Skin and Leather Quality of Ethiopian Indigenous Fat Tailed Hair Sheep as Affected by Breed and Level of Concentrate Supplementation

Mengistu Urge[1], Shashie Ayele[1, 2]*, Getachew Animut[3], and Mohammed Yusuf Kurtu[1]

[1]Haramaya University, School of Animal and Range Sciences, P.O. Box 138, Dire Dawa, Ethiopia
[2]Debre Markos University, College of Agriculture and Natural Resources, Department of Animal sciences, P.O. Box 269, Ethiopia
[3]Agricultural Transformation Agency, P.O. Box 708, Ethiopia

Abstract: This study evaluated the potential of three sheep breeds (Blackhead Ogaden (BHO), Horro, and Washera) under two concentrate supplement levels (CSL) (L1= 1% body weight and L2= 1.75% body weight) for quantity and quality of skin and leather production. Forty eight yearling intact sheep, 16 from each genotype (8 per CSL) with average initial weight of 21.3±1.5 kg (mean ±SD) were used in a 3 breed x 2CSL factorial arrangement of treatments in randomized complete block design. The animals were individually fed for 90 days a basal diet of pasture hay ad libitum supplemented with L1 or L2 and slaughtered for skin and leather quality study. Skin weight, length and width were measured. Skins were preserved and processed into leather for physico-chemical analysis. Horro breed produced leather with higher ($p<0.05$) quality of physical and chemical traits than BHO and Washera sheep. The leather produced from BHO sheep had similar tensile strength with Horro and the amount of loads required to crack and burst the grain layer were the same but larger distensions were recorded for BHO than Horro. Feeding concentrate at the rate of 1.75% body weight produced skin with higher weight, wider area, higher grain strength, and thickness than with 1% with no significance influence on tensile strength, fat content and chrome oxide uptake. In conclusion all the breeds and the two levels of supplementation produced quality leather comparable to the quality standard set by leather institutes.

Keywords: *Chemical test, Chrome content, Grain strength, Sheep, Thickness*

Introduction

Ethiopian fat tail hair sheep skins traditionally have a very good reputation for quality in the world leather market due to their fine grain and compact nature. Skin and leather from sheep is a commodity that earns income to the producers and is a source of foreign currency to the country. According to FAO (2013) the country produced 8.3 million pieces of sheep skin, exported two thousand tones in dry weight and earned 29.4 million USD. These earnings, however, are small considering the 27.54 million sheep population owned by the country, which is the second largest in Africa (FAO, 2013). Reason for this includes the unsuitability of the skins produced for export market due to various defects (Behailu, 2017) and low level of delivery of raw skin to the tannery.

Research results showed that skins from goats and sheep are often discarded in pastoral/agro-pastoral areas of the country (Dereje *et al.,* 2014). Mohammad *et al.* (2002) indicated that the quality of skins reaching to the tanneries has been deteriorating from time to time due to inadequate and poor quality feed services, poor parasite and disease control, branding with hot iron for identification purposes, inappropriate ways of slaughtering, poor collection and handling of hides and skins at different levels. Despite these problems, the leather industry is one of the leading generators of foreign currency in the country and an important sector for job creation. For instance, according to AGPLMD (2013) leather products generated USD 103.8 million foreign exchange earnings, with market share of 4%, ranking 8thamong agricultural product exports.

Research results show that breed, age, nutrition, and environment affect chemical and physico-mechanical quality of hide and skin (Stosic, 1994; Wright, 2002; Jacinto *et al*., 2011; Salehi *et al.,* 2013). However, there is limited empirical information on the physical and chemical quality of skins or leathers produced from different indigenous sheep breeds of Ethiopia (Tsegay *et al*., 2012; Fasil *et al.,* 2015). Therefore, to be competent at international markets, chemical and pysico-mechanical leather quality characteristics of indigenous sheep breeds of Ethiopia need to be assessed and information should be available for future sheep improvement program. The objective of the present study was, therefore, to evaluate the chemical and physico-mechanical qualities of chromium-tanned leather from three selected indigenous Ethiopian sheep breeds (Blackhead Ogaden, Horro, and Washera) under two levels of concentrate supplementation.

*Corresponding Author. E-mail: aklileshashie@gmail.com

ISSN 2616-8804 (Print)

Materials and Methods

Study Area

The study was conducted at Haramaya University goat farm, which is located at 9°25' N latitude and 42°2' E longitude. The area lies at an altitude of 1950 meters above sea level and receives 790 mm total average annual rainfall of bimodal type (Mishra *et al.,* 2004). It has an average temperature of 16ºC with mean maximum and minimum annual temperatures of 24.02 and 9.73 ºC, respectively.

