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Effect of Dietary Supplementation on Physico-mechanical and Chemical Quality of Hide and Leather of Dromedary Camels

Moges Dereje[1*], Mengistu Urge[1], Getachew Animut[2] and Mohammed Y. Kurtu[1]

[1]School of Animal and Range Sciences, College of Agriculture and Environmental Sciences, Haramaya University, P.O. Box 138, Dire Dawa, Ethiopia

[2]Agricultural Transformation Agency, P.O. Box: 708, Addis Ababa, Ethiopia

Abstract

This study was aimed at evaluating the effect of concentrate supplementation under feedlot condition on intake, weight gain, physico-mechanical and chemical qualities of crust and finished leather of dromedary camels. Fifteen growing *Ogaden* camels with age range of 24-30 months and mean bodyweight of 162.8±23.8 kg (Mean±SD) were purchased from *Babile* camel market and used in a 120 days fattening study. The experiment was run under RCBD where the camels were blocked according to their initial body weight and allotted randomly within the block to three dietary treatments. The experimental feed was urea (5%) treated maize stover (UTMS) basal diet given *ad-libitum* and a supplement of concentrate mix of wheat bran(66%), *Noug* seed (*Gizotia abyssinica* Cass.) meal (13%), sorghum grain (20%) and mineral-vitamin premix (1%). The supplementary diet was offered to the camels at the rate of 0.5 (D0.5=low level), 1.0 (D1.0=medium level) and 1.5 (D1.5=high level) percent of bodyweight. Levels of supplementation did not affect the chemical and most of the physico-mechanical qualities of the crust and finished leathers. Among the physico-mechanical qualities, tear load perpendicular to the back bone of crust leathers was higher ($P<0.05$) for the Medium level compared to Low level supplement while arithmetic mean of parallel and perpendicular tear loads was higher ($P<0.05$) for Medium and High level supplement groups compared to Low level supplement. Similarly, tear resistance of finished leathers was higher ($P<0.01$) for High level supplement compared to Low and Medium level supplement. In general, the crust and finished leathers produced by the camels in all dietary treatment groups have fulfilled the required standards of the quality parameters set by various leather institutes. It can be concluded that while the present feeding regime did not negatively affect the leather qualities, Medium and high level of supplements resulted in better tear load and tear resistance parameters of the crust and finished leather of dromedary camels.

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***Corresponding Author:**

Moges Dereje

E-mail:

mogesdr@yahoo.com

INTRODUCTION

The Ethiopian livestock sector contributes about 16.5% (MoFED and MoA, 2011) to the national and 47% (ICPALD, 2013) to the agricultural GDP, and is an important source of livelihood and revenue for the rural populations and the national economy. As one of the main focus area of the livestock sector, the hides, skins and leather industry in Ethiopia have huge potential towards wealth and employment creation, and economic growth. The huge population of livestock owned by the country is an indication of the potential for the development of leather industry. According to the government plan, export earning from leather export is to grow to $500 million by the end of 2025 (MoFED, 2010) versus the current value of USD 122 million (Anonymous, 2016) indicating the need for more expansion and diversification of hides and skin production as well as the export market. This requires improved livestock management and value chain improvement initiatives (MoARD, 2014). The current annual percentage production by volume of skin from goat and sheep, and hide from cattle and camel account for 50, 33, 13 and 4%, respectively (ACTESA, 2011).

Worldwide, the hide and leather of camel is considered as one of the heavy type of skins. At present, the camel leather is processed using methods defined for cattle hide and it appears to have less commercial use than cattle and small ruminant skins. However, evidence show that properly processed camel skin can produce leather that can be utilized for production of durable goods comparable to that of cattle (www.camelfarm.com; Khanna, 2000). At present camel hides and leathers are used for manufacturing of various utility items such as shoes, belts, hats, riding boots and ladies fashion garments (www.camelfarm.com). However, it has been noted that the full potential of camel hides as a product has not been realized in Ethiopia and other African countries due to their poor quality. (AU-BAR, 2006). In recent years, the marketing value of hides and leather products in the world in general is exceeding the percentage revenue from meat of livestock (FAO, 2010b), which may substantially increase the demand for camel skin by the industries in the very near future. The scenarios in Ethiopia show the absence of proper data keeping on camel hide and leather production, quality and utilization. Ethiopia being home to about 4.5 million camels (MoA, 2014), appropriate information on quality of camel hide and leather production potential is an essential prerequisite in general and related to feeding regimes in particular is an essential prerequisite in order to utilize this huge resource on the chemical and physico-mechanical qualities of the crust leather (leather that has been processed and dried, but not yet finished) and finished leather of the dromedary camels in eastern Ethiopia.

