IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 9, Issue 4 Ver. I (Apr. 2016), PP 13-17
www.iosrjournals.org

Quality Evaluation of Leathers Produced By Selected Vegetable Tanning Materials from Laikipia County, Kenya

Alex Kuria[1*], Jackson Ombui[1], Arthur Onyuka[2],Alvin Sasia[2], Cheruiyot Kipyegon[3], Pennina Kaimenyi[3], Antony Ngugi[1]

[1]Department of Public Health, Pharmacology and Toxicology, University of Nairobi. P.O Box.29053-00625 Nairobi, Kenya
[2]Kenya Industrial Research and Development Institute. P.O Box 30650-00100 Nairobi, Kenya
[3]Department of Animal Health, Jomo Kenyatta University of Agriculture and Technology. P.O Box 62000-00200, Nairobi, Kenya

Abstract: *Due to high cost and unavailability of commercial mimosa in some parts of Kenya, there is a continued research on discovering cheap and locally available tanning agents for use in leather production. The quality of leathers produced using various vegetable tanning materials from plants locally growing in Laikipia County was evaluated and compared with standard mimosa produced leathers. The leathers were produced using vegetable tanning materials from Acacia nilotica, Acacia xanthophloea and Hagenia abyssinica plants and standard mimosa. The physical properties of leathers were determined using standard IUP methods which include: tearing strength, tensile strength, flexing endurance, shrinkage temperature, grain crack and grain burst tests. The quality of leathers tanned with these vegetable tanning materials were comparable to those tanned with commercial mimosa and all of them had more than the minimum set standards such as tearing strength* $>$*20 N, tensile strength*$>$ *12 N/mm*^{2}*, flexing endurance at 100,000 flexes, shrinkage temperature* $>$ *75*^oC*, grain crack* $>$ 6.5*mm and grain burst test*$>$ *7.0 mm.In conclusion, the vegetable tanning materials from Laikipia County can be used to replace commercial mimosa in a tanning process.*

Keywords: *Tanning, Flexes, Shrinkage, Tearing, Tensile*

I. Introduction

Tanning is a process of converting the hides and skins into leather [1]. During the tanning processes, materials which are able to crosslink with reactive group of collagen are used and may be organic or inorganic[2]. In 18thcentury before the introduction of chrome tanning method, the options available to the tanners were limited to vegetable tanning, aluminium tawing, oil tanning and smoke tanning methods[3]. Chrome is the most used tanning agent but due to stringent environmental regulation there is a continuous research on alternative tanning agents that are eco-friendly and cheap [4]. Vegetable tannins are considered less polluting compared to chromium and the oldest known leather tanning agent.

Vegetable tanning involve treating the hides and skins with leaves and barks containing tannins[5]. Tannins are water soluble polyphenolic compounds having a molecular weight of 500-20,000 and ability to precipitate proteins and alkaloids[6]. There are two types of tannins based on their structure and properties. Both condensed and hydrolysable tannins have ability to crosslink with collagen to form a non-putrescible and hydrothermal stable product called leather[7]. Although the quality of leather is affected by pre-tanning and post-tanning processes, the type and sources of vegetable tanning materials have an impact on the quality of leather. The type of tanning materials used in leather production affects the physical characteristics of the leather which are produced from the same origin[2].Vegetable tanned leathers offers benefits of high tensile and tearing strength , elongation, breathability and insulating properties, capacity to absorbs and transmit moisture, lasting molding ability and flexing endurance[8]. Skins and hides tanned with vegetable tannins from different sources of vegetable tanning materials gives leathers with different physical properties. The physical properties of final leather determine its uses in preparation of the final product. All the vegetable tanned leathers for use in making leather products must meet the minimum recommended standard in order to make satisfactory products of good quality.

The leather industry in Kenya produces four million pairs of shoes each year and employs over 16,000 people. Many of the tanners are not able to buy commercial vegetable tanning material (mimosa) and therefore they are utilizing locally available tanning materials in leather production, although their quality is not known. To ensure consistent production of high quality leather products that can compete effectively with cheap synthetic products, quality leathers must be produced. Therefore, physical testing offers a rapid means of assessing the quality of leather based on its physical performance.

II. Material And Methods

2.1 Preparation of vegetable tanning materials

The barks from *Acacia nilotica, Acacia xanthophloea, and Hagenia abyssinica* selected from Laikipia County, were sundried and ground into powder using a laboratory star mill. Particles that passed through a 1.4 mm sieve were used in the tanning process.

