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Impact of Providing Cowpea (*Vigna unguiculata*) Hay, Wheat Bran, and Their Mixes on Begait Lambs' Skin and Leather Quality

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Aims:

- To evaluate the impact of adding wheat bran (WB), cowpea hay (CPH), or mixes of the two on the chemical and physico-mechanical properties of leather.
- To determine the ideal ratio for supplementing wheat bran and cowpea hay on the chemical and physico-mechanical properties of leather.

Study Design: The study employed a randomized complete block design (RCBD) with five treatments and blocks.

Place and Duration of Study: Northern Ethiopia, Humera Agricultural Research Center farm, starting from December 2016 until November 2017.

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Methodology: 25 intact male Begait lambs were bought from the local market, weighing an average of 28.02 ± 1.49 kg (mean ± SD) at 5 to 6 months of age. Based on their starting body weight, they were split into five groups and assigned randomly to each of the five treatments. The standard diet for T1, T2, T3, T4, and T5 consisted of giving natural grass hay *ad libitum* plus supplements of 300 g CPH, 225 g CPH + 75 g WB, 150 g CPH + 150 g WB, 75 g CPH + 225 g WB, and 300 g WB DM day^{-1}. Three lambs per treatment were randomly chosen, slaughtered, and dressed down using standard commercial techniques at the end of the feeding trial to assess the quality of skin and leather.
Results: Compared to the other treatment groups, the Begait lambs in T2 and T3 exhibited increased tensile strength, elongation strength, and thickness. However, the chemical makeup of skin was comparable between treatment groups.
Conclusion: Therefore, this study concluded that all test diets generated skin and leather that largely complied with the chemical and physico-mechanical quality standards demanded by the leather industry.

Keywords: Chemical, mechanical; physical; tanning.

1. INTRODUCTION

“Small ruminants produce nearly half of domestic wool requirements, as well as approximately 40% of fresh skin output and 92% of semi-processed skin” [1]. “Ethiopia also has a significant potential for producing tiny ruminant skins. 8.9 million Sheep skins and 5.3 million goat skins are among the potential skins that could be sold” [2]. “By accounting for 14–18% of the country's foreign exchange profits, hides and skins, leather, and leather goods are provided to both internal and export markets, making a substantial contribution to the Ethiopian economy. The vast animal resources available, however, only represent a small percentage of the potential income. The primary restrictions on using skins and hides are low quality and lack of grading/selection of the raw hides and skins purchased” [2,3].

“Due to their fine grain and compact structure, Ethiopian small ruminant skins, especially sheep skins, have historically enjoyed a positive reputation in the quality leather market [2,3]. The factors that affect the skin and subsequent leather quality, however, are environmental (nutrition and climate) and animal factors (breed, sex, and age), external parasites and disease, pre-slaughter/ante-mortem defects involving human activities, post-mortem/post-slaughter defects like improper flaying and skin cuts/gouges” [2,4]. “Poor nutrition is one of the environmental factors that results in thinner skin, less elastic leather, and a finer grain deposition, according to” [2] and [3].

There is limited information on the influence of feed on the leather characteristics of sheep. For instance, the study by [5] on Blackhead Ogaden sheep demonstrated that the increasing proportion of concentrate feeds considerably enhanced the physico-mechanical properties of leather. Similar to this, [3] observed that for local and cross-bred lambs, skin thickness was regulated by the level of supplementation. There isn't any documentation on Begait lamb's leather quality, though. As a result, it was necessary and opportune to conduct a study to close the information gap. The current study was carried out to determine how supplementation with wheat bran, cowpea hay, and their combinations affected Begait lamb's chemical and physico-mechanical skin and leather quality.

2. METHODS

2.1 Experimental Details

Description of the study area: This study was carried out at the Humera Agricultural Research Center (HuARC) farm, Kafta Humera, Western Zone of Tigray (WZT), Northern Ethiopia. Kafta Humera Woreda is located in the Western Zone of Tigray at 13^0 40^1-14^0 27^1 N latitude and 36^0 27^1 E - 37^0 32^1 E longitude [6]. Niguse and Aleme [7] state that the average rainfall is between 400 and 650 mm, and the mean minimum and maximum temperatures vary from 17.5 to 22.2^{0}C and 33^0 to 41.7^{0}C, respectively. Vertisol make up the majority of the soil types, followed by lithisols and nitisols [6].