MATERIALS AND METHODS

Location of the Study

The experiment was conducted at Haramaya University camel Farm located at Erer Guda, Babile district, at a distance of 545 km south east of Addis Ababa at 9^o, 14' N latitude and 42^o, 14'E longitude. The altitude ranges 1300–1600 meter above sea level. Average annual rainfall is 450mm with bi-modal nature, from March to April and from July to October. The temperature ranges between 17-31^{o}C (Tamire, 1986).

Experimental Animals Management

A total of 15 healthy growing intact dromedary camels of 2.5-3 years of age and average initial body weight of 162.8±23.8 kg (Mean±SD) were purchased from Babile camel market and used for a 120 days growth performance and hide and leather quality studies. Experimental camels were quarantined for 2 weeks to observe for any unhealthy condition before the animals were placed in individual feeding pen for acclimation to the experimental procedures and the feeds for another two weeks. During this period they were weighed, ear tagged, de-wormed against endo-parasite with a broad-spectrum anti-helmentic (albendazole) and sprayed against ecto-parasite with acaricides (vetacidin 20% EC) as a prophylactic measures and vaccinated for pasteurelosis and anthrax based on the recommendation of veterinarians**.** During the 2 weeks of the adaptation period, animals were offered the supplement feeds in such a way that the maximum per day for the individual animals is reached at the end of the period. Animals were housed individually in shaded floor pens for the duration of the experiment. The camels were slaughtered at an average body weight of 255.3±23.5 kg. All management procedures were carried out according to the institution and international guidelines for animal welfare.

Feeds, Experimental Design and Treatments

Animals were individually fed with concentrate supplement composed of wheat bran (60%), sorghum grain (20%), *Noug* seed meal (*Gizotia abyssinica* Cass.) (13%) and mineral and vitamin premix (1%) (Table 1) and maize stover treated with 5% urea (urea treated maize stover; UTMS). The UTMS was offered *ad-libitum* while the concentrate supplement was given according to the body weight of the animal. Water was given twice per day and the remaining water was removed after the animals drunk as much as they wanted.

Table 1: Chemical composition (% for DM and % DM for others) of experimental feeds

Variable	Feed type					
	UnTMS	UTMS	Wheat bran	Sorghum grain	*Noug* seed cake	Concentrate mix
DM	91.3	65.2	88.1	88	91.7	87.7
CP	4.14	9.44	18.1	9.63	34.4	16.3
OM	85.49	59	82.83	82.68	82.27	82.55
Ash	5.78	6.25	5.3	5.37	9.43	5.15
EE	0.6	1.2	4.5	4.3	5.1	4.01
CF	42.2	20.24	11.32	3.5	21.33	7.88
NDF	82.7	79.4	43.1	40.3	47.5	31.4
ADF	45.7	52.5	22.3	10.5	15.4	11
NFE	38.5	55.1	48.9	65.2	21.4	54.3
ME (MJ/kg)	6.7	10.5	11.7	11.8	9.8	11.2

DM=Dry matter; CP=Crude protein; OM=Organic matter; EE=Ether extract; CF=Crude fiber NDF=Neutral detergent fiber; ADF=Acid detergent fiber; NFE=Nitrogen free extract; ME=Metabolizable energy; UnTMS=Untreated maize stover; UTMS=Urea treated maize stover.

A randomized complete block design (RCBD) was used for the experiment. At the end of the quarantine period, the initial body weight of the camels were listed in an ascending order with corresponding animal's identification number and grouped into 5 blocks of three animals. The 3 members of each block were randomly allocated to one of the 3 treatments, namely concentrate supplementation in amount of 0.5% (Low), 1% (Medium) and 1.5% (High) body weight per day on a DM basis. Total Dry matter (DM) and crude protein (CP) intake and body weight gain were measured and reported in a companion paper (Moges *et al*., unpublished).

Chemical Analysis of the Feedstuffs

Duplicate samples of each feedstuff were analyzed according to the procedures of AOAC (1990) for dry matter (DM), crude protein (CP) as N x 6.25, ash, organic matter (OM), total nitrogen by Kjeldahl method, ether extract (EE) and crude fiber (CF). Acid detergent fiber (ADF) was analyzed according to Robertson and Van Soest (1981) and neutral detergent fiber (NDF) according to the procedure of Van Soest *et al*. (1991). Nitrogen free extract (NFE) was calculated by difference according to Dhont and Berghe (2003). Metabolizable energy (ME) contents of the feed stuffs were calculated according to MAFF (1975) and Ellis (1980).

