World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Research Article)

Check for updates

Characteristics of leather produced by using *Acacia nilotica ssp tomentosa* pods as tanning materials from Blue Nile State-Sudan

Manal Mohammed Ahmed and Mahdi Haroun *

Department of Industries, College of Applied and Industrial Sciences, University of Bahri, P.O. Box13104-Khartoum, Sudan.

World Journal of Advanced Research and Reviews, 2023, 17(01), 001–007

Publication history: Received on 03 November 2022; revised on 10 December 2022; accepted on 02 January 2023

Article DOI: https://doi.org/10.30574/wjarr.2023.17.1.1353

Abstract

Chrome salt utilization in tanning industry become spread over the world owing to its preferred quality in leather industry. However, Environmental concerns of chromium have shifted the interest of current research to metal-free and friendly processing options. Vegetable tanning, have been proven to be environmentally safe and manageable, while producing good quality leather with similar characteristics as that of chromium tanned leather. So, the objective of this research work is to determine the properties of leather using vegetable tanning materials from the pods of *Acacia nilotica ssp tomentosa* in the form of powdered pods and extract. Results indicated a significant difference in the properties of the tanned skin. Chemical properties of the tanned leathers by extracts of *Acacia nilotica ssp tomentosa* pods are found to be quite normal. Tensile strength values of tanned skin with pods extracts are higher than that tanned with powdered pods. On the other hand, tanned skin with tannin extract produced greater skin elongation 44.39% compared to tanned with pods powder which was 34.94%. This work provides useful information on the potential leather production by using vegetable tannin materials for leather industries in Sudan and beyond.

Keywords: Leather; Extract; Powdered pods; Physical properties; Chemical properties

1. Introduction

Leather industry is among the oldest technologies in human history involving production of leather and diversities of products from animal skins [1,2]. About 90% of global leather is processed by chromium salts as sole tanning agent [3]. However, negative environmental impacts associated with its tanning derivative, hexavalent chromium, have brought a major concern about the sustainability of leather industry as they are known to be carcinogenic, mutagenic and allergic agents affecting the health of human being and other organisms [4]. Having less and manageable environmental effects, vegetable tannins are highly recommended [5]. Vegetable tannins generally contain no hazardous substances, hence perceived environmentally benign if produced under green chemical processes. Vegetable tannins are plant polyphenols with high molecular weight, capable of interacting with skin collagen and stabilize the skin matrix against heat and degradation [6,7]. They are also applied in other industries such as wine, pharmaceutical, and adhesive industries with high performance and economic advantages [8]. Vegetable tannins are classified based on their chemical structures as hydrolysable tannins and condensed tannins [9,10]. Thus, different plant species can produce particular class or combination of classes of vegetable tannin categories, hence the need for their characterization and extraction efficiency optimization. With today's modern technology vegetable tannins can produce leathers with good softness, sponginess, tightness and embossing retention properties that can be refined in many ways in order to adapt to different uses [11]. However, hydrothermal stability, measured as denaturation temperature, is limited to 85°C [6]. World vegetable tannin market is dominated by commercial tannins from quebracho, Chestnut, wattle, sumac, myrobalan and tara [3,9]. In Africa commercially available vegetable tannins have not been widely used due to their shortage and high cost. In Sudan, only *Acacia nilotica ssp tomentose* (garad) extract derived from pods is available commercially. The

* Corresponding author: Mahdi Ahmed Haroun
Department of Industries, Bahri university, Khartoum North, Khartoum, Sudan.

quality of leather is poor compared to leather made of commercial extract of *A. mearnsii.* [12,13]. Further still, very little has been done to improve their extraction methods and possible blending approaches to enhance their application in leather industry. Therefore, in the work hereby determined the characteristics of the leather by using vegetable tannins from *Acacia nilotica ssp Tomentosa* pods which richly available in Sudan.