Experimental Animals and Their Management

Details of the experimental protocol for this study has been described in a companion paper (Shashie *et al.*, 2017). Sixteen intact yearling male sheep from each of the three breeds, *i.e.* BHO, Horro, and Washera were used for the 90 days growth experiment. The experiment was arranged in a 2 x 3 (2 concentrate supplement levels and 3 sheep breeds) factorial arrangement of treatments in a completely randomized block design. Animals were blocked by initial bodyweight within genotype and randomly assigned to CSL. The two CSL were supplementation of the animals at 1 and 1.75% of body weight, designated as L1 and L2, respectively and was provided in two equal proportions at 0800 and 1600 hours. The amount of concentrate offer was adjusted every 10 days based on the body weight change. Chopped natural pasture hay was used as a basal diet and fed *ad libtum* with about 20% refusal rate. The concentrate comprised wheat bran (44%), noug seed cake (29%), maize grain (26%) and salt (1%) on DM basis. Clean water was available to animals all the time.

Slaughtering, Sample Preparation, and Data Collection

At the end of the growth trial, all sheep were slaughtered at Haramaya University abattoir. The skins were properly flayed with the carcass hanging and placed on wooden slanted tables to remove excess fats, blood, and other impurities. The fresh skin weight was taken using weighing balance with sensitivity of 0.01 kg and expressed as percent body weight at slaughter (shrunk body weight (SBW). Skin length and width measurements were taken using measuring tape to calculate skin area as skin length (cm) x skin width (cm).The skins were cured with salt weighing approximately 50% of the mass of the fresh skin applied on the flesh side. In the following days, skins were turned around and salted again. After two weeks, the salt was removed from the skins by shaking the skins and weighed again to get the weight of dry-salted skins.

The cured skins were taken to Ethiopian Leather Industry Development Institute (ELIDI) for further processing and physical and chemical quality analysis. At ELIDI the skins were processed to the chrome-crusted stage passing through major processing stages as described by Dereje *et al.* (2016).

Leather Chemical Quality

Chemical quality test such as fat, moisture/volatile matter, and chromium content were determined at wet blue stage. At this stage, skins are semi-processed leathers which have been tanned by fixing chromium salts during the tanning process. The moisture or volatile matters content of skin samples was determined using standard method (SLC-3, 1996a) by oven drying of a test sample at 102ºC to a constant weight and the percentage moisture content was calculated as:

$$\text{Moisture (\%)} = \left(\frac{\text{Initial sample weight} - \text{Dry sample weight}}{\text{Initial sample weight}}\right) \text{x100}$$

The fat content of the moisture-free samples was determined using standard Soxhlet extraction according to official method of analysis (SLC-4, 1996b). The fat content was taken to be the percentage weight of substances extracted from the samples using the solvent dichloromethane. After distilling the solvent from the flask, the extracted materials were dried at 102±2°C to constant weight, removed from the oven and cooled in the desiccators for 30 minutes and weighed. The percentage fat was calculated using the following formula:

$$\text{Fat (\%)} = \left(\frac{\text{Extracted sample weight(g)}}{\textit{Initial sample weight (g)}}\right) \text{x100}$$

The chrome content of the leather after tanning, defined by the quantity of chromium compounds (Cr_2O_3) absorbed by the leather, was determined by oxidizing the leather ash and iodometric titration of hexavalent chromium ions based on official method of analysis (SLC-208, 1996c) and calculated as a percentage of the original leather weight.

Leather Physico-Mechanical Quality

The chrome crusted leathers were conditioned at a temperature of 20±2ºC and relative humidity of 65±5% for 48 hour prior to physical test based on the standard procedure (ISO 2419, 2005a). After processing to un-dyed crust, thickness was measured according to standard procedure (ISO 2589, 2002a) and duplicate samples with standard sizes were taken from the butt region (Snyman and Jackson-Moss, 2000; Dereje *et al.*, 2016) based on the standard procedure (ISO 2418, 2005b) for leather quality test and the average values were used to calculate each parameter. The butt region is considered an official sampling position for leather quality tests in lambs and it covers the back and hindquarters and it is of very even thickness and firmness. Detail procedures of the leather physical characteristics evaluated are outlined below.

Tensile strength and percentage elongation: Tensile strength is the force required for breaking a dumbbell-shaped leather sample on the test machine (dynamometer). It was expressed in relation to the diameter at the narrowest part of the dumbbell-shaped piece of leather and the thickness of the sample. Elongation at grain break was determined during the test for tensile strength. It is the percentage stretch of the dumbbell shaped leather sample before it broke. Tensile strength and percentage elongation were measured following a test method of International Organization for Standardization (ISO-3376; 2002b) and were calculated using the following formulas:

$$\text{Tensile strength } (\text{N/mm}^2) = \frac{\text{Breaking load (N)}}{(\text{Thickness (mm)X Width (mm)})}$$

$$\%\ \text{Elongation} = \left(\frac{\text{Length at break (mm)} - \text{Initial length (mm)}}{\text{Initial length (mm)}}\right) \text{X } 100$$

