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Investigating Effects of Lisuline Cufb Concentration on the Tensile Properties of Leather

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Abstract

Diverse applications of collagen-based materials such as leather have sparked research interests that seek to investigate the effect of fatliqours on their physical and mechanical properties. As the applications of these collagen materials increase, such as in the field of medicine, footwear and upholstery, more studies are required to gain more insight on how their quality and durability can be improved. Leather being one of the collagen based material is a by-product of the meat industry, made from animal hides and skins after undergoing processes such as pre-tanning, tanning, post-tanning, and finishing operations. These processes play a vital role in giving and preserving important leather properties. This study investigated the effects of Lisuline Cufb concentrations on the tensile properties of leather. Two pieces of leather were divided into five sheets, where four sheets were fatliquored with 5%, 10%, 20% and 25% while the remaining sheet acted as control experiment. For tensile strength and elongation, eight samples were cut in a dumb-shell shape, four along the backbone direction and the remaining four, perpendicular to the backbone direction from each sheet while for tear strength, eight rectangular samples with a template hole were obtained from each sheet, four along the backbone direction and the remaining four were cut perpendicular to the backbone. For reliability and consistency of the results, the samples were prepared in four replicates and subjected to standard conditions for twenty four hours before being subjected to Instron machine testing. Results showed that tensile strength, percentage elongation and tear strength increased with increase in concentration of Lisuline Cufb up to 20%, but decreased at 25%. Comprehensive information about the effects of Lisuline Cufb concentration on the tensile and mechanical properties of leather will inform the leather industries on the required concentrations of fat liquors for the production of leather material that is durable with better tensile and mechanical properties that will meet the standards for international markets.

Subject Areas

Functional Materials

Keywords

Collagen, Fatliqours, Leather

1. Introduction

The leather industry is one of the oldest known to mankind, dating back to the fall of man in the Garden of Eden [1]. Over the centuries, it has evolved into a highly significant economic sector, particularly in developing countries, where it possesses the capacity to generate substantial income and employment. Globally, countries have sought to harness this industry's immense potential through value addition, with the goal of moving up the leather value chain from raw hides to finished leather products [2].

Kenya, recognizing this untapped potential, has invested for several decades in the leather sector [3] [4]. National and county governments have implemented numerous initiatives, including the establishment of leather industrial parks and the imposition of high export taxes on semi-processed leather to incentivize local value addition [5]. These strategies were designed to promote domestic processing and enhance the quality of leather products. However, despite these efforts, economic returns have been minimal due to persistent challenges related to quality assurance and limited technological responsiveness in leather processing [6].

Leather production involves complex chemical and mechanical processes that affect the structure and performance of the end product. These stages include pretanning, tanning, and fatliquoring [7]-[9]. Among these, fatliquoring is particularly crucial, as it enhances the softness and flexibility of collagen fibers, resulting in leather that is flexible, pliable and comfortable to use [10].

These properties are crucial in high-demand application sectors such as footwear, where leather must conform to the shape of the foot while maintaining durability, and in automotive upholstery, where leather must maintain softness and resilience under varying temperatures and mechanical stresses. In furniture and upholstery, soft and supple leather enhances comfort, adding aesthetic value, and making quality a major concern for global competitiveness.

Numerous studies have investigated the role of fatliquors in determining key mechanical properties of leather. Research by [11] [12] has demonstrated the influence of fatliquoring on tensile strength, tear resistance, and percentage elongation. Despite the effort made by the government, leather produced locally in

Kenya continues to face quality challenges. There is a growing concern to improve processing techniques, specifically those that directly affect the mechanical and tactile properties of leather. This is vital for the successful implementation of the Kenya Leather Development Council Strategic Plan (2023-2027), which emphasizes the production of high-quality leather capable of competing in global markets.

This study aimed to investigate the effects of treating leather with varying concentrations of Lisuline CUFB, to understand its effect on the structural and mechanical properties of leather. Enhancing leather quality through such scientific approaches not only improves its applicability in sectors like footwear, automotive interiors, and furniture upholstery, but also supports environmental sustainability by reducing waste and promoting longer product lifespans. Development of higher quality leather are in line with national goals of value addition, industrial growth, and placing Kenya as a competitive participant in the global leather market.

2. Materials and Methods

Two wet blue pieces of leather were procured commercially from Kenya Industrial Research and Development Institute (KIRDI), Nairobi (Kenya) while Lisuline Cufb was procured from ChemKleen Products Limited, Kenya as fatliqour. The two wet blue pieces of leather were prepared for fatliquoring using the standard tannery chemicals process (See Tables 1-3).

