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Original Paper

Leather quality of some Sudan Desert sheep and goats

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This trial is aimed to study leather properties that produced from Sudan Desert sheep and goats in relation to breed type and age category. Thirty pieces of fresh sheep and goats skins were collected randomly (15 for each) during January 2015. The collected skins were tanned and the produced leather properties were studied. The Statistix 8 program for variance analysis was used for data analysis. The study samples were taken according to the Complete Randomized Design. Sheep leather results revealed that, lamb's skin was significantly (P ≥0.05) produced better quality leather than ram's and ewe's skins in elongation %, tensile strength (kg cm^{-2}), cracking load (kg), thickness (mm), tear load (kg cm^{-1}), flexibility and moisture %. While it was yielded leather with the same characteristics to ram's and ewe's leather in ash %, fat % and chrome %. Leather prosperities [elongation %, tensile strength (kg cm^{-2}), cracking load (kg), tear load (kg cm^{-1}), flexibility and ash %] were significantly (P ≥0.05) affected by breed variation. On the other hand thickness (mm), moisture %, fat % and chrome% were not significantly (P ≥0.05) affected by breed. Ram's skin was produced better quality leather than ewe's skins. Goat's leather results revealed that, kid goat's skin was significantly (P ≥0.05) produced better quality leather than bucks and doe's skin in tensile strength (kg cm^{-2}), cracking load (kg), thickness (mm), tear load (kg cm^{-1}) and flexibility degree. But kids and buck's skins were produced the same quality leather in elongation % and moisture % with significant variation (P ≥0.05) to doe's leather. Kid's skin yields leather with the same characteristics to buck's and doe's leather in ash %, fat % and chrome %. Generally Desert goats produce slightly better quality leather than Nubian goats. Leather prosperities [cracking load (kg), tear load (kg cm^{-1}) and Ash %] were significantly (P ≥0.05) affected by breed variation. Elongation %, tensile strength (kg cm^{-2}), thickness (mm), moisture %, fat %, flexibility and chrome % were not significantly (P ≥0.05) affected by goats breed.

Keywords: leather quality, Kabashi, desert sheep, Nubian goats, desert goats, Sudan

1 Introduction

The sheep population of Sudan is about 49 million, over 36 % of the livestock in the country. Most are the Desert sheep, which are distributed across the low rainfall savannah, semi-desert and desert zones (El-Hag et al., 2007). The desert sheep are distributed north of latitude 10° N, extending eastward into Eritria and westward into Chad (Wilson, 1991). Desert sheep of the Sudan comprises seven sub-types, namely Kabashi, Hamari, Meidob, Beja, Butana, Gezira and Watish (Mcleory, 1961). The desert sheep is raised mainly under extensive nomadic conditions depending on natural grazing. Kababishi (the model of the ecotype) is further classified into tribal subtypes, Hamari, Kabashi and Shanbali in West and North Kordofan and Darfur states (Mukhtar, 1985 and El-Hag et al., 2001). The tribal subtype Kabashi is raised in the northern and eastern parts of North Kordofan and Darfur States while Hamari subtype is found in the western part of Kordofan and Darfur regions with different grades of crosses between these two tribal subtypes in the middle of the region. The main colours of Kabashi are brown, light brown and spotted black or red and white. The dominant colour of Hamari is red (Ali et al., 2014). In Sudan goats were estimated at 42.5 million head forming about 31.7 % of ruminants in the country, 18.2 % of goats in Africa and 5.3 % of the world goat population (FAO, 1999; Yousif and Fadl El-Moula, 2006). This population composed of four major local breeds, Nubian, Desert, Nilotic and the Dwarf, distributed throughout the country (Wilson, 1991). The Nubian goat is considered as a milk production, while the other breeds are generally considered as meat animals (Devendra and Mcleroy, 1987; Gall, 1996). The Desert goat is characterized by the long drooping (lop) ears, as in the Zaraibi of Egypt and Nubian of the Sudan (Babeker and Elmansoury, 2013).

In forest regions and regions that are not suitable for crop cultivation and cattle production Small ruminants are the most important livestock for rural inhabitants (Daskiran et al., 2006). Goats are important in arid and semi-arid zones especially in developing countries due to their superior

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adaptation to environment and feeding habits (Devendra and McLeroy, 1987). Their inquisitive feeding habits enable them to extend their feed preferences and also perform well in situations where other ruminants may not be able to survive. Goats prefer variations in their feed and they are selective feeders (Devendra and Coop, 1982).