Slit tear strength: The test for slit tear strength involved a rectangular leather sample with a small slit cut in the middle of it. The sample was then pulled apart by a clamp attached to its base and another clamp inserted through the slit. The point at which the slit starts to tear is defined as the slit tear strength and the force applied to tear the sample is tearing force/load. The slit tear strength was expressed in relation to average leather thickness as described by standard procedure (ISO 3377-2, 2002c). Leather thickness of each sample was measured in millimeters.

$$\text{Slit tear resistance (N/mm)} = \left(\frac{\text{Force at tear (N)}}{\text{Skin thickness at tear (mm)}}\right)$$

Grain strength: Grain strength was determined by the ball burst test using a lastometer. The method involves the measure of tension of the test leather samples by applying load across the sample by a steel ball from the flesh side. The rim of the circular, flat disc of test leather was clamped leaving the central portion free to move. The force was applied via the steel ball, which was advanced manually at a steady rate. The amount of distension (mm) and applied force (N) was recorded when the grain surface first crack and then steel ball burst through the sample (ISO-3379, 2005c).

Water absorption: Percentage of water absorption by leather samples was determined according to the standard procedure (ISO 5403, 2002d) using Kubelka method after 24 hour. It is the measure of weight of water absorbed per known weight of sample leather.

$$\text{Water absorption (\%)} = \left(\frac{\text{weight of water absporbed sample (g)}}{\text{weight of initial sample (g)}}\right) \text{x}100$$

Statistical Analysis

Data were analyzed using the general linear model (PROC GLM) procedure of SAS (SAS, 2008). Adjusted Tukey test was used to locate means that are significantly different ($p<0.05$). The statistical model used was: $Yijkl = \mu + Bi + Bj + Fk + (B\times F)jk + Eijkl$. Where; Yijkl = the response variable; μ = overall mean; Bi= effect of block; Bj = effect of breed; Fk = effect of CSL; (B× F)jk = interaction between breed and CSL, and Eijkl = random error. When the interaction effects were significant, the interaction least square means were presented and discussed. In the absence of interaction, least square means of the main effects were presented and discussed.

Results

Results on the chemical composition of the feeds used in this study, as well as on the performance of animals in terms of feed and nutrient intakes, and growth rate has been published earlier (Shashie *et al.*, 2017).

Skin Physical Quality

Skin area, fresh and salted-dry weight of skins were influenced ($p<0.05$) by genotype and CSL (Table1). Because of the large body size, Horro and Washera breeds had long and large area of skin than BHO breed. But, BHO sheep had wider skin than the two breeds. Significantly higher fresh and salted dry skin weights were recorded for Washera sheep than Horro and BHO. When the fresh weight of skin was expressed as percentage of slaughter weight, Washera and BHO sheep had similar values, which was heavier than Horro sheep. Sheep supplemented with higher CSL had wider ($p<0.001$) skin area, heavier fresh and salted dry weight. On the other hand, skin length and fresh skin weight on slaughter weight basis did not show significant difference between CSL.

Physico-Mechanical Leather Quality

Tensile strength and percentage of elongation: Tensile strength significantly varied among genotypes, but not different between CSL (Table 2). Leather made from skins of Washera sheep had lower tensile strength ($p<0.02$) than Horro and BHO lambs. Percentage elongation was in the order of Horro>Washera> BHO. The percentage elongation was higher for L1 as compared to L2 CSL. Leather thickness did not show significant difference among breeds but the difference was apparent between CSL in favour of L2.

Slit tear strength: The mean force required to tear leather from Horro lambs were significantly ($p<0.0001$) greater than that from BHO and Washera sheep. The value was also higher for L2 than L1 CSL sheep leather. Breed by CSL interaction effect was detected for tear resistance. The interaction showed that Horro breed produces better quality leather at higher level of supplementation than the Washera breed, while values were similar for the three breeds at lower level of supplementation (Table 2).

Grain strength: Distensions at crack and burst, cracking and bursting loads and water absorption characteristics of leather were affected by both genotypes and CSL (Table 2). The load required to crack and burst the grain layers and the distensions at grain crack and burst of leather made from Washera breed was ($p<0.0001$) lower than that from BHO and Horro breeds. Water absorption capacity of the leather made from Horro breed was significantly ($p<0.0001$) higher by about 5% than that of BHO and Washera breeds. Sheep consumed L2 CSL had higher distensions at crack and burst, cracking and bursting loads and water absorption characteristics compared to those received L1.

Leather chemical quality: Neither breed nor CSL influenced the chromic oxide content ($p>0.05$), whereas moisture content of leather was significantly different between breeds and CSL, being higher ($p<0.0001$) in Horro and Washera sheep than in BHO and in L1 than L2 concentrate supplemented sheep ($p<0.01$) (Table 3). The fat content of BHO leather was higher ($p<0.0001$) than for Horro and Washera breeds. On the other hand, the effect of CSL on fat content of leather was not apparent.