Tensile testing

For tensile strength and elongation, eight samples were sampled in dumb-shell shape, four along the backbone direction and the remaining four, cut perpendicular to the backbone as illustrated in Figure 1.

Table 1. Neutralization process.

Process/Step	% Chemicals	Temp (˚C)	Time	Remarks
Wetting back	100% H_2O, 0.2% soap, 0.2% formic	25	1 hr.	Moisture level
Neutralization	1% sodium formate 0.2% Bicarbonate	25 25	10 min 1 hr.	P.H.6
Drain & Washing	100% H_2O	25	10 min	Drain
Basification	0.5% Bicarbonate	25	20 min	P.H.6

The two pieces of leather were then divided into five sheets, where four of the sheets were retanned using mimosa.

Table 2. Retanning process.

Process/Step	% Chemicals	Temp (˚C)	Time	Remarks
Retanning	8% Mimosa	60	1 hr	Penetration complete through x-section
Fixation	0.2% formic acid	25	1 hr.	Fixation done
Drain &Washing	100% H_2O	25	20 min	Drain

The four sheets were each fatliquored with different concentration using standard tannery chemicals.

Table 3. Fatliquoring process.

Process/Step	% Chemicals	Temp (˚C)	Time	Remarks
Fatliqouring	80% H_2O	60		Drum speed = 3 rpm
	0.5% Bicarbonate	25	10 min	PH 6.0
	5%, 10%, 20% and 25%	25	Each conc. 1 hr.	Penetration complete through x-section
Fixation	0.5% formic acid	25	30 min	Add 0.5 % formic acid
	0.5 % formic acid	25	30 min	P.H 3.5
Drain & washing	100% H_2O	25	20min	Drain

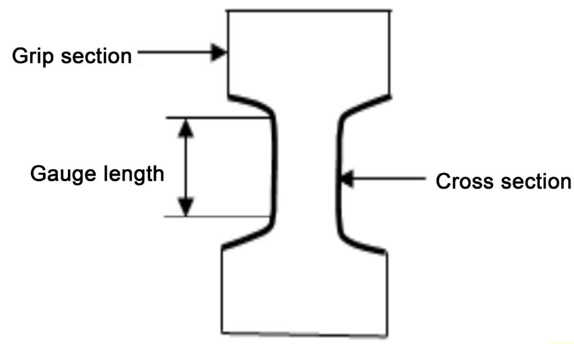

Figure 1. Schematic illustration of a standard tensile strength test sample.

For tear strength, eight rectangular samples of dimensions 50mm long and 25mm wide with a template hole were obtained from each sheet for tear strength measurements as illustrated in Figure 2.

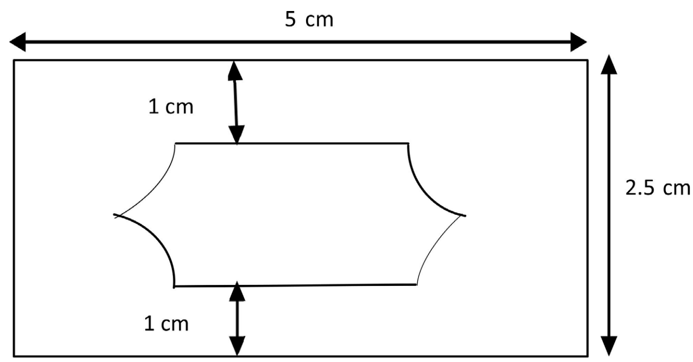

Figure 2. Schematic illustration a standard sample for tear strength testing.

After sampling, all the samples were conditioned in a standard atmosphere of 23/50, temperature of 23˚C ± 2˚C, and humidity of 50% ± 5% R.H. for 48 hours before testing as specified by ISO 2419:2024 standard. Using a digital Vernier caliper, the initial thickness, t and width, W of each sample were obtained as specified by ISO 2589:2016.

Tensile strength and percentage elongation measurements was done according to ISO 3376:2020, where eight samples were clamped, one at time at the cross-sectional area of the gauge at a uniform jaws separation speed of 100 mm/min. The machine was set to run until the sample was torn apart, the highest force reached during tearing was recorded in Newtons. The elongation of the sample was also recorded directly from the scale.

Tear strength measurement was done according to by ISO 3377-2:2016 where Pneumatic grips were replaced in the jaws of the Instron testing machine after which eight samples were clamped in the grips one at a time, the machine was run until the sample was torn apart, and then highest force reached was recorded.