2. Material and methods

2.1. Preparation of Sample

Fresh plant pods from *Acacia nilotica ssp Tomentosa* (3.0 kg) were collected from various forest in Blue Nile state- Sudan, for this research work. Soba Forestry Research Facility Herbarium confirmed the identity of the plant tissues. The samples tissues were then freeze dried and transformed into a fine homogeneous powder by crushing with a disc mill, then the residual material is prepared for the extraction process.

2.2. Extraction of Tannins

The extraction was carried out with normal water (3litres) at temperature of 100 ^{o}C for one hours using the strategy of American leather Chemist Association (ALCA) [14]. Then the mixture was cooled and filtered. A vacuum rotary evaporator was used for concentration of the filtrate, Then the extract yield was calculated [12].

2.3. Tanning Process

Tanning was done in laboratory drums with following specification (200 mm wide and 400 mm diameter (height) (Table 1). Pickled pelt (Cattle skin) was used as raw material with appropriate amount of chemical and water estimated on pickled pelt weight %. Shaving machine was used to prepare pickled pelts to a thickness of 1.4 mm. Then tanning is done with extracts of *Acacia nilotica ssp tomentosa* pods for 12 hours. After that, the skin is washed to remove residual tanning materials, then let to be dried overnight.

Table 1 Tanning process of the skin

Chemical materials	Percentage, %	Temperature, C^{o}	Time, minutes	Control
Water	50	30	20	Be=7
Sodium Chloride	6			
Adding of pelts with pH 2.5				
Sodium Format	1.5	40	60	pH 4.0
Sodium Bicarbonate	1.0			
Synthetic tannin	10		120	
Overnight run 5 minutes each two hours at pH 4.3				
Drain				
Washing	100	30	20	
Drain, squeeze, shave, &drying				

2.4. Chemical Analysis of leather

2.4.1. Preparation of Sample

Leather was cut into small pieces to pass through a screen with circular perforations of 4 mm. The pieces were thoroughly mixed and brought to a state of homogeneity by keeping them in a closed container for at least overnight. Then Moisture content, Fat content, Insoluble ash, Hide substances, Water soluble % was determined [15].

2.5. Physical Analysis of leather

2.5.1. Conditioning

The specimens for physical testing were kept in a standard atmosphere of temperature 20 ± 2°C and relative humidity 65% ± 2% during the 48 h immediately preceding their use in a test [16].

2.5.2. Tensile strength and percent of elongation

The jaws of the tensile machine (Instron 1026, Instron, UK) were set 50 mm apart, and then the sample was clamped in the jaws, so that the edges of the jaws lay along the midline. The machine was run until the specimen was broken and the highest load reached was taken as the breaking load. The tensile strength load is in Newtons [17].

$$\text{Tensile strength} = \frac{\text{Maximum breaking load}}{\text{Cross sectional area}}$$

The Percent of Elongation at Break was measured according to the society of leather technologist and chemists [17].

2.5.3. Calculation

$$\text{Elongation, \%} = \frac{\text{Final free length} - \text{Initial free length}}{\text{Initial free length}}$$

2.6. Statics analysis

The analysis is done using paired two sample for means t-Test.

3. Results and discussion

Vegetable tannins are polyphenolic substances that can be easily extracted with water from almost all plants [18] and have traditionally been used to tan leather [18,19]. Tannins are a heterogeneous group of polyphenols widely present in the plant kingdom as secondary metabolites for protective purposes, with molecular weight between 500 and 30,000 Da [20]. They occur in bark, wood, fruits, fruit pods, leaves, roots, and plant galls [21].

3.1. Analysis of pods powder

Table 2 Analysis of *Acacia nilotica ssp tomentosa* pods (% oven-dry part extracted)

Parameter	**Percentage, %**
Moisture content	11.50
Total solids (TS)%	16.2
Soluble solid (SS)%	15.7
pH	6
Ash	2.9
Water soluble materials	63.4
Tannins (T)%	16.8
Non-tannins (NT)%	9.8
Extraction Ratio (T/NT)	0.8
Catechin number	8.6
Gallic acid	-
Tannin type	Catechol
Purity (T/SS) %	0.4

The obtained data indicated that the pods powder of *Acacia nilotica ssp tomentosa* when extracted, contained 16.8 % (oven-dry basis) of tannins, the extent of business interest. An appropriate extraction ratio (tannin to non-tannin) of 0.8. The tannin purity or the ratio of tannin/soluble solids was good >0.3, for studied powdered pods (Table 2). However, the sort of tannin present and therefore the part extracted are important.

