Potential of Water Hyacinth Leaves Extract as a Leather Tanning Agent

by

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Abstract

Water hyacinth (Eichhornia crassipes) is listed as one of the worst aquatic plants in the world and its presence in Lake Tana in Ethiopia has been recognized since 2011. Currently, the plant coverage in the lake is increasing and very limited studies have been conducted in the country on practical application of water hyacinth. The aim of this study was to determine the phytochemicals, functional groups and Tannin content of the water hyacinth plant found in the Lake, which could serve as a vegetable tanning agent. Both qualitative and quantitative approaches were used to assess the quality tannin in the plant stem and leaves. On phytochemical analysis of the dried material, the tannin content was found to be 4.1% for leaves and 2.7% for stem parts. As the tannin content of the leaves was higher than the stem parts, leather tanning conducted using the 10% wt and 20% wt leaves and the quality of tanned leathers was evaluated and compared with the leather made from quebracho vegetable tanning material as a control. Most properties of leathers tanned using the leaves met the minimum specified standards for leather product manufacturing, which includes tearing strength > 45 N, percent elongation at break > 42% distension at grain crack > 6.5 mm, and distension at burst >7.8 mm. Even though shrinkage temperature is one of the most important parameters in determining the thermal stability of leather, the leather tanned with leaves extract had a shrinkage temperature of 52°C, which is lower than the standard limit (75°C) for leather product manufacturing. This indicated that, the crosslinking reaction between the hide (collagen fibers) and tannins (leaves) was weaker, implying that the leather would not be as durable or of higher quality. Similarly, the maximum tensile strength of tanned leather was 7.2 N/mm^2, which is lower than the standard requirement (20 N/mm^2) for leather product manufacturing. Therefore, water hyacinth leaves extract has limited potential as a vegetable tanning agent, and the tanned leather will not be used to make leather products that requires good thermal resistance and strength. On the other hand, the tanned leather may be utilized for leather products that need minimal tensile strain and thermal property requirements such as leather photo frames, sketchbook leather bound, etc. Since water hyacinth tannin is less than ideal as a tanning agent due the minimum shrinkage temperature and tensile strength of the tanned leather, the potential of the plant as a retanning agent should be studied in future.

Introduction

Leather production is a long and complex process that involves a number of chemical and mechanical processes. Tanning is a chemical method that converts a putrescible organic material into a stable material that can withstand biochemical attack by addition of crosslinks to collagen in order to link active tanning agents to protein functional groups.[1] Tannins are phenolic compounds that bind to collagen proteins in the hide, creating insoluble complex compounds that are more resistant to bacterial attacks.[1] Tannins are most commonly obtained from plants, but certain tannins can also be obtained from minerals. Depending on the type of animal and the intended use of the leather, hides and skins are normally tanned using either a mineral or a vegetable tanning technique.[2]

Chrome tanning is a mineral tanning technique which accounts for more than 90% of global leather production.[3] Currently, Ethiopia has more than 20 tanneries and a majority of tanneries in the country use a chromium-based tanning method that uses lots of water and chemicals. At present, approximately 90% of the tanneries in the country discharge their effluents into water bodies and land without proper treatment mechanisms.[4] Nevertheless, concerns about pollution-related issues in the global scenario have persuaded all tanneries to treat their effluents and to follow more environmentally friendly vegetable production methods.

In line with this, vegetable tanning has been identified as a viable alternative to chrome tanning, with the industry moving toward eco-labeling and green tanning chemistry.[1] However, vegetable tanning is not as widely used as chrome in Ethiopia due to the high cost of Mimosa, which is the only available vegetable tanning agent for commercial tanning purpose. Similarly, in the country there is limited knowledge and awareness about indigenous plants that could be used as vegetable tanning agents. The aim of this study was to determine the tannin content in the water hyacinth plant (stems and leaves parts), which are a threat to Lake Tana in Ethiopia, and to investigate the plant potential applications as a source of vegetable tanning agent.