2.2 Animal Management

Twenty-five intact male Begait lambs, aged between five and six months and weighing an average of 28.02 ± 1.49 kg (mean ± SD), were purchased at the nearby market. The owners gave the age information, which was confirmed through dentition. They received vaccinations against common diseases, internal parasites, and external parasites upon arriving at the center. They were also dewormed and sprayed. The 90-day stay of the lambs was preceded by a 15-day period during which they were acclimated to their new surroundings and food while considering animal welfare. During the experimental time, the lambs were housed in separate pens with plastic buckets for hydration and supplements and feeding troughs for hay.

2.3 Experimental Design and Treatments

A randomized complete block design (RCBD) with five blocks of five treatments was used (Table 1). Lambs were blocked according to their initial body weight. Lambs in each block were randomly assigned to one of the five treatment diets. The lambs were allocated to an individual pen with a dimension of 85 cm wide and 115 cm long in a naturally ventilated shed. All lambs had free access to clean, fresh water and common salt at all times [8].

2.4 Chemical analysis

Representative samples of feed were taken to determine their nutritional content. They were ground to pass a 1mm sieve mesh. Analysis for dry matter (DM), ash, and N contents was done according to Association of Official Analytical Chemists [9] procedures. DM and ash contents were determined by oven drying at 105^0c overnight and by igniting in a muffle furnace at 550^0c for 6 h, respectively. Nitrogen (N) content was determined by using the Kjeldahl method and crude protein (CP) was calculated as N×6.25. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were determined by using the procedures of [10]. Organic matter was computed as 100 minus ash [8].

2.5 Skin Handling and Processing

Lambs were slaughtered and dressed down using standard commercial techniques at the end of the feeding trial to assess the quality of skin and leather. Using the procedures of the Ethiopian Standards Authority (ESA), the wet salting method was used to preserve skin and prevent putrefaction and quality deterioration until it was transported for further processing. Before applying the salt, which was 50% of the mass of fresh skin, skins were cleaned according to [3]. The skins were preserved under the same conditions. The preserved skins were taken to Sheba Leather Industry PLC, Wukro, Tigray, Ethiopia for further processing and quality determination. Then skins were processed based on the guidelines of the Leather and Leather Products Technology Institute (LLPTI) set for sheep skin into sheep garments according to the following main steps: soaking, liming, deliming, bating, degreasing, pickling, tanning, neutralization, re-tanning, dyeing, sammying, drying, and finishing. The leather quality of lambs was assessed for chemical and physico-mechanical characteristics. Before physico-mechanical testing, the finished lamb garment leathers were conditioned at 20±2°C under 65% ±5 relative humidity for 48 h as described by [3]. Briefly, triplicate samples were taken from each skin parallel (horizontal) or perpendicular (vertical) to the backbone.

2.6 Chemical Quality

Chrome-oxide and moisture content: Similarly, the chrome-oxide (Cr_{2o3}) content of the leather was determined from the leather ash as described by [3] by oxidizing the leather ash followed by iodometric titration of hexavalent chromium ions. Moreover, the moisture contents or volatile matters of samples were determined as the percentage of weight lost by the samples when dried at 102 ± 2°C to constant weight. Finally, chrome oxide and moisture contents were obtained through the following formula:

Chrome oxide (%) = (Chrome weight (g)/sample weight (g)) × 100

Moisture content (%) = (sample weight before drying (g) - weight after drying (g)/ sample weight before drying (g)) ×100

2.7 Physico-Mechanical Quality

Tensile strength, elongation, and thickness: Tensile strength and elongation were determined following the established procedures as described by [3]. The butt region is considered an official sampling position for leather quality tests in lambs [11].

Tensile strength was expressed by the diameter of the narrowest part of the dumbbell-shaped piece of leather and the thickness of the sample. It is defined as the force required to break a dumbbell-shaped leather sample on the test machine. Elongation at grain break was determined during the test for tensile strength. It is defined as the percentage stretch of the dumbbell-shaped leather sample before it breaks. The leather thickness of each sample was measured using a standard-type measuring gauge in millimeters.

Tear load and resistance: Average tear load/arithmetic mean and resistance were determined using the test method of the International Organization for Standardization as indicated by [3]. 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 started to tear was defined as the slit tear strength. The slit tear strength was expressed as an average leather thickness.

Shrinkage temperature and boiling test: Samples for shrinkage temperature were taken from individual skins and pooled per treatment for laboratory analysis. The shrinkage temperature of leather was determined using the test method [3]. The boiling test is one of the physicochemical parameters of the skin.