Table 1. Skin physical quality of three Ethiopian fat tailed hair sheep breeds supplemented with two concentrate supplement levels

	Sheep breeds (B)				CSL			P Value		
Variables	BHO	H	W	SEM	L1	L2	SEM	CSL	B	CSL x B
Area (m^2)	0.77^b	0.91^a	0.89^a	0.02	0.82^b	0.88^a	0.01	0.0015	<.0001	0.0712
Length (cm)	99.9^b	125^a	125^a	1.18	115.8	117.3	0.97	0.289	<.0001	0.1241
Width (cm)	75.0^a	72.4^b	70.9^b	0.93	70.1^b	75.4^a	0.76	<.0001	0.01	0.0852
FW (kg)	2.8^b	2.9^b	3.2^a	0.04	2.8^b	3.1^a	0.04	0.0004	<.0001	0.1667
DSW(kg)	1.71^b	1.87^b	2.12^a	0.06	1.82^b	1.98^a	0.05	0.0262	0.0001	0.2581
FW/(% SBW)	11.7^a	10.4^b	12.3^a	0.19	11.4	11.4	0.16	0.7422	<.0001	0.8546

^{a,b}With in genotype and CSL in the same row, means with different superscript letter differ significantly ($p<0.05$); BHO= Blackhead Ogaden; H= Horro; W= Washera; L1= Hay+1% of body weight CS; L2= Hay+1.75% of body weight CS; CS= Concentrate supplement; CSL= Concentrate supplement levels; SBW= Slaughter body weight; FW= Fresh weight; DSW= Dry salted weight; SEM= Standard error of the mean.

Table 2. Physico-mechanical quality of leather from three Ethiopian fat tailed hair sheep breeds supplemented with two levels of concentrate

Variables	**Sheep breeds (B)**				**CSL**			**P value**		
	BHO	H	W	SEM	L1	L2	SEM	CSL	B	CSL x B
TS (N/mm²)	19.4^{a}	19.6^{a}	18.4^{b}	0.31	19.2	19.1	0.25	0.658	0.0226	0.114
Elongation (%)	52.1^{c}	56.4^{a}	53.4^{b}	0.39	55.8^{a}	52.1^{b}	0.32	<.0001	<.0001	0.0911
Slit tear strength (double edge tear)										
Mean tearing force (N)	15.2^{b}	18^{a}	15.3^{b}	0.39	15.2^{b}	17.1^{a}	0.32	0.0002	<.0001	0.0711
MSTR (N/mm)								0.449	0.1912	0.0019
L1	26.1^{c}	27.8^{c}	26.8^{c}	1.37						
L2	31.8^{ab}	32.6^{a}	28.5^{bc}							
Grain strength (Ball burst test)										
Cracking load (N)	237^{a}	236^{a}	219^{b}	2.5	225^{b}	235^{a}	2.07	0.001	<.0001	0.0628
Distension at crack (mm)	10.1^{a}	9.8^{b}	9.7^{b}	0.07	9.5^{b}	10.2^{a}	0.05	<.0001	0.0004	0.3226
Bursting load (N)	260^{a}	262^{a}	239^{b}	3.4	245^{b}	261^{a}	2.8	0.0003	<.0001	0.7454
Distension at burst (mm)	11.3^{a}	10.9^{b}	10.5^{c}	0.07	10.6^{b}	11.1^{a}	0.06	<.0001	<.0001	0.1134
Water absorption (%)	44.2^{b}	49^{a}	44^{b}	0.77	43.1^{b}	48.4^{a}	0.63	<.0001	<.0001	0.4321
Thickness (mm)	0.52	0.55	0.52	0.01	0.5^{b}	0.56^{a}	0.009	<.0001	0.1961	0.0634

^{a,b,c} *Within genotype and CSL in the same row, means with different superscript letter differ significantly (p<0.05). BHO= Blackhead Ogaden; H= Horro; W= Washera; L1= Hay+1% of body weight CS; L2= Hay+1.75% of body weight CS; CS= Concentrate supplement; CSL= Concentrate supplement levels; N/mm2= Newton per millimeter squares; TS= Tensile strength; MSTR= Mean slit tear resistance; SEM= Standard error of the means.*

Table 3. Chemical quality of leather from three Ethiopian fat tailed hair sheep breeds supplemented with two levels of concentrate

	Sheep breeds (B)				**CSL**			**P value**		
Variables	BHO	H	W	SEM	L1	L2	SEM	LC	B	CSL x B
Chromic oxide (%)	4.8	4.8	4.7	0.13	4.8	4.7	0.10	0.4597	0.7085	0.243
Fat (%)	13.5^{a}	11.7^{b}	11.4^{b}	0.26	12	12.4	0.21	0.2367	<.0001	0.0996
Moisture (%)	11.8^{b}	12.4^{a}	12.4^{a}	0.07	12.3^{a}	12.1^{b}	0.06	0.0076	<.0001	0.0741