In Sudan, goats and sheep play an important integral component in most traditional production systems. They provide milk for children, meat, skin and cash income from sales (Ageeb, 1992). This trail is aimed to study Sudan sheep and goats leather properties in relation to breed type and age category.

2 Material and methods

2.1 Study area

Skins samples were collected from Elobaied leather market, North Kordofan state in latitudes 11° 5′ – 13° 75′ N and longitudes 27°– 29° 5′ E in Sudan (Tibin et al., 2010). The area is located within the poor Savannah belt. The climate is warm in wet season, hot dry in summer and cool dry in winter. The rainy season is about four months (mostly from July to October), peaking at August and the annual average rainfall is between 300 – 400 mm (Abusuwar et al., 2012). The soil is generally of smooth undulating sandy plain dissected by batches of loamy sand in the southern part. The dominant vegetation is a mixture of thorny trees, shrubs, herbs, where Acacia senegal is the most important type from economic point of view, for it produces Gum Arabic which is considered as the best cash crop Yehia (2002).

2.2 Skin samples collection and tanning procedures

Thirty pieces of fresh skins from Sudan desert sheep and goats (fifteen each) were collected randomly from Elobaied Leather Market at north Kordofan state, Sudan. Three age categories were studied for sheep (lamb, ram and ewe) and the same categories for goats (kid, buck and doe). Five skins were taken to represents each age category. The collected fresh skins cured by salt-drying technique. The cured skins were transported to Khartoum National Leather Technology Centre for tanning and laboratories analysis work. Leather was prepared from sheep and goat skins according to the main steps described by Ebrahiem et al. (2015a).

Sampling and assessment of chemical and physical characteristics were done according International Standards Organization (ISO2418, 2002 and ISO 4044, 2008). Physical properties that assessed were Tensile strength and elongation percentage and it was determined according to ISO3376 (2002). Flexibility test was assed according to ISO5402 (2002). Tearing load and resistance to grain cracking was done according to ISO3377-1 (2002) and ISO3378 (2002) respectively. Moisture, total Ash, fats and oils contents were determined according to SLTC (Society of Leather Trades Chemists, 1965). Chrome content was measured according to ISO5398-1 (2007) procedures.

2.3 Statistical analysis

The data were statistically analysed using analysis of variance method. The Statistix 8 program was used for this purpose on Complete Randomized Design (CRD) according to (Gomez and Gomez, 1984). Duncan's Multiple Range Tests (DMRT) was used for means separation (Statistix 8, 2007).

3 Results and discussion

3.1 Effect of age category on sheep leather quality

As shown in table 1 Elongation percent was significantly affected (P ≥0.05) by the age category of the animals. The proper elongation percent was recorded at lamb and ram leather 58.7 ±2.8 and 58.3 ±3.6 respectively. Ewe elongation percent was 65.8 ±2.9 which exceeded the accepted limit for upper, garment and lining leather that estimated at 60 % by SSMO1 (2004), SSMO2 (2008) and SSMO3 (2008). Tensile strength (kg cm^{-2}) results were significantly affected (P ≥0.05) by animal age, and in the suitable standard of SSMO1 (2004), SSMO2 (2008) and SSMO3 (2008) for upper, lining and garment leather respectively. Cracking load (kg) was significantly affected (P ≥0.05) by animal's age, and the high records were obtained at lamb's leather followed by ram's leather and last ewe's leather. Thickness (mm) Thickness (mm) results were significantly affected (P ≥0.05) by animal's age, and the high record was in lamb's leather (1.57 ±0.1 mm). Thickness results were in the SSMO1 (2004), SSMO2 (2008) and SSMO3 (2008) standards for upper, lining and garment leather. The high records of Tear load (56.4 ±1.5 kg cm^{-1}) was assessed in lamb's leather and it significantly different (P ≥0.05) from which were reported for rams and ewes leather. Lamb's leather scored the better level of flexibility (1.4 ±0.7) followed by ewe's leather (2.3 ±0.9) and the worst degree was observed in ram's leather (3. 6 ±0.8). Chemical contents of ash %, fat %and chrome % of sheep leather were not affected (P ≥0.05) by the animal's age. While moisture % results were significantly affected (P ≥0.05) by the animal's age. The high content of moisture (12.8 ±1.7 %) was reported at ewe's leather of Kabashi sheep. All chemical constituents were in the SSMO1 (2004), SSMO2 (2008) and SSMO3 (2008) standards for leather chemical thresholds.