Water hyacinth infestation in Lake Tana, Ethiopia

Lake Tana is the Ethiopia's largest lake and the Blue Nile's second largest sub-basin, having a surface area of 15,114 km^2.[5] Fishing,

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Figure 1. Water hyacinth leaves and stems parts outdoor and oven drying

electric power generation, transportation, common grazing land and drinking water for humans and animals, and a site for various birds are some of the multidisciplinary uses of Lake Tana. However, this multi-purpose lake is currently plagued by several issues. On the shores of this sensitive Lake, one of the most ecologically dangerous weed infestations has been recognized since 2011, and the weed coverage continues to escalate from 20 ha in 2012 to more than 50,000 ha in 2014.[5-6] Even if a tremendous amount of human labor, time and money has been employed each year by both surrounding community and government, the infestation coverage continues to escalate in the range of 278.3 ha and 2504.5 ha from 2015 to 2019.[7]

In the recent past, this aquatic plant has received a lot of attention as a potential source of income in many parts of the world.[8] However, there are few studies and reports on the functional use of water hyacinth plant in Ethiopia. The aim of this research was to investigate the potential of water hyacinth extracts as a vegetable tanning agent.

Methodology

Methods

Secondary data collection techniques were applied and the data was gathered by reviewing different articles, books and reports. Similarly, both qualitative and quantitative approaches were used to assess the quality of water hyacinth plant tannin and the tanned leather properties. The research work was carried out at Ethiopian Institute of Textile and Fashion Technology found in Bahir Dar and Leather Industry Development Institute found in Addis Ababa.

Plant collection and drying

The leaves and stems of healthy water hyacinth plant were collected from Lake Tana, next to Kirstos Samra Monastery in Gonder in Ethiopia. The plant's roots section was cut off and the plant leaves and stems were cleaned, washed repeatedly with water, and cut into small chips for faster drying. As shown in Figure 1, the plant leaves and stems parts were dried outdoors for seven days at temperatures ranging from 25°C to 35°C, and then oven dried for one hour at 104°C.

Percentage yield of dried water hyacinth plant leaves and stems parts

A 2 kg of fresh sample leaves and 2 kg of fresh sample stems were weighed separately before drying. Then, the oven dried samples weighed separately, and yielded 145 g of leaves and 167 g of stem. The yield percentage of the plant leaves and stem parts were calculated as following:

$$\text{Yield \%} = \frac{\text{Dried Final Weight}}{\text{Original Weight}} \times 100$$

$$\text{Leaves Yield \%} = \frac{\text{Dried Final Weight}}{\text{Original Weight}} \times 100 = \frac{145\text{ g}}{2000\text{ g}} \times 100 = 7.25\%$$

$$\text{Stems Yield \%} = \frac{\text{Dried Final Weight}}{\text{Original Weight}} \times 100 = \frac{167\text{ g}}{2000\text{ g}} \times 100 = 8.35\%$$

Plant powder preparation

The dried leaves and stems were individually weighed and ground in a high-speed multifunction grinder with a mesh size of 50 - 300 shown in Figure 2. The fundamental idea behind grinding the plant parts was to maximize the surface area available for extraction, thereby raising the extraction rate. The powdered samples were placed in small plastic bags for later experimental usage.

Extract preparation

The form of solvent used in the extraction process has a big impact on the success of determining biologically active compounds from plant content.[9] Thus, three different solvents (distilled water, acetone, and ethanol) were used for phytochemical analysis. Separate extracts were obtained by dissolving 50 g of leaf powder and 50 g of stem powder in 500 mL distilled water, acetone, and ethanol solvents. The mixtures were then stirred for 1 hour at room temperature using a magnetic stirrer shown in Figure 3. Solids were removed using a Whatman

Figure 2. Water hyacinth leaves and stems part grounding

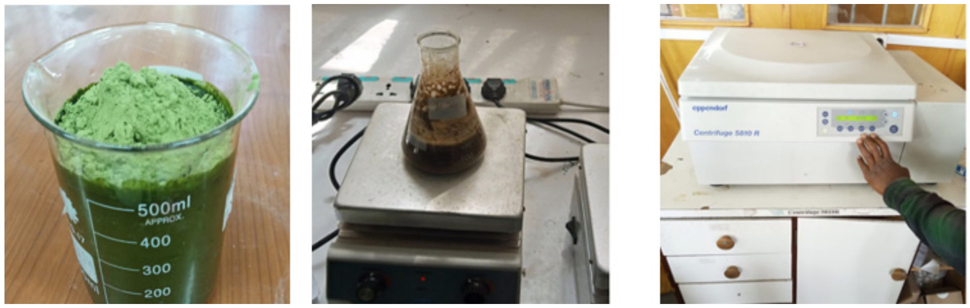

Figure 3. Water hyacinth leaves and stems extract preparation using magnetic stirrer and centrifugation.

filter 1 paper, 24 cm disc separately.[10] Each filtrate portion was then put in a glass beaker with aluminum foil on top and left to stand at room temperature for 48 h. The extracts were further purified using a centrifuge 5810 with 4000 rpm centrifugation for 15 minutes at room temperature. Each extract was then preserved in volumetric flasks in a refrigerator at 20°C, for later phytochemical analysis.