Handling and Processing of Crust & Finished Leather

After completion of the growth experiment, camels were slaughtered and hides were flayed in a very careful manner. Wet salting method was used for preservation of the hides to prevent putrefaction until it was transported to the Ethiopian Leather and Leather Products Technology Institute (LLPTI) for further processing and quality determination. Before spreading the salt, excess flesh and fat were gently removed and the skins were washed with clean tap water according to the Ethiopian Standard Authority (ES) code ES-B.J6. 003 (1990). The amount of salt used was 50% of the mass of a fresh hide following the procedure developed by Ethiopian Standard Authority (ES). Hides were processed into leather using the LLPTI recipe prepared for cattle hide after passing through major processing stages such as: deharing (removal of hair), fleshing (mechanical removal of unwanted flesh, connective tissue and fat by hand, knife or fleshing machine), liming (hide is soaked in an alkali solution to avoid unwanted proteins and keratin for the penetration of tanning agents), bating (enzyme treatment to soften the leather), degreasing (removing the natural fats), washing, pickling (a process of acidification of the scudded pelt in drum with salt solution and pre-diluted acid to preserve and condition the pelt for tanning, the process lowers the pH value and help penetration of tanning agents), tanning (a process by which skins are converted to leathers by adding tanning or materials soaking the hide in a tanning agent such as chrome solution), neutralization (adjusting pH to a value between 4.5 and 6.5), fat liquoring (fixing fats/oils and waxes to the leather fibres), drying (the leather is dried to various moisture levels) and finishing (all processes administered to leather after tanning such as colouring, masking imperfections, oiling, etc…). The crust and finished leather qualities were assessed for chemical and physico-mechanical characteristics in LLPTI physical laboratory according to the laboratory guidelines. The locations of the samples were determined according to ISO-2418 (2002). Samples were taken in accordance with ISO-2418 (2005). Triplicate samples were taken from each crust and finished leather parallel (horizontal) and perpendicular (vertical) to the backbone.

Chemical and Physico-mechanical Qualities of the Crust and Finished Leather

Chemical Qualities

The moisture content or volatile matters of the chrome crust hide were determined according to the test method of SLC-3; SLC (1996a). The moisture content was taken to be the percentage weight lost by the samples when dried at $102\pm2^{o}C$ to constant weight. The fat content of the moisture-free samples were determined using standard Soxhlet extraction method according to the Society for Leather Chemical test (SLC-4; SLC, 1996b). The fat content was taken to be the percentage weight of substances extracted from the samples using the solvent dichloromethane. The chrome-oxide (Cr_2O_3) content of the leather after tanning, defined by the quantity of the chromium compound was determined by oxidizing the leather ash and iodometric titration of the hexavalent chromium ions based on official method of analysis (SLC-208; SLC, 1996c). All of the chemical tests were conducted at the Ethiopian LLPTI laboratory. The chromic oxide content of the leather was calculated as a percentage of the original leather weight

Physico-mechanical Quality

Tensile strength and percentage elongation were assessed using a dynamometer (ISO 3376; ISO 2002b). Tensile strength 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. A rectangular leather sample with a small slit cut in the middle of it was used for tear strength test. The sample was pulled apart by a clamp attached to its base and another clamp inserted through the slit. The point at which the slit started to tear was defined as the tear strength. The tear strength was expressed in relation to average leather thickness (ISO 3377-2; ISO, 2002c). Distension at crack of the leather grain was determined by ball burst test using a lastometer (ISO-3379; ISO, 2005c).

Average tear load/arithmetic mean and tear resistance were determined using test method of ISO-3377-2 (2002c) and ISO-3376 (2000), respectively. Samples were conditioned according to ISO-2419 (2002). Thickness of samples was assessed according to BASF (2012) or ISO-2585 (2002) using a standard measuring gauge.

Absorption of water (%) by leather was determined according to the standard procedure (BASF, 2012) or ISO 5403; ISO, 2002d) for light or flexible leather. Water absorption value measures the ability of the skin or leather to absorb water within 24 hours after immersion in a sample glass apparatus called kubelka.

