Application of a novel vegetable tannin in leather processing extracted from *Xylocarpus granatum* plant bark

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Abstract

Tanning is an essential process for the production of leather using mineral and vegetable tanning agents. Tanning stabilizes proteins of raw skin/hides and determines final qualities of the finished leather. Intense pressure on the chrome-containing solid and liquid waste of tannery effluent urges the leather industry to seek alternative tanning agents due to its environmental restrictions. This work was an attempt to apply novel vegetable tanning agents in leather processing extracted from *Xylocarpus granatum* bark and a comparison with conventional mimosa and quebracho tanning agents was studied . The shrinkage temperature (Ts) of 86.34±1.52˚C, and the physico-mechanical properties such as tensile strength >230 kg/cm^2, tear strength >30 kg/cm, grain cracking load >20 kg, and distention at grain crack >7 mm of leather tanned by *Xylocarpus granatum* bark extract was well equivalent to conventional vegetable-tanned leather and met the standard recommended value set by UNIDO. The fiber structure of experimental leather was more compact than that of conventional tanned leather which was examined by Field Emission Scanning Electron Microscope (FESEM). Therefore, *Xylocarpus granatum* bark extract tannin could be used as an alternative to mimosa or quebracho as a prospective vegetable tanning agent in leather processing.

Introduction

Environmental issues are now a prime concern globally for chrome tanning though the leather is widely renowned for its strength and quality. The exploration of alternate tanning chemicals are now indispensable to evade the excessive pressure of chrome containing solid and liquid wastes created from the tannery. Vegetable tanning is an alternative way of leather processing that has been developed to produce ecofriendly leather. It has been already regarded as a "green tanning" procedure that contributes significantly to the reduction of pollutants in the environment [1]. Mimosa, quebracho, sumac, tara, valonea, divi-divi, oak, and chestnut are the most often utilized chrome-free tannins nowadays [2]. The bark of *Xylocarpus granatum* has never been used as a new source of vegetable tanning material. *Xylocarpus granatum* (Family: Meliaceae) is locally known in Bangladesh as "Dhundul." Several studies have found that the bark of several mangrove plants contains 16-48 percent tannin [5].

In this study, a comparison was made between traditional mimosa and quebracho tannin with the developed tannin. The morphological examination of the tanned leather was reported using FESEM analysis. The experimental leather was tested for physico-mechanical parameters such as tensile strength, tear strength, grain cracking load, shrinkage temperature, and distention at grain cracks, and the results were compared to the suggested standard values for shoeupper leather.

Materials and Methods

Bark collection and tannin extraction

Sample collection → Drying → Grinding → Extraction → Characterization → Application

Analysis of total tannin content

1 ml extracted sample (1mg/ml) → Distilled water (7.5ml) and folin reagent (0.5 ml) → Sodium carbonate solution (1 ml) → Shaking → Left 30 minutes at room temperature → Measured absorbance at 725 nm

Application of extracted X. granatum bark tannin on leather processing

Conventional process

Pre-soaking → Soaking → Liming → Fleshing → Deliming → Bating → Pickling → Pretanning agent (Quebracho) → Pre-tanning → Samming → Shaving → Acid wash → Neutralization → Mimosa and Quebracho → Re-tanning → Fatliquoring → Crust leather

Experimental process

Pre-soaking → Soaking → Liming → Fleshing → Deliming → Bating → Pickling → Developed tannin → Pre-tanning → Samming → Shaving → Acid wash → Neutralization → Developed tannin → Re-tanning → Fatliquoring → Crust leather

Physico-mechanical and morphological test of tanned leather

- Shrinkage temperature
- Tensile strength
- Percentage of elongation
- Tear strength
- Grain cracking resistance
- Distension at grain crack
- Ball burst resistance
- Distension at ball burst
- Field emission scanning electron microscopic analysis

Results and Discussion

Table 1. Total tannin content of Mimosa, Quebracho and *Xylocarpus granatum*

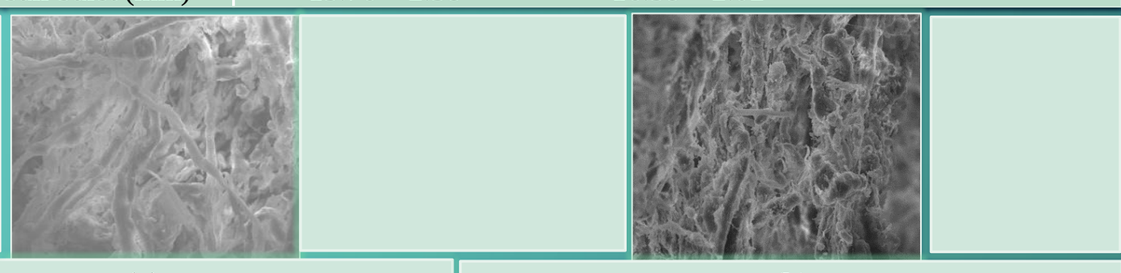
Samples	Total Tannin Content (mg of tannic acid equivalent/g of dry extract)
Mimosa	114.25 ± 1.74
Quebracho	129.96 ± 1.84
Xylocarpus granatum	121.24 ± 1.96

Table 2. Shrinkage Temperature (T_s) of leather tanned by developed and conventional tannin

Samples	Shrinkage Temperature °C (mean ± standard deviation)
Pickle Pelt	58.67 ± 1.15
Conventional wet tanned leather (Quebracho)	73.34 ± 1.15
Experimental wet-tanned leather (Extracted X. granatum tannin)	78.67 ± 1.15
Conventional retanned leather (Mimosa +Quebracho)	81.34 ± 0.57
Experimental re-tanned leather (Extracted X. granatum tannin)	86.34 ± 1.52

Table 3. Physico-mechanical properties of leather tanned by conventional and extracted tannin (mean± standard deviation)

Parameters	Conventional leather	Experimental leather	Standard values [4]
Tensile strength (kg/cm^2)	258.645 ± 16.43	297.49 ± 14.17	≥ 230
Elongation (%)	38.675 ± 3.57	42.545 ± 2.05	30 – 45
Tear strength (kg/cm)	37.205 ± 3.41	38.965 ± 4.62	≥ 30
Grain crack strength (kg)	29 ± 1.00	29.33 ± 3.05	≥ 20
Distension at grain crack (mm)	12.82 ± 1.08	14.50 ± 1.89	≥ 7
Strength at ball burst (kg)	42.33 ± 2.08	40.33 ± 2.07	-
Distension at ball burst (mm)	15.76 ± 2.38	16.58 ± 2.02	-



(a) **(b)**

Figure 1. FESEM images of leather tanned with (a) conventional vegetable tannin (using both mimosa and quebracho) and (b) developed vegetable tannin (X. granatum)

Conclusion

- **The tannin content of *Xylocarpus granatum* bark was found 121.24 mg (mg of tannic acid equivalent/gm of dry extract) comparatively higher than commercial mimosa**
- **Hydrothermal stability i.e. Shrinkage temperature of leather tanned with developed tannin higher than conventional tanned leather (mimosa and quebracho)**
- **Strength properties of experimental tanned leather exhibited higher than that of UNIDO standard value**
- **Fibers structure of tanned leather showed better compactness and good crosslinking in between collagen and tanning agent**

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