Phytochemical tests

Phytochemicals are non-nutritive plant chemicals that have defensive or disease-preventive properties. These chemicals are generated by plants to protect themselves, but studies have shown that certain phytochemicals can also protect humans from disease. Steroids, terpenoids, carotenoids, flavanoids, alkaloids, tannins, and glycosides are some of the examples of such plant bioactive constituents.[11]

Qualitative phytochemical screening helps to explain a range of chemical compounds generated by plants, and quantification of those metabolites will help to extract, purify, and identify the bioactive compounds for useful aspects to the tanning process. The extract was subjected to preliminary qualitative phytochemical screening for alkaloids, flavonoids, tannins, saponins, collagen, and phenol analysis following standard methods.

Beam house operations

Since the tannin content of water hyacinth leaves (4.1%) is higher than that of stems (2.7%), tanning experiments were conducted using the leaves extract, with quebracho vegetable tanning material used as a control. Separate and combination tanning were carried out using water hyacinth leaves powder and quebracho (control) powder. As shown in Table I, the beam-house operation carried out (i.e., soaking, liming, deliming, bating, degreasing and pickling) in the drum and the operation were same for all batches.[38]

Vegetable tanning operations

For laboratory investigation, fresh raw hides were purchased from hide and skin market in Addis Ababa. Vegetable tanning operations were done using laboratory drums having a diameter of 800 mm. Based on shown recipe in Table I,[39] separate tanning operations

Table I
Beam house operations recipe and procedure

Process	Amount (%)	Materials /Chemicals	Time/min	Remark
Soaking	300	Water	30	Drain/wash
	300	Water		
	0.4	NaoH		PH = 8.0 - 8.5
	0.05	Bactericide	60	LON 5'/h for 18 h & Drain
Liming	80	Water		
	1	Na2s		
	0.5	NaHS	60	Hair removal checked.
				LON 5'/90' and morning Fleshing
De-liming	200	Water	20	Drain wash
	80	Water		
	0.75	Amm sulphate	30	Temp 30°C, drain
	80	Water		
	0.75	Amm sulphate	40	PH = 8.0 - 9.0 drain and wash
Bating	80	Water		Temp 37°C
	0.2	TD15	40	Check temp test, D/W/2x
Degreaser	20	Water		
	0.3	GT 01	60	
	300	Water	10	D/W/3x
Pickling	40	Water		
	5	Salt	2	Be = 6.5 - 7.0
	0.5	HCOOH	60	PH = 4.8 - 5.0

Table II

Vegetable Tanning operations recipe and procedure

Process	Amount (%)	Materials /Chemicals	Time/min	Remark
Tanning- Hide weight ratio (Batch 1: 10% Water hyacinth leaves; Batch 2: Combination (5% Water hyacinth leaves and 5% Quebracho); Batch 3: 10% Quebracho (Commercial vegetable tanning agent)	12	Veg Tan x		
	12	Quebracho	180	
	5	Veg Tanx x		
	5	Quebracho		
	2	Fish oil	300	Penetration
	100	Water	20	
	0.8	Tanigal BL	60	PH = 4.0
Wet back	200	Water		Temp 40°C
	0.5% wetting agent		40	
Neutralization	100	Water		Temp 30°C
	0.2	Formic Acid	10	
	2	LSF 100	30	
	2	Sodium Formate	30	
	1.5	Sodium Bicarbonate	60	Check PH = 4.8/5.0
Retanning/Dyeing and Fatliquoring	50	Water	30	Temp 40°C
	2	Acrylic resin	30	
	4	Retanal MD 80	60	
	4	LSF-100		
	4	Mimosa/WH	60	
	3	Black dye		
	100	Water		Temp 60°C
	4	Lipsol J-622	60	
	1	Neopristol SW	60	
	2	Formic Acid	40	Check PH = 3.8/4.2