^{a,b}*Within genotype and CSL in the same row, means with different superscript letter differ significantly (p<0.05). BHO= Blackhead Ogaden; H= Horro; W= Washera; L1= Hay+1% of body weight CS; L2= Hay+1.75% of body weight CS; CS= Concentrate supplement; CSL= Concentrate supplement level; SEM= Standard error of the mean.*

Discussion

Skin Physical Quality

Skin area, weight, and length are usually considered as useful parameters for skin grading and can serve as a preliminary observation for the production of good quality leather. According to the Indian standard (IS:12435, 1988), goat and sheep skins are graded into different categories on the basis of area, which is generally based on the length of the skin. Accordingly, the skins are categorized as kid (below 71 cm in length), small (71 to 82 cm), medium (82 to 90 cm), large (90 to102 cm), and extra-large (above 102 cm). Based on this classification, the skin obtained from the three Ethiopian indigenous sheep breeds was considered as extra-large. The skin length recorded from all breeds in the present study was higher than 61.13 cm obtained for Indian Garole sheep skin (Banerjee *et al*., 2009).

The average fresh skin weight recorded in this study was higher than values (1.23-1.56 kg) reported for Sudan desert sheep breeds (Ebrahiem *et al*., 2015).The heavier skin weights recorded by sheep fed L2 CSL is an attribute of better growth rate and skin thickness as a result of the greater nutrient intake. This is in agreement with the finding reported by Cloette *et al.* (2006) and Dereje *et al.* (2016) who reported heavier raw skin weights for the high concentrate fed ostrich and goats, respectively than the group fed low concentrate diet. It is reported that skin and leather weight have high and positive correlations with leather area (Salehi *et al*., 2013) indicating that large volume of leather can be produced from the present sheep breeds skin because of their heavy skin weight.

Physico-Mechanical Leather Quality

Tensile strength and percentage elongation: The tensile strength values (18.4-19.4 N/mm^2) estimated for the sheep breeds in this study were higher than the minimum standard of 12 N/mm^2 set for lamb garment (BASF, 1984). The percentage of elongation (52.1-56.4%) was also within the acceptable range of 40-80% recommended for quality leather (BASF, 1984). Comparable tensile strength (18.1-24.6 N/mm^2) and percentage of elongation (43.6-56.3%) to present result have been reported for Ethiopian indigenous sheep and their F1 crosses with Dorper supplemented with two concentrate supplement levels (Tsegay *et al*., 2012).Unlike the present study, neither tensile strength nor percentage of elongation was influenced by breed and dietary levels ($p>0.05$) in the study of Tsegay *et al.* (2012). The fact that leather made from Horro had higher percentage of elongation compared to BHO and Washera sheep and higher tensile strength than Washera sheep could be partly explained by numerically better leather thickness. Oliveira *et al.* (2007) and Stosic (1994) noted that tensile strength and elongation at break test increases as the thickness of goats' skin increases.

High fat content is correlated with poor leather extensibility since fat influences the distension of the leather by blocking the amount of material, such as hair roots and pigments, making the fiber structure less open and poorly extensible (Stosic, 1994). Likewise in the present study, the leathers obtained from L2 fed group were less extensible than L1 probably due to dietary induced numerically higher fat content. Tancous and Schmitt (1967) noted that row cattle hide that gave low tensile strength contained greater amount of fat in the corium fiber structure. However, although BHO sheep skin had significantly higher fat content than Horro and Washera sheep skin, the tensile strength of BHO sheep leather was not affected. According to Stosic (1994) physical property such as strength and extensibility of leather is influenced by many factors other than fat content, which includes among others the skin innate property such as the amount of fibrous materials, grain to corium ratio and other structures and discontinuities such as hair follicles and sweat glands present in the skin.

Grain strength: The load required to crack and burst the grain layer and distensions of a leather use as a guide to predict how the material will perform during toe lasting process in leather product manufacturing. These tests generally give an indication of the strength of the leather as well as the amount that the leather could be stretched before the upper grain layer first crack and then burst (Stosic, 1994). In the present study, the lower values of the load required for cracking and bursting the grain layer of Washera sheep leather than BHO and Horro was probably associated with the hairiness of Washera skin, as more space is occupied by the glands from which the hair follicles grow and reduce the area available for collagen fiber bundles, which consequently reduce the resistance of the skin and leather to tearing and stretching (Jacinto *et al.,* 2004). Burns (1965) noted that high overall hair density in Nigerian goat breeds resulted in poor quality skin. The higher load required for cracking and burst the crust leather grain obtained from L2 as compared to L1 group is in agreement with the results obtained in goats (Stosic, 1994; Seid *et al.,* 2012; Dereje *et al.,* 2016) and sheep (Tsegay *et al*., 2012).