3.2. Analysis of pods extracts yields

The yield of tannin extract of *Acacia nilotica ssp tomentosa* pods produced is shown in Table 3. Which is a comparisons percentage of the extracts with the materials used. The yield of tannin was 39.4%. An appropriate extraction ratio (tannin to non-tannin) of 1.7 was obtained. The tannin purity or the ratio of tannin/soluble solids was good 0.6, for studied pods extracts (Table 3). Regarding the moisture content, ash, and pH were 13.9%, 4.6% and 6 respectively. This extract of tannins is used as a vegetable pretanning material. So, the use of this extracts on the tannery allows these substances to penetrate rapidly into the skin since it has small molecules and active binding capacity on the skin molecules. This molecule and its binding capacity can be enlarged by changing the density and pH so that it can increase the tanning power of the skin. The pH of the solution affects the solubility of a material [22].

Table 3 Analysis of *Acacia nilotica ssp tomentosa* pods extracts (% oven-dry part extracted)

Parameter	**Percentage, %**
Moisture content	13.9
Total solids (TS)%	63.1
Soluble solid (SS)%	62.1
pH	6
Ash	4.6
Tannins (T)%	39.4
Non-tannins (NT)%	22.7
Extraction Ratio (T/NT)	1.7
Catechin number	36
Galli c acid	+
Tannin type	HC
Purity (T/SS) %	0.6

3.3. Chemical analysis of leather

Table 4 Chemical characteristics of leather tanned by *Acacia nilotica ssp tomentose* pods powder and extracts

Parameter	**Native Skin**	**Tanned skin by pods powder *Acacia nilotica ssp tomentosa***	**Tanned skin by pods extracts *Acacia nilotica ssp tomentosa***
Moisture content, %	13	12	19
Fat content, %	16.5	5	8
Ash, %	25	15	20
Hide substances, %	60	40	30
Metal Oxide, %	0.7	1.5	2
Water soluble, %	8	5	3
pH	7	7	7

The chemical properties of *Acacia nilotica ssp tomentosa* pods extracts tanned leathers are found to be quite normal. The total chemical content satisfies the leather requirement compared with the native or untanned skin which has the lowest value (0.7%) (Table 4). The free oils and fats present in *Acacia nilotica ssp tomentosa* tanned leather is (5%) and (8%) for tanning done by powdered pods and extracts respectively which are comparable to that of the native leather (Table 4). The reduced water solubility (3%) indicates that *Acacia nilotica ssp tomentosa* extract tanned leather ensure better water resistance compared with the powdered pods (5%) and native skin (8%) (Table 4) (17). The studies thus indicates that vegetable tanning using indigenous *Acacia nilotica ssp tomentose* extract and powdered pods can be easily adopted in the tanneries in Sudan and those in the subregion. Their use will reduce imports of chrome and will lessen the attendant pollution. Cost benefit studies may also show considerable benefits for non-Sudanese users of *Acacia nilotica ssp tomentose* pods who may not have access to another tanning agent. Depending on the particular quality needed in the final leathers, *Acacia nilotica ssp tomentose* pods tannin can either be used as a pre-tanning or retanning agent [23].

Based on statistical analysis there is a significant difference between the leather chemical properties produced. Tanning with *Acacia nilotica ssp tomentose* extracts exhibited bound tannins and a developed degree of interaction between tannins materials and collagens compared to the use of powdered pods directly. In the leather tanned by extracts the degree or power of tanning and bonded tannin materials in the leather are 84% and 32% respectively. On the other hand, the leather tanned by powdered pods showed only 38% and 18%. Therefore, from the above scenario of tanning, the extract tanning is better than the powdered pods of *Acacia nilotica ssp tomentose* owing to different tannin reactivity. The extraction process can have an effect on tannin polymers which can form intramolecular bonds in the intermolecular cross-ring environment with skin collagen. Likewise, the mechanism of vegetable tanning forms the amount of hydrogen bonds between several phenolic hydroxyl groups from tannins with carboxyl and amine compounds in skin collagen [23].

