-tanning process without fleshing was used to make crusts. The area and weight of goat crust were determined. The leather traits were measured by using the methods introduced by the International Organization for Standardization (2002a,b,c; 2006) . For measuring the tensile strength, the leather samples were cut into two pieces by applying a press knife capable of cutting a test piece with standard dimension of 110 mm to the grain surface. Two specimens, including one test with the longer side, in parallel to the backbone and the other one with the longer side, perpendicular to the backbone, were taken. Vernier calipers were used to measure the thickness of the test specimens to the nearest 0.1 mm at the area between the grain and flesh sides. The tensile strength (T_s) was measured (kg force per mm^2) by using a tensile testing machine (model 4001 Intron[1]) with a cell force of 100 kg. The jaws of the apparatus were sited up at 50 mm ±1 mm apart for standard test piece and the clamps pulled up at the rate of at 100 mm/min. The greatest force was recorded as the breaking force and the tensile strength (T_s) in kg.f /mm^2 was converted to kg.f/cm^2 .

Statistical analysis

Data were analyzed using the general linear model. The statistical model was as follows:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk} \quad (1)$$

where Y_{ijk}, α_i, β_j, $(\alpha\beta)_{ij}$ and ε_{ijk} are observations, effect of age group, effect of sex group, interaction between age and sex, and residual, respectively. Least squares mean procedure was used for comparison of means. Thickness of hide and leather at different parts of body was compared using the t-test at 5% probability. Pearson's correlation coefficients were determined between skin and leather traits (SAS, 2002).

Results and discussion

Weight and area

Least squares means and standard errors of skin and leather traits are summarized in Tables 1 and 2, respectively. Based on the standard measures of Iranian goat, weight and area of the skin in Khuzestan adult breed (1020 g and 44 dm^2, respectively) were similar to the standard indexes of small to medium goats. Weight and area of skin in kids (643 g and 31 dm^2, respectively) can be ranked into medium size kids.

There were significant differences between genders and ages for skin and leather quantity traits (Tables 1 and 2). Compared to females and kids, male and adult goats had heavier and larger skin and leather. However, Marai and Khalil (2000) reported that the male skin was significantly heavier than that of female due to the variations in growth rate. The leather dimensions were significantly affected by age and its interaction with sex (Figure 1; $P < 0.01$). The length and width of leather in adults were 91.8±1.4 and 65.4±1.0 cm and in kids 76.6±1.7 and 57.3±1.4 cm, respectively.

Thickness

Skin and leather thickness in adults were significantly greater than in kids (Tables 1and 2) but the only significant differences with respect to the animal sex were for shoulder and back areas. The male had significantly thicker skin and leather in shoulder and back area than the females ($P < 0.005$).

[1] - Instron Ltd., Coronation Road, High Wycombe, Bucks Hp12 3Sy. England.

Table 1. Least squares means and standard errors of skin characteristic of goats by sex and age

	Skin weight (g)	Skin area (dm^2)	Skin thickness (mm) on				
			Shoulder	Back	Hip	Rib	Belt
Sex	*	*	***	*	ns	ns	ns
Male	882.1±47.9	38.3±1.2	1.6±0.04	1.6±0.03	1.5±0.04	1.3±0.03	1.2±0.03
Female	781.2±40.5	36.4±1.0	1.4±0.03	1.5±0.03	1.5±0.03	1.3±0.03	1.2±0.03
Age	****	****	***	***	*	**	****
Kid	643.4±47.9	31.1±1.2	1.4±0.04	1.4±0.03	1.5±0.04	1.2±0.03	0.9±0.03
Adult	1019.9±40.5	43.6±1.0	1.6±0.03	1.6±0.03	1.6±0.03	1.4±0.03	1.1±0.03
Overall	859.2±35.2	38.4±0.9	1.5±0.03	1.5±0.02	1.5±0.3	1.3±0.02	1.2±0.02
CV	41	25.7	19	14	17	16	18
Range	280 - 3350	18.5 - 79	0.9 - 3	1.1 – 2.7	1.0 – 2.5	0.9 – 2.2	0.8 -2.1

ns: not significant.
*, **, ***, **** Significant at $P < 0.05$, $P < 0.01$, $P < 0.005$ and $P < 0.0001$