for all batches were conducted based on the weight of the sample cow hide. Each batch was separately soaked for three days in 10 wt% water hyacinth leaves, 20 wt% water hyacinth leaves, and a combination (5 wt% water hyacinth leaves and 5 wt% Quebracho) and 10 wt% Quebracho (Control). Changes in liquor color and penetration across the pelt cross-section were used to monitor tanning progress. Meanwhile, the hides were left in it overnight, and rotated for 30 minutes before being removed from the drum and horsed up. Cutting a small piece of the pelt in the neck area was used to check for tannin penetration, and color uniformity around the pelt cross-section was used to determine tanning completion. Subsequently, fatliquoring was achieved with warm water, greasing, and toggle drying carried out.

Results and Discussion

As shown in Table III, Flavonoids, saponins, phenols, tannins, alkaloids, starch, and proteins were detected in distilled water, ethanol, and acetone extracts of water hyacinth leaves and stems.

Table III

Phytochemical analysis of water hyacinth leaves and stems parts

No	Compound	Detection Method	Distilled water extract (Leaves)	Distilled water extract (Stems)	Ethanol extract (Leaves)	Ethanol Extract (Stems)	Acetone extract (Leaves)	Acetone Extract (Stems)
1	Flavonoids	Alkaline reagent test[12]	+	++	-	++	+	+
2	Saponins	Froth Test[13]	++	++	+	-	+	-
3	Phenols	Ferric Chloride test[14]	++	++	+	++	++	++
4	Tanins	Ferric chloride test[13]	++	++	+	+	++	++
5	Alkaloids	Mayer's and Wagner's test[13]	++	+	+	+	+	-
6	Starch	Iodine test[15]	++	+	+	++	-	++
7	Protein	Biuret test[16]	++	+	+	+	+	-

Key: (-): Not detected, (+): Weak positive test and (++): Strong positive test

Flavonoids Detection: The current study found strong positive (++) flavonoids in both distilled water and ethanol extracts of the stems part and weak positive (+) flavonoids in distilled water and acetone extracts of the plant leaves (Table III). Similarly, Jayanthi and Lalitha[17] reported that flavonoids were detected in water hyacinth plant collected from both Singanallur boat house, and Tondano Lake in India.

Saponins Detection: Froth test approach revealed the existence of strong positive (++) saponins in both distilled water extracts of stems and leaves. As well as weak positive (+) saponins were detected in both ethanol and acetone extracts of the plant leaves (Table III). Similar results were found by Aravind et al.[18] who reported the presence of saponins in water hyacinth plant collected from various marshy lands in Kayamkulam, Mavelikkara, Allepy, and Kerala.

Phenols detection: In ferric chloride test, strong positive (++) phenols were detected in both distilled water and ethanol extracts of the stems and leaves parts, as well as strong positive (++) phenols detected in the acetone extracts of the stems part, and weak positive (+) phenols in detected in the acetone extract of the leaves part (Table III). Similar findings were found by Rorong et al.[19] who reported the presence of phenols in water hyacinth plant collected from Singanallur boat house, Tamil Nadu, and Tondano Lake in the district of Minahasa, india.

Tannin detection: In tannin detection using ferric chloride test, strong positive (++) tannins were detected in both distilled water and acetone extracts of stems and leaves parts, and weak positive (+) tannins were detected in both ethanol extracts of leaves and stems (Table III). Similar Rorong et al.[19] reported the presence of tannin in water hyacinth collected from Tondano Lake in the district of Minahasa, and Warangal district.

Alkaloids detection: In Mayer's and Wagner's test, the presence of strong positive (++) alkaloids detected in leaves distilled water extract and weak positive (+) alkaloids in both leaves and stems acetone and ethanol extracts was detected (Table III). Related findings by Lalitha et al.[20] showed the existence of alkaloids in Eichhornia crassipes (WH) collected from lakes near Kurichi in Coimbatore, India and Bilaspur district of Chhattisgarh, India.

Starch detection: Iodine test approach[40] detected the presence of strong positive (++) starch in the acetone and ethanol extracts of the stems part and in distilled water extract of leaves part. Likewise, a weak positive (+) starch was detected in both ethanol extracts of the leaves and stem parts, and in distilled extracts of leaves part and acetone extracts of the stem part (Table III).