2.2 Tanning process

In this study eight dry salted skins from mature sheep were used. All the pre-tanning, tanning and post-tanning processes were the same and include: Dirt soak with 200% water at 20°C for 20 minute and main soak with 200% water four hours. Unharing and liming was done with 150% water at 20°C, 1.5% Sodium sulphide, 1% lime and the drum run for one hour. After one hour, 50% water at 20°C, 1% sodium sulphide and 2% lime were added and the drums run for eight hours. The tanning drum was drained and limed pelt washed with clean water. The pelts were then fleshed before deliming. During the deliming process, 150% water at 20°C, 2% ammonium sulphate and 1% sodium metabisulphite were used and the drum run for one hour. The delimed pelts were then bated with 1% bate powder in a 100% water at 35°C for one hour. Tanning was done with 150% water and 8% vegetable tanning materials added in two steps. The drum was run until the tanning liquors was exhausted and the penetration checked through a cut on the cross-section of the skins. Formic acid (1%) was then added and the drum runs for one hour. The tanned skins were washed and left overnight for ageing. In the next morning fatliquoring was done with 100% warm water, 7% oil and the drum run for two hours. It was then fixed with 1% formic acid for one hour, then drained, washed and horsed up overnight. They were then dried using toggle drying method. Commercial vegetable tanning material (Mimosa) was also used for comparison purposes.

2.3 Comparison of Physical properties of vegetables tanned leathers

The physical properties of leathers tanned with different vegetable tannins from Laikipia County were compared with leathers tanned with commercial mimosa. The physical properties compared include shrinkage temperature, tearing strength, tensile strength; grain burst test, flex endurance and grain crack.

2.3.1Tensile strength

The tensile strength was measured using Instron 1026 according to the official method (IUP/6) [9]. The samples were cut parallel and perpendicular to the backbone using a dumbbell shaped press knife. Each sample was measured in triplicate. The jaw of the tensile machine (Instron 1026) was set 50 mm apart, and sample clamped in the jaws, so that the edges of the jaws lie along the mid line. The machine was run until the specimen broke and the highest load reached was taken as the breaking load.

2.3.2 Shrinkage temperature determination

The shrinkage temperature of the tanned skins was measured using SATRA STD 114 test apparatus according to the official method (IUP/16) [10].Strips of leather 50 mm × 2mm were cut from the vegetable tanned leather assessed. The specimens were cut along and across the backbone. Holes were punched at the ends of the leather to allow the specimen to be held vertically in the test chamber filled with water and a small weight was attached to the lower end. The position of the lower end was indicated by an adjustable marker outside the tube to help judge when the shrinkage occurred. The apparatus was then closed and water heated at approximately 4°C by applying the external heat source to the boiler components. The temperature at which the leather started to shrink was taken as the shrinkage temperature.

2.3.3 Measurement of tear strength

The tearing strength was measured using Instron 1026 according to the official method (IUP/8) [11].This method is intended for use with any types of leather. The specimens were cut 50 mm long and 25 mm wide by use of a press knife which cuts out the specimen and slot in one operation parallel and perpendicular at each position. Instron 1026 having a uniform speed and separation of the jaws of 100 mm per minute was used. The machine was run until the specimen was torn apart and the highest load reached at the point of tearing recorded as the tearing load.

2.3.4 Ball burst test

The ball burst test was measured using a lastometer according to the official method (IUP/9) [12]. A disc shaped specimen of the leather was firmly held with the grain side up between the clamping rings, with the spherical tip of the steel rod just touching the flesh surface. The specimen was moved downward against the rod, distending the grain of the leather immediately above the rod, while the surface was watched for incipient cracking and bursting. The point at which the grain side of the leather cracked and bursted was observed. Force and distension values were recorded.

2.3.5 Flexing endurance

The flex endurance test was measured using a bally flexometer according to the official method (IUP/20) [13]. Leather specimen of dimension 70× 45 mm was folded and fixed to the jaws of the instrument in such a manner that the grain side remained outside with fold on the specimen. The motor was switched on having one clamp fixed and the other moved backward and forward causing folds in the specimen to run along it. The leather samples were flexed up to 100,000 cycles in a folded condition and it was observed periodically for any signs of crack on the grain surface of the leather.

2.4 Data analysis

The results obtained were analyzed using SPSS statistical packages version 21. ANOVA was used to test the level of significant for the physical properties of the vegetable tanned leathers. The P-value was used to indicate the level of significant between the means of the physical properties tested.