2.8 Statistical Analysis

Data on skin quality were subjected to analyses of variance (ANOVA) procedure according to a Randomized Complete-Block Design using the Generalized Linear Model (GLM) of the Statistical Analysis System for Windows (SAS, 2002) to detect treatment effects. Treatment means were compared using Fisher's Least Significant Difference (LSD) Test at a 5% level of probability.

The statistical model used for the analysis of the experiment was:

$$Y_{ij} = \mu + T_i + Bj + e_{ij}$$

where: Y_{ij}: response variable
μ: the overall mean
T_i: the i^{th} treatment effect
B_j: the j^{th} block effect (initial BW)
e_{ij}: i^{th} random error

3. RESULTS AND DISCUSSION

3.1 Chemical Composition of Experimental Feeds

The grass hay had low CP, and high NDF and ADF, all of which are indicators of poor feed, and it fell short of the minimum needs (7 percent DM) for sheep to maintain appropriate microbial protein synthesis in the rumen [12]. The cowpea hay's CP content is comparable to previously reported levels [13,14,15]. Similar to [16,17,18,19] and [15], wheat bran's CP content is comparable.

3.2 Chemical Quality of Skin and Leather

Chrome oxide and moisture content: The treatment groups' concentrations of moisture and chrome oxide (Cr_{2o3}) did not differ significantly (*P* > 0.05) (Table 3). The leather's chrome oxide content in the current study is higher than that of the local Arsi-Bale goat reported by [20], but equivalent to that of Blackhead Ogden sheep and Sudan Desert sheep reported by [5] and [21], respectively. But it is lower than [3] for the Blackhead and Hararghe highlands and their crosses with Dorper sheep.

Despite this, the chrome oxide concentration of Begait lambs is higher than the minimum standard (2.5%) for shoe upper leather and the maximum standard (3.5%) for garment leather, except for T1 and T2. The leather's resistance to decomposition depends on the amount of chrome oxide present/ content. A higher level of chromium oxide in the skin denotes flexibility, strength, and resistance to higher temperatures up to 90 °C, which allows it to endure for a long time (durability). The greater the skin quality, the greater the chemical retention ('Bisrat, personal communication, 2017').

The values for leather moisture at the wet blue stage are equivalent to those reported by [5] and [20], respectively for Blackhead Ogaden sheep and local (Arsi-Bale) goat. It is also higher than the minimum criteria (60 percent) set by the Ethiopian Quality Standards Authority (ES-1188, 2005), which is significant for the creation of high-quality leather items. Variation in breeds, levels, and types of meals, as well as age of the experimental animals, perhaps the cause of the variation in moisture and chrome oxide concentrations among the investigations.

Table 1. Experimental treatments

Treatment	Grass hay	Amount of CPH Supplement (g)	Amount of WB Supplement (g)	Supplement amount (g) head^{-1}day^{-1}	CP(g)	ME(MJ)
1	*Ad libitum*	300	0	300	51.4	6.7
2	*Ad libitum*	225	75	300	50.9	7.9
3	*Ad libitum*	150	150	300	50.5	7.9
4	*Ad libitum*	75	225	300	49.9	7.2
5	*Ad libitum*	0	300	300	49.5	8.2

CPH= cowpea hay; WB = wheat bran; CP= crude protein; ME= metabolizable energy

Table 2. Chemical compositions of experimental feeds

Feed offered		CP	NDF	ADF	ADL	Ash
	DM %	**DM %**				
Cowpea hay	88.8	17.2	60.0	50.3	14.5	12.5
Wheat bran	88.2	16.5	38.5	16.4	5.75	6.45
Natural grass hay	90.7	5.46	77.2	53.3	14.8	9.13

CP: crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; ADL: acid detergent lignin; DM: dry matter

Table 3. Effect of feed on chemical tests of skin

Product Type	T1	T2	T3	T4	T5	SL	PSE
Wet-blue stage							
Chrome oxide (%)	2.67	2.50	4.17	3.75	3.52	ns	0.308
Moisture (%)	72.33	71.62	71.63	71.57	70.94	ns	1.389

Ns: not significant; PSE: pooled standard error of mean; SL: level of significance; T1: 300g cowpea hay; T2: 225g cow pea hay + 75g wheat bran; T3: 150g cowpea; hay + 150g wheat bran; T4: 75g cow pea hay + 225g wheat bran; T5: 300g wheat bran