Table 1 Effect of age category on leather quality of Sudan Kabashi desert sheep during Janury 2015

Quality parameters	Age category		
	ram	ewe	lamb
Elongation %	58.3 ±3.6^{B}	65.8 ±2.9^{A}	58.7 ±2.8^{B}
Tensile strength (kg cm^{-2})	186.80 ±12.9^{B}	159.10 ±13.1^{C}	206.40 ±12.3^{A}
Cracking load (kg)	19.2 ±1.1^{B}	16.1 ±1.4^{C}	22.5 ±1.3^{A}
Thickness (mm)	1.34 ±0.1^{B}	1.22 ±0.1^{C}	1.57 ±0.1^{A}
Tear load (kg cm^{-1})	43.5 ±1.4^{B}	33.6 ±1.2^{C}	56.4 ±1.5^{A}
Flexibility degree	3.6 ±0.8^{A}	2.3 ±0.9^{B}	1.4 ±0.7^{C}
Moisture (%)	9.6 ±2.1^{B}	12.8 ±1.7^{A}	9.7 ±1.9^{B}
Ash (%)	2.74 ±0.2^{A}	2.75 ±0.1^{A}	2.64 ±0.3^{A}
Fat (%)	4.07 ±0.4^{A}	3.78 ±0.7^{A}	4.30 ±0.5^{A}
Chrome (%)	3.08 ±0.5^{A}	3.02 ±0.7^{A}	3.01 ±0.6^{A}

Means in the same row with the same letter are not significantly different (P ≥0.05)

Table 2 Age category effect on Sudan goat's leather quality during January 2015

Quality parameters	Age category		
	buck leather	doe leather	kid leather
Elongation (%)	58.3 ±3.6^{B}	61.8 ±2.9^{A}	58.7 ±2.6^{B}
Tensile strength (kg cm^{-2})	194.40 ±5.5^{B}	159.1 ±13.1^{C}	226.1 ±16.2^{A}
Cracking load (kg)	19.8 ±1.1^{B}	16.3 ±1.3^{C}	24.5 ±1.2^{A}
Thickness (mm)	1.34 ±0.1^{B}	1.22 ±0.1^{C}	1.57 ±0.1^{A}
Tear load (kg cm^{-1})	43.5 ±1.4^{B}	33.6 ±0.7^{C}	58.4 ±1.6^{A}
Flexibility degree	3.3 ±0.6^{A}	2.1 ±0.8^{B}	1.2 ±0.5^{C}
Moisture (%)	9.6 ±2.2^{B}	10.8 ±1.6^{A}	11.7 ±2.3^{B}
Ash (%)	2.74 ±0.2^{A}	2.75 ±0.4^{A}	2.64 ±0.2^{A}
Fat (%)	4.07 ±1.1^{A}	3.78 ±0.7^{A}	4.30 ±0.9^{A}
Chrome (%)	3.08 ±0.5^{A}	3.02 ±0.6^{A}	3.01 ±0.4^{A}

Values in the same row with different superscripts differ significantly

3.2 Effect of age category on Sudan goat leather quality

As shown in table 2 goats leather Elongation percent was significantly affected (P ≥0.05) by the age category of the animals. The proper elongation percent was recorded at bucks and kid's leather 58.3 ±3.6 and 58.7 ±2.6 respectively. Bucks, does and kids elongation percentages were in the accepted limit for upper, garment and lining leather that estimated at 60 % by SSMO1 (2004), SSMO2 (2008) and SSMO3 (2008). Tensile strength (kg cm^{-2}) results were significantly affected (P ≥0.05) by animals age, and in the suitable standard of SSMO1 (2004), SSMO2 (2008) and SSMO3 (2008) for upper, lining and garment leather respectively. Cracking load (kg) was significantly affected (P ≥0.05) by the animal's age, and the high records were obtained at kid's leather followed by buck's leather and last doe's leather. Thickness (mm) results were significantly affected (P ≥0.05) by the animal's age, and the high record was in kid's leather (1.57 ±0.1 mm). Thickness results were in the SSMO1 (2004), SSMO2 (2008) and SSMO3 (2008) standards for upper, lining and garment leather respectively. The high records of Tear load (58.4 ±1.5 kg cm^{-1}) was assessed in kid's leather and it significantly different (P ≥0.05) from which were reported for buck's and doe's leather. Kid's leather scored the better level of flexibility (1.2 ±0.5) followed by doe's leather (2.1 ±0.8) and the worst degree was observed in buck's leather (3.3 ±0.6).

