Salt Free Preservation of Raw Goat Skin Using Swietenia Mahogany (Seed) Extract

by
Md. Abdur Razzaq,* Murshid Jaman Chowdhury and Md. Tushar Uddin
Leather Research Institute (LRI)
Bangladesh Council of Scientific and Industrial Research (BCSIR)
Nayarhat, Savar, Dhaka-1350, Bangladesh

Abstract

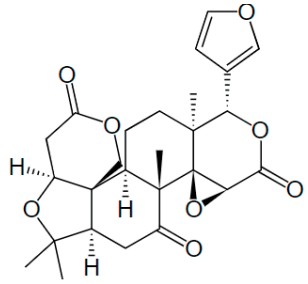
Curing of hides and skins using sodium salt is a well-established and economical preservation technique worldwide. But it contributes to generating a large amount of total dissolved solids (TDS) and increasing the salinity of water during leather processing which is a threat to the environment. The current research is an attempt to preserve goat skin using mahogany (*Swietenia mahogany*) seed's extract. In real practice different percentages of mahogany seed extract were applied on raw goat skin and 3% (by weight of skin) of it showed best result. To evaluate the preservation efficiency, related parameters of preservation viz. odor, hair slip, shrinkage temperature, moisture content, bacterial count etc. were monitored regularly for 30 days. The obtained results were compared with conventional salt curing process. The experimental trial showed efficiency in lessening TDS value and chloride content. The preserved goat skins of both trials were treated following conventional leather processing techniques and physical properties were studied. The discussed preservation method exhibited comparable result in every index.

Introduction

Curing is a short-term preservation technique to store and transport raw hides and skins safely for forthcoming processing operations. It is a reversible process with the objective to restore the hides and skins to the original raw condition.[1] It is essential to subject raw hides and skins to any preservation technique within 5–6 hrs after the death of the animal or flaying the skin to prevent degradation.[2] Bacteria may attack the flesh surface of hides and skins within 8–12 hours of flaying and may also form serious grain peeling and voids within 15–24 hrs.[3]

Almost 40-50% common salt (based on the green weight of skin) is applied in the curing operation which dehydrates the skin leading to hindering bacterial putrefaction.[4] The salt is discharged in the environment contributing in 70% of Total Dissolved Solids (TDS) generation during leather manufacturing.[5] Researchers around the world are in continuous effort to determine a convenient and environmentally friendly curing technique. Mentionable alternative techniques are sun drying, controlled drying, cooling and chilling, vacuum, dry ice, aryl alcohols, sodium silico-fluoride, and sulphites.[6-13] Notable chemical preservation methods are potassium chloride, boric acid, soda ash, benzalkonium chloride, antibiotics, bacteriocin, formaldehyde, silica gel, Vantocil IB, chlorites and hypochlorites, sulphates, and bisulphite-acetic acid.[14-24] None of these are accepted and practiced commercially due to potential hazards or economical non-viability.

Swietenia mahogany, a locally available, large, deciduous and economically beneficial timber tree, is commonly known as "Mahogany tree".[25] It is under the family Meliaceae and the super family swietenioideae. It is vastly available in Bangladesh as well as India, China, Africa and different parts of North and South American countries.[26] Various parts of the Mahogany viz. root, bark, seed etc. are used for the treatment of hypertension, diabetes, malaria, amoebiasis, coughs, chest pain and tuberculosis, and as an abortifacient, antiseptic, astringent, depurative, and tonic.[27] S. Mahogany seed extract can now be applied in the agricultural field to control pesticides.[28-30] Mahogany seed extract holds fatty acids like linoleic, oleic, stearic and palmitic which show activity against microorganisms.[31,32] The mahogany (Meliaceae) family is characterized by synthesis of modified triterpenes known as limonoids having a 4,4,8-trimethyl-17-furanyl steroid skeleton.