Protein detection: Biuret test revealed the presence of strong positive (++) protein in the distilled water extract of leaves part (Table I). Correspondingly, weak positive (+) protein is detected in both distilled water and ethanol extracts of stems part and in both ethanol and acetone extracts of leaves part (Table III). Similarly, Jayanthi[17] reported the presence of protein in water hyacinth collected from lakes near Kurichi in Coimbatore, India.

Tannin and tannin content determination by Hide powder method

Tannins are amorphous, astringent compounds found in a broad range of plant materials, including bark, wood, leaves, and resinous exudations.[21] Tannins are non-crystalline, colorless compounds that form colloidal solutions in water and have an astringent flavor. Tannins are polymeric phenolic compounds with various hydroxyl groups and chemical structures that are very complex. The tannin content of water hyacinth leaves and stems was determined by means of the Hide powder method[21] and the tannin content of water hyacinth leaves and stems parts were determined at the Central Leather Research Institute (CSIR) Laboratory in India.

As shown in Table IV, the tannin content of water hyacinth leaves was higher (4.1%) than that of the plant stems part (2.7%). The tannin content of water hyacinth leaves is close to that of Salix folium (4.0%) and Kepok banana bunch (4.1%),[22] but higher than that of acacia Senegal barks (3.49%).[21] However, the tannin content in the *water hyacinth leaves is* lower than that of Acacia seyal bark, 28.9%.[22] Similarly, the tannin content in this study is higher than that of water hyacinth leaves (0.98%), as investigated by Sangbrita,[41] but lower than that of water hyacinth roots (5.4%) and leaves (6.9%), as investigated by Lara-Serrano.[2]

FT-IR Analysis

Fourier transform infrared (FTIR) spectroscopy is an important technique used for chemical analysis of biological substances.[23] Based on this, the leaves and stems parts of water hyacinth plants were analyzed using FTIR to determine the plant's relative functional group.

Table IV
Tannins content found in the Water Hyacinth plant's leaves and stems

Water Hyacinth Plant part	Tannin (%)	Total Ash (%)	PH water soluble	Test Method
Leaves	4.1	14.8	6.3	IS 5466: 2013
Stems	2.7	15.6	5.8	IS 5466: 2013

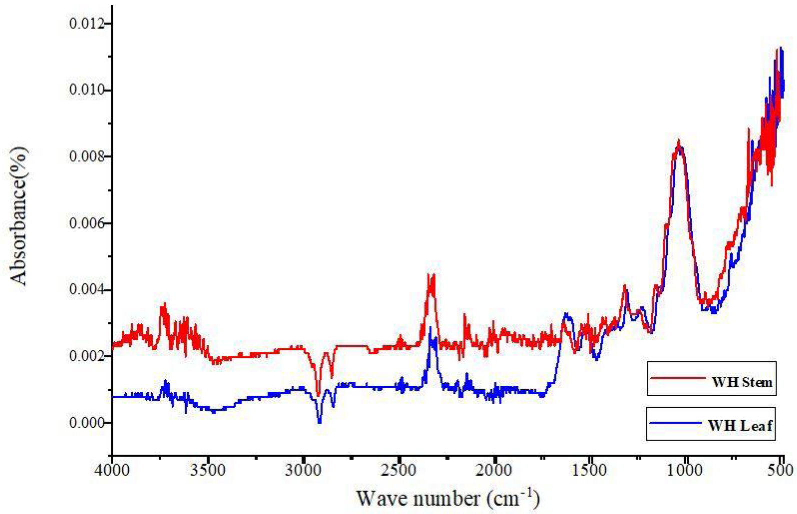

Figure 4. FT-IR spectra of Water Hyacinth plant leaves and stem part

The FTIR spectra of water hyacinth plant leaves and stem parts are shown in Figure 4.