3. Results and Discussion

Data were analyzed statistically by Microsoft Excel ©2019 for t-test assuming equal variance and expressed as p to assess the significance. The alpha (α) was set at 0.05. Hence, significance of the null hypothesis was rejected whenever $p \leq \alpha$. The results for tensile strength, percentage elongation, and tear strength for samples fatliquored with Lisuline Cufb of concentration 5%, 10%, 20%, and 25%, and those not treated with fatliqours are presented in **Tables 4-7** respectively.

Table 4. Tensile strength (N/mm^2) of hide treated with 5%, 10%, 20%, 25% Lisuline Cufb concentration and control sample.

Sample code	0% (control)	5%	10%	20%	25%
A	21.86	25.63	30.76	34.08	27.14
B	22.05	26.77	29.57	36.50	25.31
C	22.52	25.77	29.63	32.88	27.36
D	23.24	26.08	28.82	34.43	25.5
Average	**22.42**	**26.06**	**29.70**	**34.47**	**26.33**

The average value for the control sample was 22.42 N/mm^2. After fatliquoring with 5% of Lisuline Cufb, the strength increased to 26.06 N/mm^2. The value increased further to 29.70 N/mm^2 and then 34.47 N/mm^2 after increasing the concentrations to 10% and further to 20%. After 20% of fatliquoring, the strength reduced sharply to 26.33 N/mm^2.

Table 5. Percentage elongation of hide treated with 5%, 10%, 20%, and 25% Lisuline Cufb concentration and control sample.

Sample code	0% (control)	5%	10%	20%	25%
A	17.85	22.90	25.53	31.47	25.79
B	20.34	24.02	27.17	31.04	25.87
C	20.53	24.23	27.53	31.06	24.90
D	19.78	24.06	28.63	32.02	24.96
Average	**19.63**	**23.80**	**27.22**	**31.40**	**25.38**

From **Table 5**, the value of % elongation for the control sample was 19.63%. The value increased consistently from 23.80 to 27.22 and then 31.40% as the concentration of Lisuline Cufb increased from 5% to 10% and then 20%. At 25%, the value of elongation dropped drastically to 25.38%.

Table 6. Tear strength (N/mm) of hide treated with 5%, 10%, 20%, and 25% Lisuline Cufb concentration and control sample.

Sample code	0% (control)	5%	10%	20%	25%
A	179.30	212.00	225.00	235.25	190.60
B	170.35	207.15	223.50	242.3	185.60
C	175.60	203.80	232.25	236.25	185.80
D	181.58	210.15	227.42	237.77	186.67
Average	**176.71**	**208.28**	**227.04**	**237.89**	**187.17**

The values of tear strength increased from 176.71 N/mm for the control sample to 208.28 N/mm. The strength increased further as the concentration increased until at 25wt% when the tear strength decreased to 187.17 N/mm. Fatliquored samples had higher tear strength than control samples.

Table 7. Average results obtained for control and fatliquored samples.

Concentration	Tensile Strength	% Elongation	Tear Strength
0%	22.42	19.63	176.71
5%	26.06	23.80	208.28
10%	29.70	27.22	227.04
20%	34.47	31.40	237.89
25%	26.33	25.38	187.17

From **Tables 4-7**, it can be shown that the average of tensile strength, percentage elongation, and tear strength for samples fatliquored with Lisuline Cufb increased with increase in concentration until at 25 wt% when the average tensile strength, percentage elongation and tear strength decreased. The data indicates that concentration of fatliqours increases the tensile properties (p =0.001115), percentage elongation (p = 0.0000771472) and tear strength (p = 0.001115) until at a concentration of 20% before it starts to fall, hence null hypothesis was rejected.

The increase in tensile strength, percentage elongation and tear strength up to 20% can be explained by lubrication of leather, which makes the leather more flexible and softer [13]. The decrease in tensile strength, percentage elongation, and tear strength beyond 20% is due to over-lubrication which reduces fiber-to-fiber interactions, fibers slide past each other easily when subjected to stress. This reduces the ability of leather to withstand excess load [14]. Excess fatliqour level weakens hydrogen bonds and van der waals forces which maintains structural

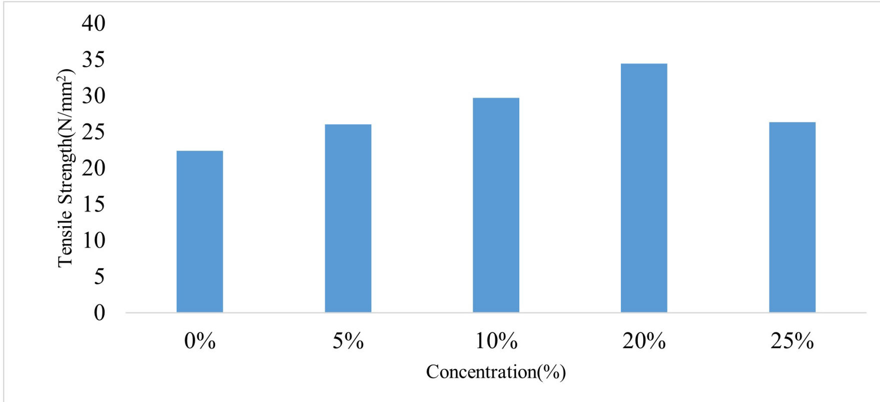

Figure 3. Effect of lisuline concentration on tensile strength of hide.