There were significant differences in the thickness of skin and leather in the shoulder, back, hip, ribs and belt, but not in the back and hip. The minimum and maximum thicknesses in skin and leather were found for the belt and hip (Tables 1 and 2). Generally there is a steep dorso-ventral gradient in the skin thickness on either side of the median dorsal line, which showed a high degree of bilateral symmetry, with the skin being thicker near the vertebral column. Wodzicka (1958) showed that skin was thicker near the tail along the back of the sheep and, in the oldest sheep, and also towards the neck; however, it was an area of uniform skin thickness, in the middle of the back, on either side of and parallel to the vertebral column. Skin thickness is greater on the back of animals than on other parts of the body. This is associated with the fact that the back is the part of the animal most exposed to wind, rain and snow. Shihong (1981) measured skin thickness on the shoulder blade, the back and the knee of 70 live female yaks, with an average thickness at the three positions of 5.6 ± 0.36, 7.5 ± 0.83 and 5.6 ± 0.40 mm, respectively. Ouyang and Qianfei (1984) measured the thickness of epidermis and dermis combined. Again, the back had the thickest skin (average 5.13 mm) and the densely haired parts had a thickness of as little as 2.36 mm. Adel and Elboushi (1994) reported that skin thickness was dependent on the breed, varieties, age, sex and different parts of the body.

Physical and mechanical qualities of leather

Physical properties of goat leather as affected by the sex, age, body parts and specimen position are summarized in Table 3. There was a large variation in the tensile strength (94 to 448 $kg.f/cm^2$) of the samples with regard to the extent of thickness (0.5 to 1.4 mm) and breaking force (6.7 to 58 kg.f) of leathers. However, total means are in accordance with the BASF standards of leather quality, in which tensile strength is 200 $kg.f/cm^{-2}$ and the acceptance range for percentage of extension is 40 to 80% (BASF, 1984). According to Bri-

Table 2. Least squares means and standard errors of the leather characteristics by sex and age

	Weight (g)	Area (dm^2)	Thickness (mm)				
			Shoulder	Back	Hip	Rib	Belt
Sex	*	*	***	**	ns	*	ns
Male	376.4±22.1	59.5±1.8	1.1±0.03	1.0±0.03	1.1±0.03	0.9±0.03	0.8±0.03
Female	315.5±18.6	57.7±1.5	0.9±0.02	0.9±0.02	1.1±0.02	0.8±0.02	0.8±0.02
Age	****	****	****	****	****	****	****
Kid	261.6±22.1	49.5±1.8	0.9±0.03	0.9±0.03	1.0±0.03	0.8±0.03	0.7±0.03
Adult	431.3±18.6	67.6±1.5	1.1±0.03	1.1±0.02	1.2±0.02	1.0±0.02	0.9±0.02
Overall	357.4±16.2	60.3±1.4	1.0±0.0	1.0±0.0	1.1±0.0	0.9±0.0	0.8±0.0
CV	45.2	23.5	22.5	21.4	18.5	20.2	22.9
Range	110 - 1425	30.6 – 116.1	0.5 – 2.2	0.6 – 2.0	0.7 – 2.0	0.5 – 1.9	0.4 – 1.9

ns: not significant.
*, **, ***, **** Significant at $P < 0.05$, $P < 0.01$, $P < 0.005$ and $P < 0.0001$

Table 3. Physical properties of goat leather as affected by sex, age, body parts and specimen position

	No	Thickness (mm)	Breaking load (kg.f)	Tensile strength (kg.f/cm^{-2})	Extension (%)
Sex		*	****	***	ns
Male	40	0.89±0.02	24.1±0.7	272.7±5.5	57.2±0.9
Female	60	0.82±0.02	20.6±0.6	248.4±4.7	56.0±08
Age		****	****	***	***
Kid	40	0.79±0.02	19.7±0.7	246.7±5.5	54.0±0.9
Adult	60	0.90±0.2	25.1±0.6	274.4±4.7	59.2±0.8
Part of body		****	****	****	****
Shoulder	200	0.86±0.01	28.0±0.8	318.8±6.2	52.5±1.0
Hip	200	0.74±0.01	20.2±0.8	267.0±6.2	61.2±1.0
Ribs	200	0.95±0.01	18.9±0.8	195.9±6.2	56.1±1.0
Specimen position		*	****	****	***
parallel	300	0.87±0.01	25.7±0.7	294.4±5.5	52.5±1.1
perpendicular	300	0.83±0.01	19.1±0.7	226.7±5.5	60.7±1.1
Total mean	600	0.86±0.01	22.6±0.5	260.9±4.8	57.0±06
CV		19.5	37.4	29.4	17.9
Range		0.5 - 1.4	6.7 – 58	94 – 448	33 - 93

ns: not significant.
*, ***, **** Significant at $P < 0.05$, $P < 0.005$ and $P < 0.0001$

tish Standards (BSI, 1984) the standard for cloth leather is 150 kg.f/cm^2; however, the tensile strength of the goat leather obtained in this study (Table 3) was generally higher. Leather is expected to have strength and flexibility depending on the field of use (Bitlisli et al., 2004). Compared to leather of wool and hairy type breeds (Snyman and Jackson–Moss, 2000), the leather of goats in the present study had a higher breaking force, more tensile strength, but lower extension at break. Oliveira et al. (2007) reported lower respective thicknesses for the sheep and goat leather compared to those ones obtained in the present study. Stosic (1994) suggested that leather of goat had more tenacity and strength in comparison to the leather of sheep, which is likely due to grain and protein fibers that make it a very good material for making boots and garments.