3.4. The Physical analysis of Leather

The tensile strength and percentage elongation of the tanned leather using *Acacia nilotica ssp tomentosa* powdered pods, extracts, and native skin are shown in Table 5. Vegetable tannins material is capable of diffusing into the molecular pore dimensions. An increase in the tensile strength can be interpreted in terms of the number of covalent cross-links formed during the tanning processes. However, a decrease in the tensile strength at a higher concentration of vegetable tannin material may be owing to the increased stiffness (shown by the decreasing elongation) results in a brittle fiber; consequently, it breaks more easily at a reduced load. Based on the outcomes of the statistical analysis tensile strength of skin tanned with *Acacia nilotica ssp tomentosa* powdered pods and tannin extract showed significantly different results. Tensile strength values of tanned skin with tannin extracts are higher than that tanned with powdered pods. On the other hand, tanned skin with tannin extract produced greater skin elongation 44.39% compared to tanned with pods powder which was 34.94%. The bonds extent of the vegetable tanning skin collagen provides an explanation of the increased tensile strength of skin fiber. On the other hand, the strength properties of the native skin fiber under the same conditions of are 20±4 (Table 5), this is attributed to the fact that the deposition of material with a hardness higher than that of collagen fibers may well reduce the thermomechanical properties [24].

Table 5 Physical characteristics of leather tanned by *Acacia nilotica ssp tomentose* pods powder and extracts

Parameter	**Native skin**	**Tanned skin by pods powder *Acacia nilotica ssp tomentosa***	**Tanned skin by pods extracts *Acacia nilotica ssp tomentosa***
Tensile strength %	20	35	60
Elongation, %	25	40	55
Softness, mm	1.0	2.2	3.2
Water vapor permeability mg/cm2/h	4	6	8
Water uptake during water vapor permeability mg/cm2 /h	80.0	100	90

4. Conclusion

A vegetable tanning using extracts and powdered from *Acacia nilotica ssp tomentose* pods has been found to increase the physical and chemical properties of the produced leather in case of doing tanning with extracts. The bound tannin value and tanning degree using tannin extracting materials were higher than leather tanned with powdered pods, in conclusion, we have displayed evidence for the possible chemical modifications of collagen brought about by vegetable tannin. This will further add to our understanding of the tanning of leather that might confirm the mechanism of vegetable tanning as postulated by researchers.

Compliance with ethical standards

Acknowledgments

The authors are grateful to Bahri University and forest National cooperation, for financial support and national Centre for research for giving the possibility to use the resources and facilities of their laboratory.

Disclosure of conflict of interest

Authors have declared that no conflict of interests exists.

References

[1] Brown, E.M., Dudley, R.L., Approach to a tanning mechanism: study of the interaction of aluminum sulfate with collagen. J. Am. Leather Chem. Assoc. 2005, 100: 401-409.

[2] Sarkar, K.T. Theory and Practice of Leather Manufacture 1981. (Revised ed.).

[3] Pizzi, A. Tannins: major sources, properties and applications. Monomers, Polymers and Composites from Renewable Resources. Elsevier, 2008, pp. 179-199.

[4] Fathima, N.N., Saravanabhavan, S., RAO, J.R., NAIR, B.U. An eco-benign tanning system using aluminum, tannic acid, and silica combination. J. Am. Leather Chem. Assoc. 2004, 99:73-81.

[5] Madhan, B., Aravindhan, R., Siva, M., Sadulla, S., Rao, J.R., Nair, B.U. Interaction of aluminum and hydrolysable tannin polyphenols: an approach to understanding the mechanism of aluminum vegetable combination tannage. J. Am. Leather Chem. Assoc. 2006, 101:317-323.