Chemical contents of ash %, fat % and chrome % of goat leather were not affected (P ≥0.05) by the animal's age. While moisture % results were significantly affected (P ≥0.05) by the animal's age. The high content of

Table 3 Breed effect on leather quality of Sudan Kabashi desert sheep during Janury 2015

Quality parameters	Breeds	
	hamari	kabashi
Elongation (%	64.93 ±3.1^{A}	59.27 ±3.7^{B}
Tensile strength (kg cm^{-2})	168.80 ±29.3^{B}	189.40 ±32.1^{A}
Cracking load (kg)	19.13 ±3.7^{B}	23.33 ±3.6^{A}
Thickness (mm)	1.37 ±0.2^{A}	1.39 ±0.2^{A}
Tear load (kg cm^{-1})	44.53 ±8.9^{B}	54.47 ±10.5^{A}
Flexibility degree	2.13 ±1.1^{B}	3.73 ±1.3^{A}
Moisture (%)	10.47 ±2.2^{A}	10.93 ±2.7^{A}
Ash (%)	2.88 ±0.2^{A}	2.54 ±0.2^{B}
Fat (%)	3.79 ±0.7^{A}	4.31 ±1.1^{A}
Chrome (%)	3.09 ±0.6^{A}	2.98 ±0.5^{A}

Means in the same row with the same letter are not significantly different (P≥0.05)

Table 4 Breed effect on Sudan goat's leather quality during January 2015

Quality parameters	Breeds	
	desert	nubian
Elongation (%)	59.93 ±3.1^{A}	59.27 ±3.7^{A}
Tensile strength (kg cm^{-2})	196.1 ±29.3^{A}	190.4 ±32.1^{A}
Cracking load (kg)	23.8 ±3.7^{A}	18.6 ±3.6^{B}
Thickness (mm)	1.37 ±0.2^{A}	1.39 ±0.2^{A}
Tear load (kg cm^{-1})	59.53 ±8.3^{A}	41.47 ±9.5^{B}
Flexibility degree	2.13 ±1.1^{B}	2.73 ±1.3^{A}
Moisture (%)	10.93 ±2.2^{A}	10.47 ±2.7^{A}
Ash (%)	2.88 ±0.2^{A}	2.54 ±0.2^{B}
Fat (%)	4.31 ±0.8^{A}	3.79 ±1.1^{A}
Chrome (%)	3.09 ±0.6^{A}	2.98 ±0.5^{A}

Values in the same row with different superscripts differ significantly

moisture (11.7 ±2.3) was reported at kid's leather. All chemical constituents were in the SSMO1 (2004), SSMO2 (2008) and SSMO3 (2008) standards for leather chemical thresholds.

3.3 Effect of breed type on leather quality of Sudan Desert sheep

As shown in table 3 elongation percents were significantly (P ≥0.05) affected by breed. Hamari Sudan desert sheep breed was reported the highest elongation percent (64.93 ±3.1). These results were exceeded the estimated value of elongation percentage of (60.6 ±0.9) which reported by Sudha et al. (2009); Salehi et al. (2014) and Passman and Sumner (1983). Otherwise, these findings were similar to Teklebrhan et al. (2012) Craig et al. (1987) and Jacinto et al. (2005) reports on native Ethiopian sheep lamb leathers, which had numerically higher tensile strength and percentage elongation at break. Tensile strength kg cm^{-2} parameter was reported statistically significant difference (P ≥0.05.) between Hamari and Kabashi subtypes. Ebrahiem et al. (2015a); Teklebrhan et al. (2012) and Oliveira et al. (2007) mentioned that, significant difference in strength properties among sheep lamb breeds was not detected when they studied Ethiopian sheep. However, it is below the estimated value for the parameter (203.6 ±5.1 kg cm^{-2}) which mentioned by Sudha et al. (2009); Salehi et al. (2014) and Passman and Sumner (1983). In addition, these results were in line with Teklebrhan et al. (2012) Craig et al. (1987) and Jacinto et al. (2005) whom reported that, the native Ethiopian sheep lamb leathers had numerically higher tensile strength and percentage elongation at break. This is evidence that leather produced from these breeds is