Statistical Analysis

Data were analyzed using the one way analysis of variance procedure of SAS software (SAS, 2008). The model for data analysis was: $Y_{ij} = \mu + t_i + b_j + e_{ij}$, where Y_{ij}: the response variable, μ: overall mean, t_i: treatment effect, b_j: block effect and e_{ij}: error. Duncan's multiple-range test (Duncan, 1955) was used to test the significant differences between means when an F-test declared significance at $P < 0.05$.

RESULTS AND DISCUSSIONS

Feeds Intake and Body Weight Gain

Details of the feed intake and body weight gain of camels were reported in a companion papers (Moges *et al*., unpublished). The urea treated maize stover consumed by the animals had a CP content of 9.44%, which is higher than a threshold required for optimum function of rumen microorganisms (Whiteman, 1980) indicating that urea treatment increased crude protein content of stover. The concentrate mix, as expected, had a moderate source of CP and ME and the animal consumed the supplement with no refusal every day during the experiment period. The ME and CP content of the concentrate mix used in the present study were comparable with that used by Intisar *et al*. (2007) for fattening young camels, which contained 11.0 MJ ME and 16.5% CP while the CF (11.5%) was lower.

The total daily DM intake was 5.24, 5.66, and 6.30 Kg (SEM=0.48) for camels supplemented with concentrate at a rate of 0.5, 1 and 1.5% of body weight and it is significantly increased with increasing level of concentrate feeding (p=0.000). The camels in Low, Medium and High level of supplement grew by 0.68, 0.80, 0.84 g/day (SEM=0.08) and the gain was lower (p=0.022) in Low level of supplement group than the other groups.

Chemical Qualities of the Crust Leather

Supplementation has no significant effect on chemical qualities of the crust leather (Table 2). Though there were few general studies conducted on hide and leather of camels (Salehi *et al*., 2013; Anastasia *et al*., 2013; Hekal, 2014; Nasr, 2015), literature sources relating levels of nutritional supplements to camel crust and finished leather qualities appears to be lacking. Even with other species of livestock, there were few sources dealing with these parameters. Therefore, sources in similar areas of studies, but with different species were utilized to compare and contrast the findings of the present study. Natural fat content that cannot be removed sufficiently during the process affects the extent of the leather to accept fatliquor substances and degreasing operation that are carried out to eliminate the excess fat substances. In the current study, the fat contents were not significant (P>0.05) among treatments, but numerical values for fat percentage were lower in Low level supplement group than the Midium and High level dietary groups indicating higher levels of concentrate feeding may produce leather with higher fat content. Previous work in goat (Tadesse *et al*., 2015; Stosic, 1994) and sheep (Fasil *et al*., 2015; Tsegay *et al*., 2012) noted that low level concentrate feeding resulted in a numerically lower skin fat than high concentrate feeding. Leather with high chrome oxide content has better resistance to decomposition (Fasil *et al*., 2015). The values obtained by all dietary treatment levels in the current study resulted in chrome-oxide above the required values (>3.5%) for garment leather (BASF, 1984) and >2.5% for shoe upper leather (ES-1188, 2005). The moisture content is an important characteristic of leathers. The amount of moisture determines the quality of leathers. Extremely dried leather is susceptible to embrittlement (ability to break/tear) of the grain and excessive content of moisture may cause formation of mould. The ideal moisture content of leather is 12-14% (SATRA Spotlight, 2006). The moisture content of the camel leather in the current study was well within the requirement (12%) set by the Ethiopian Standards Authority (ES-1195, 2005). Nasr (2015) noted higher moisture content (14.21%) of young male Egyptian camel (24-30 month) leather made from hides collected from abattoir than the current result. Higher moisture content of leather was also reported for poorly fed goat (Stosic, 1994) and sheep (Fasil *et al*., 2015).

Table 2: Effects of supplementation on chemical property of camel crust leather

Parameter	Dietary treatment levels*			SEM†	*P*-value
	Low	Medium	High		
No. of camels	5	5	5		
Chromic oxide (%)	5.42	5.44	5.30	0.38	0.819
Fat content (%)	16.98	17.06	17.34	0.34	0.245
Moisture content (%)	12.72	12.46	12.28	1.18	0.367

*Low = *adlibitum* UTMS + concentrate mix of 0.5% of bodyweight;
Medium = *adlibitum* UTMS + concentrate mix of 1.0% of bodyweight;
High = a*dlibitum* UTMS + concentrate mix of 1.5% of bodyweight in DM basis per day;
†SEM = standard error of the mean.