[6] Covington, Anthony D. Tanning chemistry: the science of leather. Royal Society of Chemistry, 2009.

[7] Laura, A., Alvarez-Parrilla, E., Gonzalez-Aguilar, G.A., Fruit and Vegetable Phytochemicals: Chemistry, Nutritional Value and Stability. John Wiley & Sons. 2009.

[8] TANAC. Next Generation Extract for Upholstery Application. International Leather Maker, London, 2016, pp. 62-64

[9] Dutta, S.S. An Introduction to the Principles of Leather Manufacture. Indian Leather Technologists' Association, 1985.

[10] Schroepfer, M., Meyer, M. Investigations towards the binding mechanisms of vegetable tanning agents to collagen. Res. J. Phytochem. 2016,10: 58-66.

[11] Kuria, A.N. Evaluation of Tanning Strength and Quality of Leathers Produced by Selected Vegetable Tanning Materials from Laikipia County, Kenya Department of Public Health Pharmacology and Toxicology. University of Nairobi, 2015.

[12] Mahdi, H., Palmina, K., Glavtch, I. Characterization of Acacia nilotica as an indigenous tanning material of Sudan. J. Trop. For. Sci. 2006,18: 181-187.

[13] Kuria, A., Ombui, J., Onyuka, A., Sasia, A., Kipyegon, C., Kaimenyi, P., Ngugi, A. Quality evaluation of leathers produced by selected vegetable tanning materials from laikipia county, Kenya. IOSR J. Agric. Vet. Sci. 2016b, 9: 13-17.

[14] American Leather Chemists Association (ALCA). Methods of Sampling and Analysis. (1957).

[15] Borasky, R. and Nutting, G.C. Microscopic method for determining shrinkage temperature of collagen and leather. J. Am. Leather Chem. As., (1949). 44:830-841.

[16] Adewoye, R.O. and Bangaruswamy, S. Acacia nilotica (bagaruwa)-chromium combination tannage–a boon to the leather industry. J. Soc. Leath. Tech. Ch., (2000), 73:141-143.

[17] Society of Leather Technologists and Chemists, (SLTC). Official Methods of Analysis. 3rd ed. SLTC. Redbourn, UK, (1996). 250p.

[18] Falcão, L., Araújo, M.E.M. Tannins characterization in historic leathers by complementary analytical techniques ATR-FTIR, UV–vis and chemical tests. J. Cult. Herit. 2013, 14: 499–508.

[19] Venter, P.B., Sisa, M., van der Merwe, M.J., Bonnet, S.L., van der Westhuizen, J.H. Analysis of commercial proanthocyanins. Part 1: the chemical composition of quebracho (Schinopsis lorentzii and Schinopsis balansae) heartwood extract. Phytochemistry, 2012, 73:95–105.

[20] Falcão, L., Araújo, M.E.M. Application of ATR? FTIR spectroscopy to the analysis of tannins in historic leathers: the case study of the upholstery from the 19th century Portuguese Royal Train. Vib. Spectrosc. 2014, 74:98–103.

[21] Ricci, A., Olejar, K.J., Parpinello, G.P., Kilmartin, P.A., Versari, A. Application of fourier transform infrared (FTIR) spectroscopy in the characterization of tannins. Appl. Spectrosc. Rev. 2015,50: 407–442.

[22] Kasim, A., Novia, D., Mutiar, S., & Pinem, J. Karakterisasi kulit kambing pada persiapan penyamak dengan gambir dan sifat kulit tersamak yang dihasilkan. Majalah Kulit, Karet dan Plastik. 2013, Vol. 29. No. 1.

[23] Hassan, E. A., & Ibrahim, M. T. Ebtesam A. Hassan 1. Mohamed T. Ibrahim 1 and Sally K. A. 2. Journal of Agricultural and Veterinary Sciences, 2014, 15:(1) 87–94.

[24] Heidemann, E. Practical and theoretical aspects of tanning. In: Fundamentals of Leather manufacture, Eduard Roether K.G, Darmstadt, Germany, 1993, p269-294.