stronger and could be extend more before the grain cracks. Resistance to grain cracking N cm^{2-1} was affected by breed. Kabashi subtype was scored the high load (23.33 ±3.6) Similar results of significant difference was reported by Ebraheim et al. (2015a) Sudha et al. (2009); Salehi et al. (2014) and Passman and Sumner (1983) when they studied different breeds leather proprieties. Craig et al. (1987) and Oliveira et al. (2007) reported that the strength and distension at grain crack and break of a leather act as a guide as to how the material will perform when a multi-directional stress is applied. Grain crack is primarily considered as a measure of the strength of the grain layer within the tested material. Generally, these variables are more important in shoe upper leather, although optionally used in garment leather as physical quality parameter. The leather thickness was resulted in no statistically difference (P ≥0.05) between Hamari and Kabashi subtypes. This result was in line with Ebrahiem et al. (2015a); Oliveira et al. (2007) Sudha et al. (2009); Salehi et al. (2014) and Passman and Sumner (1983) whom observed that, thickness of skin was not affected by sheep lamb breed and high degrees of homogeneity in thickness among different genotypes was obtained. Kabashi Sudan desert sheep subtype was reported the high tear load (54.47 ±10.5 kg cm^{-1}) and this was statistically different (P ≥0.05) from which were recorded by Hamari (44.53 ±8.9 kg cm^{-1}). These findings were similar to Ebrahiem et al. (2015a); Sudha et al. (2009); Salehi et al. (2014) and Passman and Sumner (1983) estimation for tear load at 37.9 ±0.5 kg cm^{-1} on crust tanned sheep leather from different types.

Hamari subtype scored the better degree of flexibility test results (2.13 ±1.1). This value was significantly different (P ≥0.05.) from which was reported by Kabashi (3.73 ±1.3). Similar result of significant difference in flexibility properties among desert sheep breeds was detected by Ebrahiem et al. (2015a). While Teklebrhan et al. (2012) and Oliveira et al. (2007) reported no significant difference when they were studied different sheep leather of different breeds. No significant difference was detected (P ≥0.05) among the two studied subtypes of Kabashi desert sheep. This result is different from which was reported by Ebrahiem et al. (2015a) who detected significant different among Sudan desert sheep subtype's leather moisture percent. Otherwise, this result is in line with Sudha et al. (2009); Salehi et al. (2014) and Passman and Sumner (1983) and their estimation for moisture percent of 11.3 ±0.2 on crust tanned sheep leather.

Significant different (P ≥0.05) was detected on leather Ash of Hamri and Kabashi subtypes of desert sheep. Different result of insignificant difference in desert sheep leather was reported by Ebrahiem et al. (2015a). However, the assessed values of ash % 2.88 and 2.54 for Hamri and Kabashi subtypes leather were below the estimated value for the parameter (6.2 ±0.4 %) that reported by Sudha et al. (2009); Salehi et al. (2014) and Passman and Sumner (1983).

No significant difference (P ≥0.05) was detected at leather fat % between Hamri and Kabashi subtypes. Different result was reported by Ebrahiem et al. (2015a) who mentioned that, the estimated values of fat contents within Sudan desert sheep leather were reported significant difference (P ≥0.05) between breeds. These values of fat contents were in Sarkar (1991) estimated range of natural fat content of sheep leather after degreasing (reducing the natural fat content) that ranged from 3–5 %.

No significant difference was detected at chrome % between desert sheep subtypes. Different result was reported by Ebrahiem et al. (2015a) who mentioned that, Chrome oxide percent was significantly affected (P ≥0.05) by breed.

3.4 Effect of breed type on leather quality of Sudan goats

As shown in table 4 Elongation percent was not significantly affected (P ≥0.05) by the breed. This result is different from which was found by Ebrahiem et al. (2015b); Teklebrhan et al. (2012); Craig et al. (1987) and Jacinto et al. (2005) whom reported significant differences on goats and sheep leather in relation to breed variation.

Tensile strength (kg cm^{-2}) was not affected (P ≥0.05) by the breed. Similar results were obtained by Ebrahiem et al. (2015b); Teklebrhan et al. (2012) and Oliveira et al. (2007) whom reported that, significant difference in leather strength properties among goat's breeds was not detected.

Cracking load (kg) was affected (P ≥0.05) by the breed. Similar result of significant different was reported by Ebrahiem et al. (2015b) on Sudan goat's leather.