Triterpenoids present in mahogany family are an important group of constitutive defense substances against microbes.[33] Many papers have reported about the antimicrobial properties of Swietenia Mahogany seed extract.[32-38] Fresh hides and skins are attacked by bacteria like Bacillus subtilis, Escherichia coli, Micrococcus spp., Proteus vulgaris and Pseudomonas aeruginosa.[39] Sweitenia Mahogani seed extract shows antibacterial property against Bacillus Subtilis, Escherichia Coli, S. Aurous, S. typhimurium, P. aeruginosa etc. with strong inhibition zones.[26, 32] That is why it was estimated that it might be effective for the preservation of raw skin.

*Corresponding author email: arazzaq-lri@bcsir.gov.bd
Manuscript received July 23, 2021, accepted for publication September 5, 2021.

Material and Method

Collection of Skin

Freshly flayed goat skins were purchased from a local hides and skin trader in Dhamrai, Dhaka, Bangladesh. Then the skins were washed with water to remove dirt, filth, blood etc. impurities. Finally, the skins were hanged for few minutes to exude water.

Chemicals

Chemicals and auxiliaries used in the control preservation, beamhouse and post tanning operations were of commercial grade. For biochemical and pollution index determination, analytical grade chemicals were used.

Collection and Extraction of Mahogany seed

Seeds were collected from the garden of Leather Research Institute; shells were peeled and sun dried. The collected seeds were cleaned by washing with running tap water followed by drying in the sun. Then seeds were crushed into fine powder using an analytical grinder. The fine powder was extracted in a Soxhlet apparatus with methanol for 8 hours. Then the solvent was evaporated by employing a rotary evaporator at 40°C. The oily extract was then stored in a refrigerator at 4°C.

FTIR Analysis

To find out the functional group of the mahogany seed extract a Perkin-Elmer FTIR spectrophotometer with UATR was used. The absorbance, FT-IR Spectra of the samples was recorded. The FT-IR was first calibrated for background scanning signal against a control sample of pure KBr.

Application of Extract for Curing

To find out the optimum percentage of extract required for the preservation an initial trial was conducted. Two freshly flayed goat skins were made half to get four samples. Variable percentages (w/w) of extract were applied on the raw goat skin to find out the optimum percentage. The physical changes e.g., odor, hair slip, and moisture content were assessed periodically (fresh, 1st, 4th, 7th, 15th, and 30th days of preservation) and the optimum percentage was found to be 3% (w/w). During our final trial, one piece goat skin was made half to get two samples. One half was for the control trial and 50% (w/w) common salt was applied. Then the skin was kept for preservation. For the experimental trial 3% (w/w) extract was pasted on the flesh side of the other half and kept for preservation without folding. Both samples were kept in the same environmental conditions and temperature. The preservation parameters viz. moisture content (%), hair slip, odor, bacterial count, shrinkage temperature and extractable nitrogen were assessed periodically (raw, 1st, 4th, 7th, 15th and 30th days of preservation.

Moisture Content

Small pieces (1-2g) of skin samples were cut and the moisture content was determined using a High-performance Moisture Analyzer model WBA-110M.

Nitrogen Content

To determine nitrogen content a known weight (5g) from the preserved samples was taken and treated with ten times (w/v) its weight of distilled water into a conical flask. The flask was shaken at 200 rpm for 30 minutes by keeping it on a shaker. Then the liquor was filtered through a filter paper and transferred to the digestion unit of an automated Kjeldahl chamber. The nitrogen content was determined following the method described in the literature.[40]

Bacterial Count

During different stages of preservation skin samples of known weight (5g) were cut and followed the procedure of nitrogen content determination up to filtration. 1 ml of the filtrate was taken and diluted to 10 ml with sterile water. The solution was shaken well to get identical suspension of bacteria and 0.1 ml was taken in a sterile petri plate. Then, molten nutrient agar was added and shaken carefully for identical distribution of bacteria. Finally, petri plates were kept for 48 hours at 37°C in an incubator.[41]The bacterial population was counted using a bacterial colony counter.