Physico-mechanical Qualities of Crust and Finished Leather

Tensile Strength and Percentage Elongation

The physico-mechanical qualities of the crust and finished camel leather are shown in Tables 3 and 4. Levels of supplementation have not brought significant (P>0.05) effect on tensile strength and percentage elongation on the crust and finished leathers. This might suggest that the levels of supplementation used in the current study are all good enough to impact tensile strength and percentage elongation of leathers, which might be an indication for leather to be less sensitive to supplemental concentrate levels as compared to body weight gain. Salehi *et al.* (2013) reported comparable tensile strength (21.47 N/mm^2) but superior leather elongation (61%) to the current result for fattened adult dromedary camels. Study conducted by Tsegay *et al*. (2012) on lamb skin found numerically better tensile strength and percentage elongation of supplemented lamb skin.

Table 3: Effects of supplementation on physico-mechanical qualities of camel crust leather

Parameter	Dietary treatment levels*			SEM**	p-value
	Low	Medium	High		
No. of camels	5	5	5		
Tensile strength (N†/mm^2)	21.66	22.08	21.16	3.60	0.920
Percentage elongation at break (%)	52.98	54.18	55.40	4.99	0.750
Mean tear load1 (N) parallel to back bone	65.38	75.80	75.32	9.07	0.160
Mean tear load2 (N) perpendicularto back bone	71.62^b	93.00^a	90.22^{ab}	11.60	0.026
Av. tear load/force (N) [mean of 1 and 2]	68.44^b	84.40^a	82.78^a	9.49	0.039
Tear resistance/strength (N/mm)	43.16	48.80	47.04	5.48	0.387
Water absorption (%)	81.06	84.82	83.90	3.74	0.291
Distention at crack (mm)	10.84	10.44	10.42	0.74	0.612
Load at crack (N)	385.52	439.98	384.28	50.46	0.170
Distention at burst (mm)	12.00	11.30	11.72	0.50	0.123
Load at burst (N)	462.60	514.52	545.06	71.66	0.225
Thickness (mm)	1.58	1.64	1.66	0.12	0.562

^{ab}Different letters within a row denote significant difference at ($P \le 0.05$); *Low = *adlibitum* UTMS + concentrate mix of 0.5% of bodyweight; Medium = *adlibitum* UTMS + concentrate mix of 1.0% of bodyweight; High = *adlibitum* UTMS + concentrate mix of 1.5% of bodyweight in DM basis per day; **SEM = standard error of the mean, †N = Newton.

Table 4: Effects of supplementation on physico-mechanical qualities of finished camel leather

Parameter	Dietary treatment levels*			SEM**	p-value
	Low	Medium	High		
No. of camels	3	3	3		
Tensile strength (N[†]/mm^2)	24.07	24.00	25.37	0.97	0.232
Percentage elongation at break (%)	52.67	50.67	76.80	6.33	0.519
Mean tear load1 (N) parallel to back bone	74.77	76.30	83.97	6.26	0.235
Mean tear load2 (N) perpendicular to back bone	76.67	89.17	98.30	11.77	0.148
Av. tear load/force (N) [mean of 1 and 2]	75.28	83.33	91.27	8.67	0.157
Tear resistance/strength (N/mm)	56.00^b	63.57^b	74.37^a	4.03	0.004
Water absorption (%)	79.07	80.37	75.27	3.78	0.301
Distention at crack (mm)	10.40	9.77	10.03	0.53	0.399
Load at crack (N)	396.23	413.70	418.63	37.77	0.758
Distention at burst (mm)	11.67	11.47	11.43	0.59	0.876
Load at burst (N)	535.37	545.23	586.40	54.89	0.521
Thickness (mm)	1.33	1.43	1.30	0.09	0.273

^{ab}Different letters within a row denote significant difference at (P ≤ 0.05); *Low = *adlibitum* UTMS + concentrate mix of 0.5% of bodyweight; Medium = *adlibitum* UTMS + concentrate mix of 1.0% of bodyweight; High = *adlibitum* UTMS + concentrate mix of 1.5% of bodyweight in DM basis per day; **SEM = standard error of the mean, [†]N = Newton.