As shown in Figure 4, the FTIR data was recorded with a scan speed of 2 mm/s and the plant samples were added as a powder with a wavelength resolution of 4000 cm^{-1} - 500 cm^{-1}.[24] FTIR analysis, revealed the presence of amines (N-H stretching) by the peak between 3340 - 3400 cm^{-1},[25] and the presence of alkanes/lipids (C–H stretch) were revealed by the peak between 2890 cm^{-1} and 2889 cm^{-1}.[26] The alkynes have a plateau at 2346 cm^{-1} and 2347 cm^{-1} (C-C Stretch).[27] The peak at 1640 cm^{-1} revealed carboxyl group absorption (C=O stretch)[28] and the presence of lignin content at 1609 cm^{-1} (C-C stretch).[29] The O–C=O asymmetrical stretching caused the peak at 1318 cm^{-1}, and a peak at 1063 cm^{-1} showed the presence of hemicellulose (C–C stretch). The absorption bands of lignin, cellulose, and hemicelluloses are well known to be in the wavelength range of 1800 - 800 cm^{-1} (stretching and bending vibrations within the molecules, also known as the fingerprint region).[30] A peak of 1035 cm^{-1} revealed C–O stretching of primary alcohol in cellulose and hemicelluloses.[28] As shown in Figure 4 the recorded values of FTIR spectra nearly identical for both the leaves and stems part of the water hyacinth plant.

Due to OH stretching vibration,[42-43] all tanning compounds, including quebracho,[44] have a strong band between 3600^{-1} and 3400cm^{-1}, however FTIR analysis of water hyacinth leaves indicated a very small peak between 3400^{-1} and 3600 cm^{-1} in the study. Because of this, the water hyacinth lacks key O-H stretching functional groups required for maximum tanning effect.

Physical characteristics of vegetable tanned leather

Each batch of tanned leather was labelled, and physical property characterization carried out using standard instruments available at Leather Industry Development Institute Laboratory, Addis Ababa. Shrinkage temperature, tearing strength, tensile strength, percent elongation at break, distention at grain crack, distension at burst, and thickness were assessed for leathers tanned with water hyacinth (WH) leaves, combination (i.e., water hyacinth and quebracho) and quebracho tanning material (control). Physical/mechanical strength tests, moisture-related tests, and chemical analysis are the three major categories of leather tests. These properties have variations depending on the various factors but most importantly the type of tanning agent. Since leather is an inconsistent material by nature, independent leather testing and analysis is necessary prior to usage especially when a new tanning material is proposed.[31]

The tanned leathers were taken for final testing after the vegetable tanning was completed. As shown in Table V, the experiments were assessed for both hide tanned with water hyacinth lives and quebracho (control) experiments.

Tearing strength: This refers to the consistency level relating to tearing load indicates the strength of the leather goods in use, and the minimum tearing strength required for leather product making should be at least 35N.[33] This study found the tearing strength of all tanned leathers with water hyacinth leaves were higher than 35 N. The tanned leather with 10 wt% and 20 wt% water hyacinth leaves had a tearing strength of 37 N and 45 N respectively. Similarly, the tanned leather with 5 wt% quebracho and 5 wt% water hyacinth leaves (combination) had a tearing strength of 106.2 N and 10 wt% quebracho (control) had 115 N. As shown in Table V, the study finding revealed that the tanned leather with water hyacinth fulfilled the minimum tearing strength (35 N) requirement for leather product making.[32]

Shrinkage temperature: Shrinkage temperature is a very important parameter in characterizing the thermal stability of leather and it is the temperature at which the leather sample starts to shrink in water or over a heating medium.[34] The shrinkage temperature provides

Table V
Physical test results of vegetable tanned leather

S/n	Physical Properties	Physical test result				
		10 wt% WH Leaves	20 wt% WH Leaves	5 wt% WH Leaves and 5 wt% Quebracho (Combination)	10 wt% Qubracho (Control)	Minimum recommended value for leather products making[32]
1	Shrinkage Temperature (T_S °C)	55	52	58	76	Min > 75°C
2	Tear Strength (N)	37	45	106.2	115	Min > 35 N
3	Tensile strength (N/mm^2)	6	7.2	8.9	22	Min > 20 N/mm^2
4	Percent Elongation at break (%)	47	42	60.5	62	Min > 40%
5	Distention at grain crack (mm)	7	6.5	9.4	10	6.5 mm
6	Distension at burst (mm)	7.8	9	12.5	11.4	7 mm
7	Thickness (mm)	2	2.5	3.3	2.2	> 0.5 mm

information about the degree of tanning because better crosslinking reaction between collagen fibers and tannins increases the shrinkage temperature.[1] In the current study, the hide tanned with 10 wt% quebracho (control) had the maximum shrinkage temperature of 76°C whereas the hides tanned with 10 wt% and 20 wt% water hyacinth leaves had 55°C and 52°C, respectively and combination tanning (5 wt% quebracho and 5 wt% water hyacinth leaves) had 58°C. This indicates that the tanned hide with 10% and 20% water hyacinth leaves resulted in a shrinkage temperature of between 52 - 58°C, which is below the acceptable shrinkage temperature (75°C) for leather product making.