Hydrothermal Property

Shrinkage temperature indicates the hydrothermal property of hides and skins. It was determined by using SATRA STD 114 shrinkage temperature tester.[42] Test samples (20×3 mm) were cut and hooked in the holder of the shrinkage temperature apparatus which was then immersed in a bath containing a glycerin/water solution in the ratio of 70:30. The temperature was gradually increased with the rate of the heat increase. The shrinkage starting temperature was noted as the shrinkage temperature of that particular skin.

Leather Making

The skins that were preserved for 30 days were processed up to crust leather by following conventional leather processing method.

Pollution Load Analysis

The wastewater in the soaking operation generated from the control as well as experimental trial was collected and analyzed for biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS) and chloride content. The standard APHA methods were followed in analysis and all the experiments were triplicated.[43]

Physical Properties Analysis

The prepared crust leathers were left about 1 month for aging. Physical strength of the leathers was determined after conditioning at temperature 23 ± 2°C and relative humidity 65 ± 2% for 48 hours. Then the samples were taken from the specified sampling location.

The properties such as the tensile strength, elongation at break, tear strength, and bursting strength were assessed following SATRA TM 43, TM 162, and TM 24 respectively.

SEM Analysis

To evaluate the morphological characteristics of crust leathers from the preserved control and experimental goat skins samples from each were subjected to JEOL Field Emission Scanning Electron Microscope (JSM-7610F, Japan). The photographs of the grain surface were taken at an accelerating voltage 15.0 kV with magnification 40X. The fiber images (flesh side) were assessed by accelerating voltage 15.0 kV with magnification 1000X.

Results and Discussion

Organoleptic Properties

Organoleptic properties of the preserved skins were assessed periodically from the zero (0) day to the 30th day of preservation.

Table I

Organoleptic Properties of goat skin preserved with mahogany seed extract

Day	Hair slip	Odor	Physical feel
0	No	No	Soft
1	No	No	Soft
3	No	No	Medium hard
6	No	No	Medium hard
12	No	No	Medium hard
18	No	No	Medium hard
24	No	No	Medium hard
30	No	No	Medium hard

Hair slip, odor and physical feel are common organoleptic properties of skin preservation. Those properties are illustrated in the Table I. There was no hair slip during the whole preservation period. The skin gradually became hard and reached a medium hardness at the 3rd day of preservation. No bad odor was generated. This indicates that neither significant bacterial growth nor putrefaction occurred.

FTIR Analysis

Based on the IR spectrum of mahogany seeds extract, it was seen that the sharp peak at 2923.08 cm-1 showed the presence of -CH and 2853.71 cm-1 with a range of -CH_2, and at 1377.88 cm-1 showed the presence of -CH_3 group. Absorption band at 1458.26 cm-1 is for N-O stretching and shows the presence of nitro compound. The peak at1181.15 cm-1 stands for C-O stretching and identifies tertiary alcohol. The spectrum at 1743.65 cm^{-1} shows the C=O stretching and proved the presence of ester which proves antimicrobial possibility of mahogany seed extract.[44]

Moisture Content

The moisture content is one of the important parameters to assess the effectiveness of a curing agent. The analysis of the moisture content of both trials is displayed in Table II covering the whole preservation of 30 days. Gradual decreases of moisture with the increase of preservation time have been depicted in Table II. The moisture content of control trial decreases gradually and ends at 35% after the preservation period. On the other hand, moisture content of experimental trial decreases to 40% within preservation period of a single day. The final moisture content of the experimental was found 19% after 30 days preservation. It indicates that the experimental trial dehydrates the sample more than the control trial. The greater reduction in moisture content might be due to that the skin's water gradually evaporates by atmospheric action since fatty acids of mahogany seed extract react a little with water.[45] In case of the control trial, hydrolysis reaction occurred and a mentionable amount of water prevails on the surface of skin.