Thickness (mm) was not significantly affected by the breed (P ≥0.05). Similar results were obtained by Ebrahiem et al. (2015b); Oliveira et al. (2007) Sudha et al. (2009); Salehi et al. (2014) and Passman and Sumner (1983) whom observed that, thickness of skin was not affected by breed and high degrees of homogeneity in thickness among different genotypes was obtained.

Tear load (kg cm^{-1}) was significantly affected (P ≥0.05) by the breed variation. Similar result of significant difference was reported by Ebrahiem et al. (2015b); Sudha et al. (2009); Salehi et al. (2014) and Passman and Sumner (1983). Breed effect was detected among goat leather flexibility and Ash. Similar results were reported by

Ebrahiem et al. (2015) findings on theses parameters at Sudan goat's leather.

Chrome oxide and fat percentages were not significantly affected (P ≥0.05) by the breed. A different result of significant was obtained by Ebrahiem et al. (2015) on Sudan goat leather in relation to breed variations.

4 Conclusions

Lambs and kids skin was produced better quality leather than rum's, bucks, ewes and does skins in most of leather quality parameters. Leather properties were affected by breed variation. Kabashi and Desert goat breed were yielded the better quality leather in comparison to Hamari and Nubian goat skins.

References

ABUSUWAR, A.O., AHMED, E.O. and BLAL, A.M. (2012). Effect of Feeding Treated Groundnut Hulls with Molasses on Performance of Desert Sheep during Late Summer in Arid Rangelands of Western Sudan. *International Journal of Theoretical & Applied Sciences,* vol. 4, no. 2, pp. 122–127.

AGEEB, A.A. (1992). Production and reproduction characteristics of a flock of Baggara goats of Southern Kordofan. *Sud. J. Anim. prod.,* vol. 5, pp.1–24.

ALI, M.A.M., et al. (2014). Pre-weaning Body Measurements and Performance of Desert Sheep (Tribal Subtypes Hamari and Kabashi) Lambs of Kordofan Region, Sudan. Malaysian Society of Animal Production. *Mal. J. Anim. Sci.,* vol. 17, no. 1, pp. 35–45.

BABEKER, E.A. and ELMANSOURY Y.H.A. (2013). Observations concerning haematological profile and certain biochemical in Sudanese desert goat. *Journal of Animal and Feed Research,* vol. 3, no. 1, pp.80–86.

CRAIG, A.S., EIKENBERRY, E.F. and PARRY, D.A.D. (1987). Ultrastructural organization of skin: classification on the basis of mechanical role. *Connective Tissue Research,* vol. 116, pp. 213–223.

DASKIRAN, I., KOR, A. and BINGOL, M. (2006). Slaughter and carcass characteristics of Norduz male kids raised in either intensive or pasture conditions. *Pakistan J. Nut,* vol. 5, no. 3, pp. 274–277.

DEVENDRA, C. and COOP, I.E. (1982). Ecology and distribution of sheep and goat. world aninal Science. In: Coop, I.E (e. d.) *Sheep and goat production,* vol. 3. New York: Elsevier, pp. 1–14.

DEVENDRA, C. and MCLEORY, G.B. (1987). *Goat and sheep production in the Tropics. Intermediate Tropical Agriculture Series,* London: Longman.

EBRAHIEM, M.A., GALALLYN, H.A. and BASHIR, A.Y. (2015a). Skin/Leather Quality of Some Sudan Goats under Range Condition. *Global Journal of Animal Scientific Research,* vol. 3, no. 2, pp. 329–336.

EBRAHIEM, M.A., et al. (2015b). The effect of breed on Skin/Leather Quality of Sudan Desert Sheep. *Global Journal of Animal Scientific Research,* vol. 3, no. 1, pp. 6–10.

EL-HAG, F.M., et al. (2007). Supplementary feeding to improve Desert sheep productivity under dryland farming. *Trop. Sci.,* vol. 47, no. 1, pp. 26–32.

EL-HAG, F.M., FADLALLA, B. and MUKHRAR, H.K. (2001). Some production characteristics of Sudanese Desert sheep under range condition in North Kordofan, Sudan. *Trop. Anim. Heal. and Prod.,* vol. 33, pp. 229–239.

FAO (1999). *Production Yearbook:* volume 52. Rome: FAO.

GALL, C. (1996). Goat breeds of the world. C.T. A. Weikersheim: Margraf Verlag.

GOMEZ, K. and GOMEZ, A.A. (1984). Statistical procedure for the agriculture research. 2nd ed. New York: Wiley and Sons.