Grain crack and Grain burst: Other physical tests used to assess the leather quality are the grain crack and grain burst tests. They indicate how resistant the grain is to cracking during the top lasting of the shoe uppers. All the tanned hides exceeded the minimum recommended values of grain crack (7 mm) and grain burst (6.5 mm). The WH leaves had a maximum grain crack of 7 mm (10 wt% WH leaves) and a grain burst of 9 mm (20 wt% WH leaves). Different studies on vegetable tanning materials have found different values for grain crack and grain burst.[35]

Tensile Strength: In the present study, hide tanned with 10 wt% quebracho (control) had the highest Tensile strength of 22 N/mm^2. However, the hide tanned with 10 wt% and 20 wt% of water hyacinth leaves had a tensile strength of 6 N/mm^2 and 7.2 N/mm^2, respectively, and a combination (5 wt% quebracho and 5 wt% water hyacinth leaves) had a tensile strength of 8.9 N/mm^2.

This shows that the tensile strength of hide tanned with 10 wt% and 20 wt% water hyacinth leaves and a combination (5 wt% water hyacinth and 5 wt% quebracho) were less than the expected minimum requirement of tensile strength of (20 N/mm) leather product making. Therefore, the hide tanned with water hyacinth leaves has inadequate tensile strength and it cannot be used to produce leather products with good strength requirement.

Elongation Analysis: The percentage elongation of leather is another physical property measured when assessing the leather quality and this has a relationship with the tensile strength. Elongation refers to the ability of a leather product to lengthen/stretch when stress is applied to it and represents the maximum extent leather can stretch without breaking.[36]

From Table V, hide tanned with 10% and 20% water hyacinth leaves, as well as a combination (5 wt% water hyacinth and 5 wt% quebracho), had 47%, 42%, and 60.5% elongation, respectively, which were lower than commercial quebracho 62% elongation. However, all tanned hides had ≥ 40% percentage elongation, and are comparable to those reported from other studies.[37] Likewise, Nasr et al.[35] reported vegetable tanned leather with quebracho and Mimosa had percent elongation 59.06% and 55.32% respectively.

Thickness (mm): In the present study, the thickness of all tanned hide found between 2 mm to 3.3 mm, which were greater than the minimum recommended thickness (0.5 mm) for leather products making.

Conclusion

Leather is a durable and flexible material made from raw hide and skin by tanning process, which prevents the collagen fibrous protein in animal skins or hides from putrefaction. The most commonly used tanning methods are chrome and vegetable tanning. The tannin content of water hyacinth plant leaves was 4.1%, which is less than that of conventional quebracho (>40%) vegetable tanning material. Most of the recommended parameters for leather product manufacturing, such as tear strength, elongation at break, grain crack, grain burst and thickness, were realized in the hide tanned with water hyacinth leaves. However, the leather had a tensile strength of 7.2 N/mm^2 and a shrinkage temperature of 52°C, which are both below the minimum standards for leather product manufacturing. Thus, water hyacinth leaves extract has limited potential as a vegetable tanning agent, and the tanned leather will not be appropriate to produce leather products which requires good tensile and thermal properties. However, the water hyacinth leaves tanned leather will be used to produce leather products that requires minimal tensile strength and thermal properties such as leather photo frames, bound leather sketchbook etc. Since water hyacinth leaves tannin is less than ideal as a tanning agent due the minimum shrinkage temperature and tensile strength of the tanned leather, the potential of the plant leaves as a retanning agent will be studied in the future.

Recommendation

This study mainly focused to determine potential of water hyacinth leaves extract as a leather tanning agent. The study revealed that water hyacinth leaves extract has limited potential as a vegetable tanning agent. The water hyacinth-tanned leather had low tensile strength and thermal property, failing to meet the minimum requirements for leather product manufacture. Since water hyacinth tannin is less than ideal as a tanning agent owing to the tanned leather's minimum shrinkage temperature and tensile strength, the plant's potential as a retanning agent should be investigated in the future.

Competing Interests

The authors declare that they have no competing interests.

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