III. Result and Discussion

Table 1: Physical properties of leathers

Physical properties		Mimosa	*Acacia nilotica*	Acacia *xanthophloea*	*Hagenia abyssinica*	Minimum recommended value	p-values from ANOVA
Ball burst extension (mm)	Grain crack	8.21±**0**.26	7.66±**0**.23	7.98±1.25	8.97±**0**.23	6.50	0.16
	Grain burst	8.67±**0**.36	8.42±0.40	8.81±**0**.55	9.35 ±**0**.34	7.00	0.07
Shrinkage temperature (°C)		83±0.50	82.5±0.50	85±0.50	80±	75	0.001
Flexing endurance		No damage @ 100000	No damage @ 100000	No damage @ 100000	No damage @ 100000	No damage @ 100000 flexes	
Tensile strength (N/mm^2)		28.80±7.29	29.22±6.55	20.36±2.95	27.91±5.37	>12	0.07
Tearing strength (N)		34.22±11.08	42.67±7.09	34.92±4.22	31.25±3.94	>20	0.07

Physical properties of leathers tanned with all different vegetable tanning materials were analyzed and compared. The results revealed a significant difference (p= 0.01) in shrinkage temperature with *Acacia xanthophloea* having the highest shrinkage temperature of 85°C while the leathers tanned with commercial mimosa had (83°C), *Acacia nilotica* (82.5°C) and *Hagenia abyssinica* 80°C. Shrinkage temperature is one of the most important parameter in characterizing the thermal stability of leather. It is the temperature at which the leather sample starts to shrinks in water or over a heating media [14]. It provides information about the degree of tanning becausebetter crosslinking reaction between collagen fibres and tannins increases the shrinkage temperature [15]..*Acacia xanthophloea* is known to have a higher tanning strength (tannins/ soluble non-tannins ratio) of 3.3 and this might also be the reason for its highest shrinkage temperature. Research by Covington showed that leathers tanned with condensed tannins have a shrinkage temperature of more than 80^0C. He concluded that an observed shrinkage temperature of 80^0C is a strong indication that the condensed tannins have been used in a tanning process [16]. All the four vegetable tanning materials had an acceptable shrinkage temperature range of 75-85°C.

A comparison of the physical properties indicated no significant difference in tensile strength (p> 0.05). Leathers tanned with *Acacia xanthophloea* had the lowest tensile strength of 20 N/mm^2 while *Hagenia abyssinica*, commercial mimosa and *Acacia nilotica* had a tensile strength of 27.91 N/mm^2, 28.8 N/mm^2 and 29.22 N/mm^2 respectively. Tensile strength of leather is the greatest longitudinal stress leather can bear without tearing apart. The tensile strength of leather was determined by fibrous structures that constitute the collagen network structure and the modification of structure by tanning agents. Good overall tensile strength value of leather is known to vary depending on the types of the tannins applied to them and the application levels [17]. Since the amounts of tannins applied were equal in all vegetable tanned leathers, the difference may be due to the structure of the tanning agents. The tensile strength of the leathers tanned by all the three vegetable materials in this study was way above the expected minimum of $12N/mm^2$. .These was comparable to the tensile strength of leathers tanned with commercial mimosa. A study done in Ethiopia on the leather quality of indigenous and cross breed sheep reported an average tensile strength of 24.36 N/mm^2 which was comparable to the findings of this study [18]. Analysis on the tearing strength, showed no significant difference in all vegetable tanned leathers (p= 0.07). This study found the tearing strength of all the vegetable tanned leathers studied to be higher than the minimum expected value of 20 N [19].This is comparable to a study by Ashebre , which found the tearing strength of sheep skins leathers to be 28 N [20]. The type of tanning materials and the beamhouse processes are some of the factors known to affect the tearing strength of leather [21].

The ball burst test is another physical property for testing quality of leathers. It is intended to indicate the grain resistance to cracking during top lasting of the shoe uppers. All the leathers tested had more than 6.5 mm and 7.0 mm the minimum recommended value for grain crack and grain burst tests respectively. Various studies have found different value for grain crack and grain burst tests for sheep skins tanned leathers. For example, grain crack of 6.74 mm and a grain burst test of 7.72 mm [22], grain crack of 9.9 mm and grain burst of 10 mm [18], grain crack of 10 mm and grain burst of 10 mm [20]. The breed of sheep, pre-tanning, tanning and post-tanning processes are known to affect the grain crack and grain burst test which vary from different tanners [23].

Flexing test is normally done on the leathers intended for making shoes or products that flex several times [24]. Flexing test was applied to the respective leathers and there was no damage at 100,000 flexes to any of the leathers. All the leathers passed the flexing test. A study on vegetable tanned leathers finished with polyvinyl alcohol failed the flexing test at 20,000 flexes while the leathers finished with nitrocellulose did not show any effect at 20,000 flexes [25]. Heavy re-tanning and type of finishing affect the flexing endurance of the leather.

IV. Conclusion

Although there was a significant difference in some physical properties of leathers produced by various vegetable tanning materials, all the physical properties tested were superior to the minimum set standards: tearing strength >20 N, tensile strength> 12 N/mm2, flexing endurance- no breaking at 100,000 flexes, grain crack >6.5mm grain burst > 7 mm and shrinkage temperature >75^{o}C. Therefore these vegetable tanning materials from Laikipia County can be used to replace commercial mimosa in a tanning process.