The distention at grain break and burst obtained in this study were comparable to values of 8.6-10.3 mm reported for BHO, Hararge highland and their Fl crosses with Dorper sheep (Tsegay *et al.,* 2012). Nevertheless, distention at grain break and burst were not affected by breed and dietary treatments in experiment using sheep breeds (Tsegay *et al.,* 2012) and goat breeds (Seid *et al.,* 2012; Dereje *et al*., 2016). Generally the present study showed that all sheep breeds produced leather having greater distention at grain crack and burst than the minimum standard value of 7 mm set for quality shoe upper leather (BASF, 1984).

Leather thickness: The leather thickness values obtained in the present study were comparable to the 0.43-0.5mm reported for BHO sheep, Hararghe highland sheep, and their F1 crosses with Dorper (Tsegay *et al.*, 2012). In their study, level of supplement showed variation and higher leather thickness was recorded for lambs supplemented with high level of concentrate, but the effect of breed was not apparent unlike to the present study. On the other hand, the current values of skin thickness were lower than that reported by Fasil *et al.* (2015) who noted 0.8-1.3 mm thickness with the highest value observed at high level of concentrate supplementation for the crust leather of BHO sheep. The BHO sheep used by Fasil *et al.* (2015) are slaughtered at mature age, which could have been a reason for thicker skin than in the present study. Various researchers reported that skin thickness increase as age increase in goat (Stosic, 1994; Salehi *et al.,* 2013) and sheep (Passman and Sumner, 1987). The positive effect of supplementation on skin thickness has also been reported by Stosic (1994).

Slit tear strength/resistance: Slit tear strength is the measure of the resistance of the upper leather due to tear or puncture and it is a function of' leather thickness. The slit tear strength values registered by the three breeds and dietary groups in the current study were above the standard recommended for shoe upper leather (>25N/mm) but less than garment leather (>35N/mm) set by BASF (2012). The higher slit tear strength for Horro sheep leather than leather from the other two sheep breeds was because of relatively higher leather thickness. The slit tear strength of leathers recorded in the present study was higher than 12.3-15.3 N/mm reported by Tsegay *et al.* (2012), but much lower than 47.9-54.9N/mm recorded by Fasil *et al.* (2015), which could be an attribute of breed type of sheep and age at slaughter.

Water absorption: Water absorption is a measure of comfort and hygienic properties of leather. According to the BASF (2012) standards, the performance requirement of water absorption for the leather upper shoe should be <85%. Therefore, in the present study the results from all sheep breeds were not greater than the quality standard set by BASF (2012) indicating that leathers from these breeds are suitable for manufacturing of shoe upper leather. The higher water absorption capacity of the leather obtained for Horro breed and the groups consumed higher level of concentrate supplement was probably due to better leather thickness.

Leather Chemical Quality

Chromic oxide uptake by the leather sample is affected by the fat content of the leather. This is because when the natural fat is high or not sufficiently removed from the skin, the fiber structure remains less open and reduces the uptake of chromium oxide during the process of leather making (Stosic, 1994). In the present study, there was significant breed effect on leather fat content. However, the chromic oxide content was similar among breeds, may be because the difference in leather fat content among breeds might be low to bring change in chromic oxide uptake of the leather. The amount of chromium oxide absorbed by leather is known to have significant effect on storage properties of wet blue leather. According to Stosic (1994) a minimum of about 2.5% chromic oxide is required to prevent loss of tensile strength and grain damage during storage of wet blue leather. The leather made from all breeds contained more than 2.5% chrome oxide and was within the normal acceptable levels for wet blue leather storage. Comparable results were reported by Fasil *et al.* (2015) but slightly lower values were reported by Tsegay *et al.* (2012).

In the present study, the lower moisture content of the leather obtained from BHO and for sheep supplemented with higher level of concentrate was due to the fact that they have higher fat in the leather as the two are inversely related (Stosic, 1994). The value of moisture content in the present study was slightly higher than the 9.6-10.1% reported by Fasil *et al.* (2015) for leather from BHO sheep regardless of levels of supplement and that of Ebrahiem *et al.* (2015) who reported 8.95-11.6% for five Sudan desert sheep breeds with significant breed effect. The moisture content of the sheep leather of the present study was within the range of 12-14% set for ideal moisture content of leather (SATRA Spotlight, 2006) and fulfils the value (12%) set by the Ethiopian Standards Agency (ES-1195, 2005).

Conclusion

Results from the present study showed that almost all physical leather traits as well as some chemical quality attributes were influenced by breed and CSL. Washera sheep leather had lower tensile and grain strengths than BHO and Horro sheep leathers. Nevertheless, the three sheep breeds produced leather with physical and chemical characteristics compatible with the quality standards required by the leather industries. Although Ethiopian hair sheep skins is known to have a very good reputation for quality in the world leather market, the present study indicated that there still exists leather quality difference between indigenous hair sheep breeds. Although concentrate supplementation at the rate of 1.75 % of body weight resulted in the production of leathers with good strength and thickness than 1% body weight, the two feeding levels produced leather compatible to quality standard set by different leather industry.