Tear Loads and Tear resistance

Differences (*P*>0.05) were not observed among the dietary treatments in the crust leather tear load (force) parallel to back bone and tear resistance (strength). Significant differences (*P*<0.05) were observed among the diet level groups for tear load perpendicular to the back bone, whereby the Medium level group exhibited greater value of the crust leather than the Low supplemental group but not from the High level group. The arithmetic mean of the parallel and perpendicular tear load of the crust leather in the Medium and High level dietary groups were higher (*P*<0.05) than the Low supplemental group. Tear Strength is the median force required to propagate a cut in a specified test specimen. Significant differences (*P*<0.01) were observed among the dietary treatment groups with regard to tear resistance of the finished leather whereby High level dietary group resulted in higher values as compared to the other two groups signifying the importance of higher level of dietary supplements in camel leather strength. Tear resistance results of the finished leather of the current study were comparable with the results obtained by Hekal (2014) for un-supplemented adult Maghrebi (68.14N/mm) and Sudanese (70.57N/mm) dromedary camels. The values registered by the three dietary groups in the current study for tear resistance of camel crust and finished leather were well above the standard recommended for shoe upper leather (>25N/mm) and garment leather (>35N/mm) set by BASF (2012). Comparison of the parallel and perpendicular sampled crust and finished leather of the current study revealed that the vertical samples required more tear forces (stronger) than the parallel samples. These results were supported by Tsegay *et al*. (2012) who noted that vertical sampling direction requires numerically higher force (8.9N) to tear when compared to the horizontally sampled skin (7.5N). Nevertheless, results obtained by Craig *et al*. (1987) and Oliveira *et al*. (2007) showed that horizontal sampling direction has higher (*P* <0.05) values compared to the vertical direction of sampling. The possible reason for the discrepancy could be the difference in the arrangement of the collagen fibers cross linkage of the camel crust and the goat skin.

Distention and Strength of Grain, Thickness and Water Absorption

There were no significant (*P*>0.05) differences among dietary treatments with regard to load at crack and load at burst values of the crust and finished leather grains. This could be for the reason that all the current dietary treatment levels might have produced good enough leathers with similar values of grain layer. This result did not agree with the report of Stosic (1994) who found that leathers made from the skins of goats kept on the high nutritional regime tended to resist higher loads at crack and burst of the grain than leathers from goats in the Low dietary supplement. Similarly, in the case of distension performance of the grains, all treatment groups exhibited equally good distention at crack and burst values of the crust and finished leathers grains. On the contrary, Stosic (1994) reported that grain layers of goats' leather from Low level of nutrition exhibited higher distention at crack and burst. This result of Stosic (1994) could be explained by the fact that as hides become thicker (due to age or high level of nutrition) the extensibility of the leather reduces which was not evident in the current camels' leather. The amount of fat may influence the distension ability by blocking the amount of material to be removed from the grain layer during processing. This makes the fiber structure less open and less able to distend. There were also no significant differences among the camel groups, with regard to the thickness of crust and finished leather. This result might also indicate that the levels of the supplements might be enough to produce comparable values among the groups. In the report of Stosic (1994), however, high level of concentrate supplement resulted in better thickness of goats leather. The thickness results in the current study were within the range 1.0-2.2 mm reported for Tunisian camels (Leather.com, 2006) and >1.1mm recommended by INESCOP (Center for Technology and Innovation, for cattle leather). On the other hand, the current result did not agree with the reports of Salehi *et al*. (2010) who observed 3.3 and 1.75mm thickness for the crust and leather, respectively, of un-supplemented Iranian dromedary camels. Possible reasons for the differences could be variations in method of processing and analysis, breed type, environment, age, sex and sample sites (Adel and Elboushi, 1994). No differences were observed for the water absorption capacity of the crust and finished leather among the dietary groups. Even then, these present results from all levels of the supplement were in agreement with BASF (2012) standards which noted that value for water absorption of shoe upper leather to be <85%. According to the chemical and physico-mechanical test results of the camel crust and finished leather (Table 2, 3 and 4), almost all values were within and above the minimum standard requirement values set by the Institutes for Assays and Research on Footwear Production (BASF, 2012; ES (Ethiopian Standards Authority), 2005; UNIDO, 1994 and IS (Indian Standards Institution), 1986).

CONCLUSSION

The present study indicated that all levels of dietary supplements, despite their differences, produced crust and finished leathers with chemical and physico-mechanical characteristics comparable and even with better quality standards than required by the leather industries. In general, medium and high level dietary supplementation plus *ad-libitum* UTMS could be one of the better feeding strategies to improve the growth performance and tear load of the crust and tear resistance of the finished leather qualities of the dromedary camels.

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Conflict of Interest

Authors declared that there is no any conflict of interest.

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