Acknowledgements

The authors acknowledge University of Nairobi and Kenya Industrial Research and Development Institute (KIRDI) for funding and technical support.

References

[1] Mehmet, M. M., Arife, A. Z., Marian, C., Stelian, S. M., Viorica, D., luminita, A., Gurbuz, G.,Behzat, O. B and Bahri, B (2012). Eco-leather: Chromium-free Leather Production Using Titanium, Oligomeric Melamine- Formaldehyde Resin, and Resorcinol Tanning Agents and the Properties of the Resulting Leathers. Ekoloji 21, 82, 17-25 doi: 10.5053/ekoloji.2011.823

[2] Ork N, Huja O, Mehemet H, Ziymet O (2014). Comparative determination of physical and fastness properties of garment leathers tanned with various tanning materials for the leather skirt production.Tekstil ve Konfeksiyon *24 (4)* 413-418

[3] Ann, L. (2002).Conservation Experience in Working with Chrome Tanned Leather. The Book and Paper Group Annual 21: 99-103

[4] Mahdi, H., Palmina, K., Gurshi, A and Covington, D (2009). Potential of vegetable tanning materials and basic aluminum sulphate in Sudanese leather industry. Journal of Engineering Science and Technology,4(1) 20 - 31

[5] Koloka, O and Moreki, J. C. (2011) Tanning hides and skins using vegetable tanning agents in Hukuntsi sub-district, Botswana. Journal of Agricultural Technology.*7(4):* 915-922

[6] Frutos, P., Hervás, G., Giráldez, J. and Mantecón, A. (2004). Review. Tannins and ruminant nutrition, *Spanish Journal of Agricultural Research* 2 (2), 191-202

[7] Bunglavan, S.J and Duttan, N (2013). Use of tannins and organic protectants of proteins in digestion of ruminants. Journal of livestock science, 4:67-77

[8] Jones C, (2000). The manufacture of vegetable tanned light leathers part 1, word leather, pp.80-83

[9] International Union of Leather Technologist and Chemist societies (2001) IUP/6: "Measurements of tensile strength and percentage elongation". Society of Leather Technologist and Chemists

[10] International Union of Leather Technologist and Chemist societies (2001) IUP/16: "Measurements of shrinkage temperature up to 100^{o}C". Society of Leather Technologist and Chemists.

[11] International Union of Leather Technologist and Chemist societies (2001) IUP/8: "Measurements of tearing strength". Society of Leather Technologist and Chemists

[12] International Union of Leather Technologist and Chemist societies (2001) IUP/9: "Measurements of distention and strength of grain by the ball burst test". Society of Leather Technologist and Chemists.

[13] International Union of Leather Technologist and Chemist societies (2001) IUP/20: "Measurements of flex resistance by flexometer method". Society of Leather Technologist and Chemists.

[14] Ali S.D, Haroun H.E, Musa A.E. (2013). Haraz bark powder extracts for manufacture of Nappa upper leather as alternatives retanning agents. Journal of forest production and industries, *2(5)*25-29,

[15] Heideman, E. (1993). Fundamental of leather manufacture. Eduard Routher KG. P.221.ISBN 3-7929-0206-0

[16] Covington, A. (2011). Tanning chemistry, the science of leather. Published by the Rayal Society of chemists, Cambridge CB4, UK Page 881-314. ISBW: 978-1-84973-434-9

[17] John, G. (1997). Possible defects in leather production. Druk partners Rubeimann, Hemsbach page 4-10

[18] Teklebrham, T., Mengistu U. and Yoseph, M (2012). Skin/ Leather quality of indigenous crossbreed F1 sheep. Livestock research for Rural Development, 24:4-8

[19] Anonymous (2007). Pocket book for the leather technology. Basf publisher. Pp. 70-80

[20] Ashbre, M (2014). Performances of upper leathers of local foot wear products and the determinants. International Journal of Advancements in Research and Technology, 3: ISSN 2778-7763

[21] Bassaran, B., Iscam, M., Bitlisii, B. and Asian, A. (2006). Heavy metal content of various finished leathers. Journal of the Society of Leather Technology and Chemist 90: 229-234

[22] Lawal, A. S and Odums (2015). Tanning of different animal skins / hides and study of their properties for textile applications. British Journal of Applied Science and Technology, 6: 588-594
[23] Selehl. M, Lavvat, A and Farahvash T (2013). Skin quality and physical properties of leather based on sex, age and body parts of goat reared on sub-humid hill country. Iranian Journal of Applied Animal Science, 3: 853-857
[24] UNIDO, (1994). Acceptable quality standards in the leather and foot wear industries. Page 15
[25] Gumel, S.M., Dambatta, B.B. (2013). Application and evaluation of the performance of polyvinyl alcohol and it's bled with nitrocellulose in leather top coating. International Journal of Chemical Engineering and Applications, 4:4-8