Acknowledgements

The Authors would like to thank Haramaya University for the financial and research facility support, Ethiopian Agricultural Research Institute for covering the laboratory fee and the second Author would like to thank Debre Markos University for providing study leave, salary and supplementary research money.

Conflict of Interests

The authors declare that they have no competing interests.

References

AGPLMD (Agricultural Growth Project-Livestock Market Development) (2013). Livestock Market Development Value Chain Analysis for Ethiopia: Meat and Live Animals, Hides, Skins, Leather and Dairy. Expanding livestock markets for the small-holder producers, pp: 160.

Banerjee, R., Mandal, P. K., Bose, S., Banerjee, M. & Manna, B. (2009). Quality Evaluation of Meat, Skin and Wool from Garole Sheep-a Promising Breed from Indian. *Asian Journal of Animal Science,* 3 (2): 39-46.

BASF (Baden Aniline and Soda Factory) (1984). Vademecumpara el tecnico en curticion, 2nd ed., BASF, Ludwigshafen, Germany.

BASF (Baden Aniline and Soda Factory) (2012). Booklet Book for the Leather Technologist, 4th ed., Revised and Enlarged. Ludwigshafen, Germany.

Behailu Amde (2017). Major Factors Affecting Hide and Skin Production, Quality and the Tanning Industry in Ethiopia. *Advances in Biological Research,* 11 (3): 116-125.

Burns, M. (1965). The Histology of some Nigerian Goats. *Journal of Tropical Agriculture,* 42 (3): 243-259.

Cloette, S. W. P., van Schalkwy, S. J., Brand, T. S., Hoffman, L. C. & Nel, C. J. (2006). The Effects of Dietary Energy and Protein Concentrations on Ostrich Skin Quality. *South African Journal of Animal Science,* 36 (1): 40-44.

Dereje Tadesse, Mengistu Urge, Getachew Animut & Yoseph Mekasha (2014). Perceptions of Households on Purpose of Keeping, Trait Preference, and Production Constraints for Selected Goat Types in Ethiopia. *Tropical Animal Health and Production,* 46: 363-370.

Dereje Tadesse, Mengistu Urge, Getachew Animut & Yoseph Mekasha (2016). Effects of Diet on Leather Quality and Longissimus Muscle Composition of Three Ethiopian Indigenous Goat Types. *Animal Production Science,* 56: 1946-1952.

Ebrahiem, M. A., Turki, I. Y. & Haroun, H. E. (2015). Effect of Breed Variation on Skin/Leather Quality of Sudan Desert Sheep. *Global Journal of Animal Scientific Research,* 3 (1): 136-141.

ES (Ethiopian Standard Authority) (2005). Determination of Moisture Content of Leather, ES 1195: (2005). Leather and Leather products Technology Institute, Addis Ababa, Ethiopia.

FAO (Food and Agriculture Organization) (2013). World Statistical Compendium for Raw Hides and Skins, Leather and Leather Footwear 1993-2012. Trade and Markets Division Food and Agriculture Organization of the United Nations, pp: 169.

Fasil Negussie, Mengistu Urge, Yoseph Mekasha & Getachew Animut (2015). Effects of Different Feeding Regimes on Leather Quality of Finished Blackhead Ogaden Sheep. *Science, Technology and Arts research Journal,* 4 (2): 222-227.

Indian standard (IS:12435) (1988). Guidelines for Grading of Hides and Skins on The Basis of Mass and Size.

ISO (International Organization for Standardization) (2002a). ISO 2589. Test Method for Measuring of Thickness of Samples. Leather and Leather Products Technology Institute, Addis Ababa, Ethiopia.

ISO (International Organization for Standardization) (2002b). 'ISO 3376. Test Methods of Tensile Strength and Percentage Elongation' Ethiopian Leather Industry Development Institute, Addis Ababa, Ethiopia.

ISO (International Organization for Standardization) (2002c). 'ISO 3377-2. Sampling methods for tear load and tear resistance. Ethiopian Leather Industry Development Institute, Addis Ababa, Ethiopia.

ISO (International Organization for Standardization) (2002d). 'ISO 5403. Test Methods of Determination of Water Resistance for Light Leather'. Ethiopian Leather Industry Development Institute, Addis Ababa, Ethiopia.

ISO (International Organization for Standardization) (2005a). ISO 2419. Methods for Preparation and Conditioning of Test Samples for Physical and Chemical Tests. Ethiopian Leather Industry Development Institute, Addis Ababa, Ethiopia.

ISO (International Organization for Standardization) (2005b). ISO 2418. Determination of Sampling Site for Physico-Mechanical Test. Ethiopian Leather Industry Development Institute, Addis Ababa, Ethiopia.

ISO (International Organization for Standardization) (2005c). 'ISO 3379. Test Methods of Distension and Strength of Grain'. Ethiopian Leather Industry Development Institute, Addis Ababa, Ethiopia.