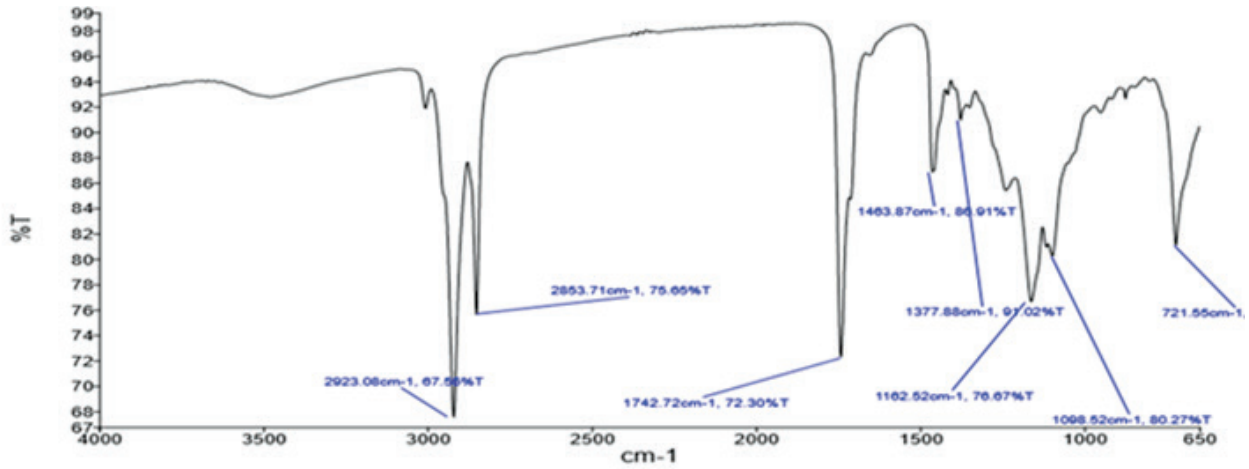


Figure 1. FTIR Spectrum of mahogany seed extract.

Table II

Moisture Content (%) of preserved skins

Day	Experimental (Mahogany seed extract based preservation, 3% of raw weight)	Control Trial (Common Salt preservation, 50% of raw weight)
0	66	66
1	40	58
4	34	55
7	30	49.4
15	20	44
30	19	35

Table III

Nitrogen Content (gm/kg of sample) of preserved skins

Day	Experimental (Salt Cured) (gm/kg)	Control trial (MSE Cured) (gm/kg)
0	1.18±0.04	1.18±0.02
1	0.3±0.03	0.6±0.02
4	0.1±0.02	0.5±0.03
7	0.05±0.01	0.1±0.03
15	0.28±0.03	0.24±0.02
30	0.37±0.02	0.28±0.01

Values are mean ± standard deviation of three determinations.

Nitrogen Content

Total extractable nitrogen for the skin preserved with experimental and control trial has been illustrated in Table III. Gradual decrease in total extractable nitrogen was found in control and experimental trial. The final result after the preservation period was 0.28 gm/kg and 0.37gm/kg for control and experimental trial respectively. This might be due to the antimicrobial activity of the preservatives, thus inhibiting putrefaction.

Bacterial Count

The bacterial count in the preserved skins is depicted in Table IV. In raw goat skin bacterial count was 3×10^3 CFU/g. The bacterial count of the experimental trial was 4×10^3 after day 1 whereas it was 2×10^8 in the control trial. The drastic reduction in bacterial count at the experimental trial might be due to reduced moisture and nitrogen content. The bacterial count of both trials showed steadiness during the 30 days preservation period. The bacterial counts of experimental and control trial were 1×10^4 and 6×10^8 respectively. The increase of bacteria in the experimental trial might be due to the increase of nitrogen content. Literature shows inhibition of mahogany seed extract against various microbes. Amongst various microbes the Bacillus Subtilis was inhibited strongly. [26, 32]