Table 4. Effect of feed on physico-mechanical quality of skin

Product Type	T1	T2	T3	T4	T5	SL	PSE
Sheep upper (crust)							
Tensile strength (N/mm^2)	19.67^{c}	22.44^{a}	21.40^{ab}	20.00^{bc}	20.40^{bc}	*	0.337
Elongation (%)	55.21^{b}	60.72^{a}	56.11^{ab}	45.99^{c}	53.08^{b}	***	1.415
Tear strength (N/mm)	68.08^{b}	85.49^{a}	81.29^{a}	60.41^{c}	73.89^{b}	***	2.522
Tear load (N)	47.33^{b}	55.17^{a}	51.33^{ab}	40.00^{c}	51.00^{ab}	**	1.548
Thickness (mm)	0.60^{b}	0.82^{a}	0.69^{ab}	0.52^{b}	0.62^{b}	*	0.034
Shrinkage (^{o}C)	110.00^{ab}	104.33^{bc}	115.00^{a}	100.00^{c}	105.00^{bc}	**	1.386
Boiling test (%)	1.58^{a}	0.37^{b}	2.13^{a}	0.81^{b}	1.67^{a}	***	0.183

*a-c, means with different superscripts in a row are significantly different; ***= (P<0.001); **= (P<0.01); *= (p<0.05; PSE= pooled standard error of mean; SL=level of significance; T1=300g cow pea hay; T2=225g cowpea hay + 75g wheat bran; T3=150g cowpea hay + 150g wheat bran; T4=75g cow pea hay + 225g wheat bran; T5=300g wheat bran*

3.3 Physico-Mechanical Quality

Tensile strength, elongation, and thickness: T2 exhibited the same elongation as T3, but had a greater (*P* < 0.001) value than T4, T5, and T1 (Table 4). T2, like T1, T5, and T4, had a higher (*P* < 0.05) tensile strength. The current study's tensile strength and elongation values are lower than those previously reported [22,5,20], but they are comparable to those reported by [3] for Blackhead and Hararghe Highland and their crosses with Dorper sheep. Quality leather must have a minimum tensile strength of 19.6 N/mm^2 and an acceptable elongation of 40–80 percent [23]. Consequently, every leather utilized in this investigation possesses elongation values that are deemed acceptable and beyond the minimum required for tensile strengths. Higher elongation and tensile strength numbers in leather imply that it is more durable and can withstand more stretching without cracking the grain layer [3]. The thickness of lamb skins was likewise significantly (*P* < 0.05) influenced by feed, with increased thickness being observed in T2 and T3. The value obtained for skin thickness is, in comparison to [3] and [5], greater and lower, respectively. According to earlier studies [20,3,5], the higher value of the leather thickness of Begait lambs was ascribed to higher strength and elongation. Leather thickness is also said to boost garment strength [24].

Tear load and resistance: The treatment groups differed significantly in terms of strength and tear load (P < 0.001 and *P* < 0.01, respectively). In comparison to the skin from lambs in T1 and T4, the skin from T2 needed a greater (*P* < 0.01) mean force (N) to rip. In comparison to T5, T1, and T4, the tear strength for lambs' skin in T2 and T3 was also greater (*P* < 0.001). However, there was no discernible variation in tear load between T2, T3, and T5. In comparison to [22], who reported 60.3–74.7 N/mm, the tear strength value of leather from Begait lambs is higher than the minimum (49.1 N/mm) set for good quality leather, indicating that the leather from these lambs is suitable for the production of durable leather clothing and gloves.

Shrinkage temperature and boiling test: Compared to T5, T4, and T2, the shrinkage temperature of lamb skin in T3 was higher (Table 4). While similar to that of [3], the shrinkage temperature of the Begait lambs' is greater than the figure reported by [5]. Additionally, it exceeds the Ethiopian Quality Standard Authority's (EQSA) minimal requirement (90 ^{o}C) for chrome-tanned leather [25]. This suggests that until the temperature exceeds 90 ^{o}C, lamb skins from all treatment groups do not shrink or alter in length from the original samples. Parallel to this, T2's enhanced boiling test result implies that the skins of Begait lamb are of a higher class. In the current study, Begait lamb skins are generally deemed satisfactory.

4. CONCLUSION

This study discovered that nutrition had an impact on the physico-mechanical condition of the skin. As a result, the quality of strength, elasticity, and thickness increased significantly in well-fed lambs. The study confirmed that supplementing lambs with T3 and T2 outweighs most of the physical quality parameters of leather produced from Begait lambs. This study concluded that all test diets generated skin and leather that largely complied with the chemical and physico-mechanical quality standards demanded by the leather industry.

ETHICAL APPROVAL

Animal Ethic committee approval has been collected and preserved by the author(s)

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The author hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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