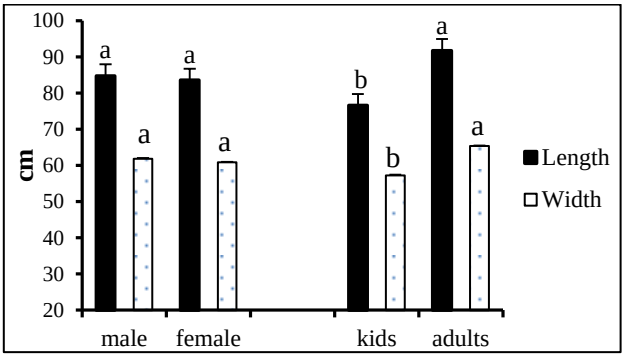

Figure 1. Leather length and width as affected by age and sex in goats [a, b]: Means followed by the different letter are significantly different at P<0.

A significant difference ($P < 0.005$) was observed between genders for tensile strength (Table 3). Males had stronger leather (275.2±6.8 kg.f/cm^2) than females (248.5±5.9 kg.f/cm^2), in agreement with Bal (1978), reporting a lower strength for the leather of pregnant and lactating goats.

There were significant differences in the breaking load, tensile strength and percentage of extension between the two age groups ($P < 0.005$).The kid's leather showed poorer properties than adult goats; adult goats produced thicker and more percentage in extension than kids. Higher values in physical performance related to the thickness were observed with gradual increases of age in sheep (Passman and Sumner, 1987) and ostrich (Cloete et al., 2004).

The physical traits of leather between different parts of the body were significantly different ($P < 0.0001$). The leather samples from shoulder had higher breaking force, more tensile strength and were considerablystronger than those of hip and rib but vice versa for the extension at break (Table 3). In Balady goats, the extension at break and strength between flank and rump regions were different (Abdelsalam and Haider, 1993).

The average tensile strength of the parallel and perpendicular test pieces are shown in Table 3. The break-

ing force and the tensile strength of parallel leather samples were higher and the percentage of extension was lower than those for the perpendicular samples. Sivasubramaniana et al. (2008) reported the parallel and perpendicular tensile strengths of goat skin ranged from 203 to 255 and 153 to 204 kg.f/cm^{2,} respectively. For cattle hides, they reported ranges of 255 to 306 and 204 to 255 kg.f/cm^2, respectively. They also reported that the extension at break of parallel and perpendicular samples were 40 to 80 and 60 to 80 percent for goat skin and cattle hide, respectively.

In Merino sheep skin and leather, tensile strength was highly dependent on the sample position and its orientation to the backbone (Gordon,1995). According to Gordon (1995), the strength of samples taken in parallel to the backbone decreased as the distance from the backbone increased. Stosic (1994) and Oliveira et al. (2007) reported that sampling direction significantly affected ($P < 0.05$) tensile strength and percentage extension. These findings supported a previous findings by Craig et al. (1987), who reported that higher tensile strength was attributed to the arrangement of leather fibers when horizontal sampling direction was used. Contrary to the above and present result, Teklebrhan et al. (2012) reported that sampling direction did not affect tensile strength and percentage extension.

Correlation between skin and leather characteristics

Leather weight and area were increased as skin weight and area increased. The correlations of skin and leather thickness with skin and leather weight were 0.7 and 0.8, respectively. The breaking force was generally increased as the leather thickness increased (r = 0.8). Similarly, tensile strength and extension increased as the leather thickness increased (r = 0.7 and r = 0.5 respectively). In a study on leather produced from lambs, Passman and Summer (1987) reported that tensile strength of lamb skin increased as its thickness increased.

Conclusion

The findings of this study showed that native goats in hot regions in Iran produce leather with acceptable range of tensile strength and extension, despite individual variations in quantitative and qualitative characteristics of skin and leather. To achieve better quality skin products, attention should be paid to factors affecting the skin quality such as sex and age and to the use of advanced techniques for leather processing.

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