Shrinkage temperature

Hydrothermal stability (Shrinkage temperature) is another important indicator of stability of leather and is reported in Table V. The initial shrinkage temperature was 66°C. Although the shrinkage temperature of the experimental trial was found to slightly decrease after 1 day preservation period, it started to increase slowly. On the other hand, the control trial exhibited a gradual decrease and the final shrinkage temperature was 62°C whereas, the final shrinkage temperature of the experimental trial was 73°C. Literature shows the presence of tannins and phenolic compounds in swietenia mahagoni.[46] Thus, elevation in shrinkage temperature of experimental trial might be due to the tanning effect of the seed extract.

Pollution load Analysis

The pollution load status of the experiment has been depicted in Table VI. There is little change in the BOD and COD levels, but significant reduction in TDS and Chloride content in the experimental trial. Since there was no use of salt, chloride content is completely reduced. Besides, the value of total dissolved solid (TDS) was significantly reduced to 97%.

Table IV

Bacterial Count in the preserved skins

Day	Experimental (CFU/g)	Control (CFU/g)
0	3×10^3	3×10^3
1	4×10^3	2×10^8
4	5×10^3	6×10^9
7	2×10^4	5×10^9
15	3×10^4	3×10^7
30	1×10^4	6×10^8

Table V

Shrinkage Temperature (°C) of Preserved Skins

Day	Experimental (°C)	Control (°C)
0	66±1	66±1
1	64.2±1	65.5±2
4	68±1	63±1
7	66.5±2	62±1
15	68±2	61±2
30	73±1	62±1

Values are mean ± standard deviation of three determinations.

Table VI

Pollution Load Status of soaking liquor

Pollution Parameter	Experimental (mg/L)	Control (mg/L)
BOD	1012	1178
COD	2120	4166
TDS	525	18000
Cl	36	11768

Physical properties study

Physical strength evaluation of the crust upper leather of experimental in comparison with the control has been done. The crust leathers were assessed for softness, grain tightness, fullness, and smoothness. The tabulated physical properties in Table VII indicate that the physical strength values e.g., tensile strength, elongation at break, tear strength and grain crack of the experimental skin preserved with mahogany seed extract were comparable with corresponding control method. The elongation at break (%) and load at grain crack (kg) values fulfilled the required values.

Table VII

Physical properties of processed crust leather.

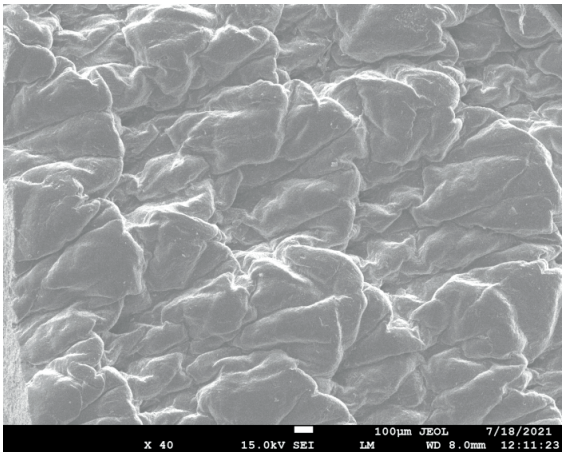
Parameter	Experimental	Control
Tensile strength	29.5±0.8 N/mm^2	30±0.7 N/mm^2
Elongation at break	52.5±0.5 N	46.5±0.6 N
Tear strength	69±0.8 N	89.5±0.8 N
Ball Burst Test	71.6±0.6 N	74.5±0.6 N

Values are mean ± standard deviation of three determinations.