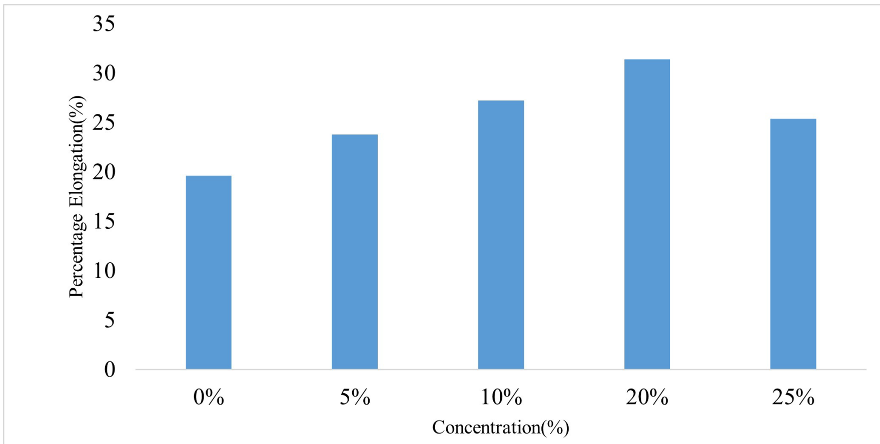

Figure 4. Effect of lisuline concentration on percentage elongation of hide.

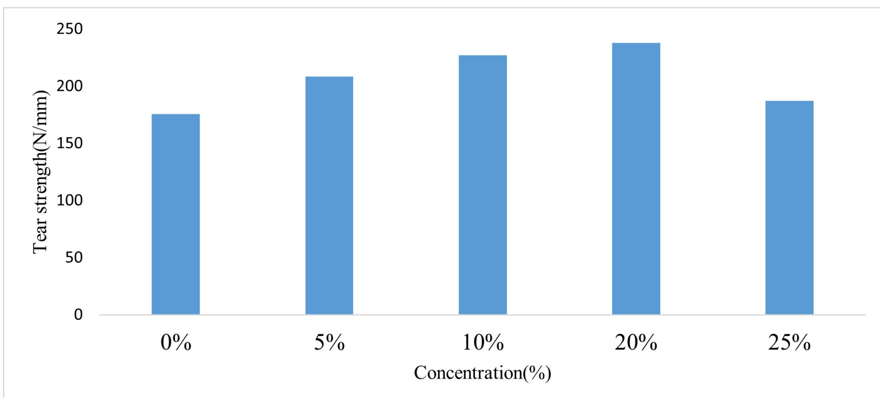

Figure 5. Effect of lisuline concentration on tear strength of hide.

integrity of leather materials, these leads to weak fiber cohesion. It's interesting to note from Figures 3-5, that 20% of Lisuline Cufb is the optimal concentration for the production of leather materials with the better tensile properties, subsequent reduction in tensile properties was noted at a concentration above that. The results for tensile strength, percentage elongation, and tear strength are in agreement with those reported by [15] for rabbit leather, which was treated with fatliqour of concentrations 8%, 10%, and 12%. Within these concentration levels, the values of tensile strength, percentage elongation, and tear strength increased with an increase in fatliqour. The results for percentage elongation and tear strength are also in agreement with results reported by [16] but contradicted those of tensile strength. This discrepancy in tensile strength values can be because of tanning agents used, type of leather used and type of fatliqour used [12].

4. Conclusions

From the study, it was clear that varying concentration of Lisuline Cufb significantly affected tensile and mechanical properties of leather. A 20% Lisuline Cufb concentration was found to enhance flexibility and strength, making leather suitable for applications such as footwear and furniture.

The study has some limitations such as only one type of leather was used and only selected range of fatliqour concentration was chosen. The environmental conditions under which samples were conditioned may not reflect variability worldwide. Further research should be done to assess the effect of Lisuline Cufb concentration on different types of leather by assessing its effect on durability.

From the findings, leather industries should control application of Lisuline Cufb to improve durability and performance of leather products.

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Conflicts of Interest

The authors declare no conflicts of interest.

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