ISO2418 (2002). International Standards Organization. Leather chemical, physical and mechanical and fastness tests-Sampling location.

ISO3376 (2002). International Standards Organization. Leather physical and mechanical tests – Determination of tensile strength and percentage extension.

ISO3377-1 (2002). International Standards Organization. Leather physical and mechanical tests – Determination of tear load – Part 1: Single edge tear.

ISO3378 (2002). International Standards Organization. Leather – Physical and mechanical tests – Determination of resistance to grain cracking and grain crack index.

ISO4044 (2008). International Standards Organization. Leather chemical tests preparation of chemical test samples.

ISO5398-1 (2007). International Standards Organization. Leather chemical determination of chromic oxide content – Part 1: Quantification by titration.

ISO5402 (2002). International Standards Organization. Leather physical and mechanical tests – Determination of flex resistance by flexometer method.

JACINTO, M.A.C., DA SILVA, S.A.G. and COSTA, R.G. (2005). 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,* vol. 33, no. 4, pp. 1001–1008.

MUKHTAR, H.K. (1985). Constraints to desert sheep production in the sedentary and nomadic systems of North Kordofan. In: M.E. Lazim (ed.), Annual Research Report (1984–85), (El-Obeid Research Station, Agricultural Research Corporation (ARC), Wad Medani, Sudan), pp. 40–55.

McLEROY, G.B. (1961). The sheep of Sudan ecotype and tribal breeds. *Sudan J. Vet. Sci. and Husbandry,* vol. 2, pp. 101–161.

OLIVEIRA, R.J.F., et al. (2007). Influence of genotype on physico-mechanical characteristics of goat and sheep leather. *Small Ruminant Research,* vol. 73, no. 13, pp. 181–185.

PASSMAN, A. and SUMNER, R.M.W. (1983). Sumner Effects of breed and level of feeding on leather production from 18-month-old weathers. *New Zealand Journal of Experimental Agriculture,* vol. 11, pp. 47–52.

SALEHI, M., et al. (2014). Effects of type, sex and age on goat skin and leather characteristics. *Animal Production Science,* vol. 54, pp. 638–644.

SARKAR, K.T. (1991). Hide and skins processing technique. In: *How to processing raw hide and skins in the tannery.* Madrus: Indian Leather Producer Association.

SLTC (1965). *Society of Leather Trades Chemists. Official methods of analysis.* 4. rev. ed. Redbourn: Society of leather trades chemists.

SSMO1 (2004). *Sudanese Standard and Meterology Organization. Leather standards: for garment leather.* Khartoum.

SSMO2 (2008). *Sudanese Standard and Meterology Organization Leather standards: for vegetable and chrome tanned upper leather.* Khartoum.

SSMO3 (2008). *Sudanese Standard and Meterology Organization. Leather standards: for lining leather.* Khartoum.

SUDHA TB, et al. (2009). Comfort, Chemical, Mechanical and Structural Properties of Natural and Synthetic Leathers Used for Apparel. *Journal of Applied Polymer Science,* vol. 114, pp. 1761–1767.

STATISTIX 8 (2007). For the Plant Materials Program. Version 2.0. United States Department of Agriculture (USAD) and Natural Resources Conservation Service (NRCS). USA.

TEKLEBRHAN, T., URGE, M. and MEKASHA, Y. (2012). Skin/leather quality of indigenous and crossbred (Dorper × Indigenous) F1 sheep. Dire Dawa: Haramaya University, School of Animal and Range Sciences.

TIBIN, I.M., SALAH, S.A. and NOOR, I.A. (2010). Effect of management and feed supplementation on the reproductive performance of Hammari sheep under range conditions in North Kordofan, Sudan. In: *Tropentag 2010: ETH Zurich, September 14–16, 2010, Conference on International Research on Food Security, Natural Resource Management and Rural Development.*

WILSON, T. (1991). Small ruminant production and the small ruminant genetic resource in tropical Africa. *FAO Animal Production and Health Paper,* no. 88, p. 181.

YEHIA, E. (2002). *Ecology of some herbaceous forage in North Kordofan.* M.Sc. Thesis. Khartoum: Institute of Environmental Studies, University of Khartoum.

YOUSIF, A. and FADL EL-MOULA, A. (2006). Characterization of Kenana cattle breed and its production environment. *Food and Agriculture Organization. Agri.,* vol. 38, pp. 47–56.