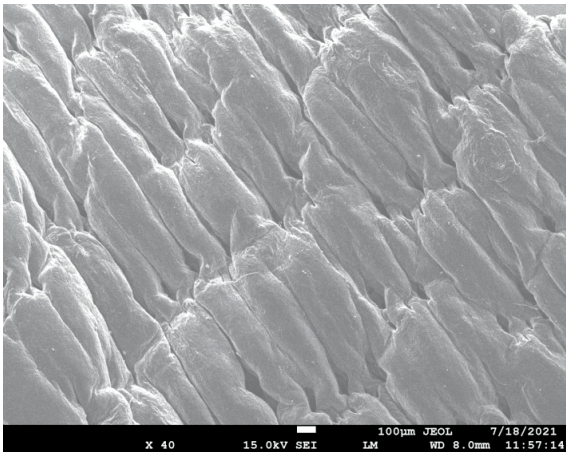
SEM Analysis

SEM photographs of the leather processed from the control trial and experimental trial have been illustrated. The Figure 2 shows the images of the grain side of experimental and control trials respectively. Both samples show slight flatness of the grain texture (grain side).

The Figure 3 shows the fiber pattern (flesh side) of both trials. It indicates that there are no significant change in the leather prepared from the experimental goat skin compared with the control. This proves that the texture and quality of the goat skin was almost the same using the new preservation method.

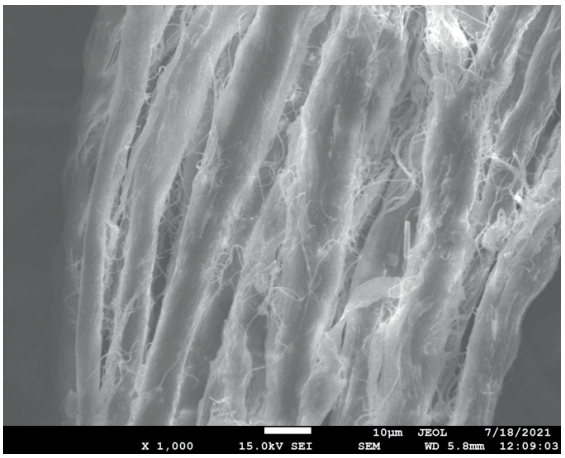


SEM image of grain pattern of experimental trial

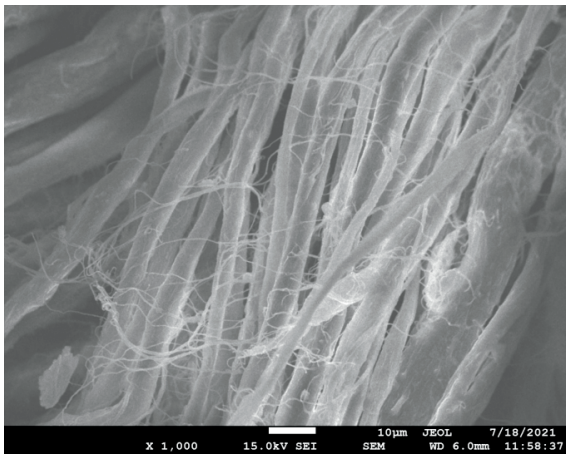


SEM image of grain pattern of control trial

Figure 2.



SEM image of fiber pattern (flesh side) of experimental trial



SEM image of fiber pattern (flesh side) of control trial

Figure 3.

Conclusion

Due to environmental compliance, researchers as well as factory owners are highly interested to find an alternative to salt curing. The mahogany seed extract can be an alternative way of animal skin curing. This is a salt-free curing technique which remarkably decreases the environmental pollution load in every index. In addition to that, the experimental curing technique can preserve skin for more than one month. Thus, it is expected to be one of the more viable curing techniques for preservation of skins in the leather industry.

Acknowledgement

Authors wish to thank the personnel who helped to conduct this research at the Leather Research Institute (LRI). Authors also convey special gratitude to the director of LRI and Chairman of Bangladesh Council of Scientific and Industrial Research (BCSIR) for aiding in every step of compliance and funding.

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