Jacinto, M. A. C., Junior, F. M. deV., Martins, C. F., Pinto, G. dos S., Reis, F. A. & de Oliveira, A. R. (2011). Influence of Genotype on the Quality of Sheep Leather. *Revista Brasileira de Zootecnia,* 40 (8): 1830-1836.

Jacinto, M. A. C., Silva Sobrinho, A. G. & Costa, R. G. (2004). Anatomic and Structural Characteristics of Wool and Non-Wool Sheep (*Ovis aries L.*) in Regard to the Physico-Mechanical Aspects of the Leather. *Brazilian Journal of Animal Science,* 33: 1001-1008.

Mishra, B. B., Heluf Gebrekidan, Kibebew Kibret, Mohammed Assen & Bruk Eshetu (2004). Soil and Land Resource Inventory at the Alemaya University Research Farm with Reference to Land Evaluation for Sustainable Agricultural Management and

Production. *Soil Sciences Bulletin No. 1*, Haramaya University, Ethiopia.

Mohammad Jabbar, Kiruthu, S., Berhanu Gebremedhin & Simeon, E. (2002). Essential actions to meet quality requirements of hides, skins and semi-processed leather from Africa. *Report prepared for the common fund for commodities Amsterdam, the Netherlands*, pp: 62.

Oliveira, R. J. F., Costa, R. G., Sousa, W. H., Medeiros, A. N., Dal Monte, M. A. B., Aquin, D. & Oliveira, C. J. B. (2007). Influence of Genotype on Physico-Mechanical Characteristics of Goat and Sheep Leather. *Small Ruminant Research,* 73: 181-185.

Passman, A. & Sumner, R. M. W. (1987). Effects of Breed and Age at Slaughter on Leather Produced from Export Lambs Reared on Hill Country. *New Zealand Journal of Experimental Agriculture,* 15: 309-316.

Salehi, M., Lavvaf, A. & Farahvash, T. (2013). Skin Quality and Physical Properties of Leather Based on Sex, Age and Body Parts of Goats Reared on Sub-Humid Hill Country. *Iranian Journal of Applied Animal Science,* 3: 853-857.

SAS (Statistical Analysis Systems Institute) (2008). version 9.1, SAS Institute Inc., Cary, North Carolina, USA.

SATRA Spotlight (2006). The Chemical Testing of Leather. SATRA Technology Centre. Retrieved from www.satra.co.ukSATRA Spotlight, 2006.

Seid Mohammed, Mengistu Urge, Getachew Animut, Kassahun Awgichew, Girma Abebe & Goetsch, A. L. (2012). Effects of Level of Concentrate Supplementation on Growth Performance of Arsi-Bale and Boer×Arsi-Bale Male Goats Consuming Low-Quality Grass Hay. *Tropical Animal Health and Production,* 44: 1181-1189.

Shashie Ayele, Mengistu Urge, Getachew Animut & Mohammed Yusuf (2017). Feed Intake, Digestibility, Growth Performance and Blood Profiles of Three Ethiopian Fat Tail Hair Sheep Fed Hay Supplemented with Two Levels of Concentrate Supplement. *Open Journal of Animal Sciences,* 7: 149-167. Available at https://doi.org/10.4236/ojas.2017.72013

SLC (Society for Leather - Chemical test) (1996a). Official Methods of Analysis (SLC-3) for Determination of Moisture Content and Volatile Matters in Leather. Ethiopian Leather Industry Development Institute, Addis Ababa, Ethiopia.

SLC (Society for Leather - Chemical test) (1996b). Official Methods of Analysis (SLC-4) for Determination of Fats and Other Soluble Substances in Leather. Ethiopian Leather Industry Development Institute, Addis Ababa, Ethiopia.

SLC (Society for Leather - Chemical test) (1996c). Official Methods of Analysis (SLC-208, 1996c) for Determination of Chromium In Leather. Ethiopian Leather Industry Development Institute, Ethiopia.

Snyman, M. A. & Jackson-Moss, C. A. (2000). A Comparison of Leather Properties of Skins from Ten Different South African Sheep Breeds. *South African Journal of Animal science,* 30: 129-130.

Stosic, P. (1994). Biological Factors Influencing the Nature of Goat Skins and Leather. MSc Thesis. University of Leicester, England.

Tancous, J. J. & Schmitt, R. (1967). Pulpiness and Weakness in Side upper Leather as Related to Fresh Hides. *Journal of American Leather Chemist Association,* 62 (12): 781-804.

Tsegay Teklebrihan, Mengistu Urge & Yoseph Mekasha (2012). Skin/Leather Quality of Indigenous and Crossbred (Dorper x Indigenous) F1 sheep. *Livestock Research for Rural Development,* 24 (56). *Retrieved from http://www.lrrd.org/lrrd24/4/tekl24056.htm*

Wright, W. T. (2002). Cattle Management Factors that Affect Hide Quality. MSc Thesis, the University of Texas Graduate Faculty of Technology, pp: 61.