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Indigenous Alternatives to Vegetable Tanning Agents –

Experimental Validation and Case Study

1Muthukumaran, 2P, Renganath Rao, 3Ramesh, R Aravindhan

1Technical Assistant, Research Scholar, MS (By research), 2RSenior Scientist, 3Senior Principal Scientist

CSIR-Central Leather Research Institute and Department of Leather Technology, AC Tech, Anna University

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Abstract

India’s leather industry depends substantially on imported vegetable tannins such as mimosa, quebracho and chestnut extracts, resulting in high production costs and vulnerability to international supply fluctuations. Meanwhile, several Indian industries—including fruit-processing, juice and beverage units, nut-processing mills, areca and plantation-based industries—generate large quantities of polyphenol-rich by-products that remain underutilized. These materials, including, babul seedpod by-products, areca husk fractions, cashew husk extracts and other plant-derived industrial sidestreams, are rich in natural tannins and bioactive compounds with strong collagen-binding characteristics.

This study investigates the conversion of such industrial by-products into indigenous vegetable tanning agents to strengthen domestic raw-material security. Extracts obtained through standardized hotwater extraction and filtration showed high phenolic content and demonstrated excellent tanning behaviour. When applied to pelt, these extracts imparted desirable properties such as improved firmness, fullness, and lightfastness, comparable to commercial vegetable tannins. Their application in combination tanning systems also yielded stable grain patterns and high-quality crust leather, confirming their suitability for industrial leather processing.

Correspondence Email address: muthukumar.clri@csir.res.in

The significance of this work lies in establishing a resource-recovery model that transforms underutilized by-products from other industries into high-value tanning materials. This supports national import substitution, reduces cost dependency, and promotes cross-sector collaboration between the leather sector and allied processing industries. The approach enhances sustainability by reducing waste burden while generating new revenue streams from materials traditionally treated as low-value residues.

Overall, this study highlights the potential of India’s diverse industrial by-products to serve as reliable, cost-effective, and sustainable alternatives to imported vegetable tanning agents.

Keywords :Industrial by-products, vegetable tanning, phenolic extracts, import substitution, circular economy, sustainability.

1. Introduction

The Indian leather industry plays a significant role in the national economy by contributing substantially to employment generation, export earnings, and overall industrial growth [1]. Vegetable tanning represents an important segment of the leather sector, particularly for the manufacture of sole leather, saddlery, upholstery, and other eco-friendly leather products due to its renewability and biodegradability [2].

However, the Indian leather industry depends heavily on imported vegetable tanning materials such as mimosa,

quebracho, and chestnut extracts to meet its processing requirements [3,4]. This reliance on imported tanning extracts results in increased production costs and exposes the sector to international supply disruptions and price volatility [4]. At the same time, India generates large quantities of agro-industrial and plantation-based byproducts from fruit-processing units, juice and beverage industries, nut-processing mills, and areca and cashew plantations [5]. Many of these materials, including babul seed-pod residues, areca husk fractions, cashew husk byproducts, and similar plant-derived side-streams, remain underutilized or are disposed of as waste, leading to environmental concerns [5,6].

Several studies have shown that these agro-industrial byproducts are rich in polyphenols and natural tannins, which possess strong collagen-binding ability and are essential for effective leather tanning [2,6]. The utilization of such indigenous tannin-rich resources offers a sustainable alternative to imported vegetable tanning agents while simultaneously promoting waste valorisation, environmental protection, and reduction in processing costs [7].In this context, the present project focuses on evaluating the potential of selected Indian agro-industrial by-products as alternative vegetable tanning agents for leather processing, with the aim of developing sustainable, eco-friendly, and economically viable tanning solutions for the Indian leather industry [8].

2. Objectives of the Study

- To identify tannin-rich agro-industrial by-products available in India
- To extract and characterize vegetable tannins from selected plant-based wastes
- To study the tanning performance of these extracts on hides/skins
- To compare the properties of leather tanned using indigenous extracts with conventional vegetable tannins
- To assess the economic and environmental benefits of using indigenous tannin sources

3. Scope of the Study

The scope of this study is limited to:

- Selected agro-industrial by-products, such as areca husk fractions and cashew husk residues
- Extraction and tanning application studies
- Evaluation of physical and organoleptic properties of vegetable-tanned leather

4. Methodology

4.1 Collection of Raw Materials

Tannin-rich by-products, such as areca husk fractions and cashew husk wastes, were collected from agro-processing and plantation-based industries.

4.2 Preparation of Raw Materials

The collected materials were:

- Cleaned to remove impurities
- Sun-dried or oven-dried
- Pulverized into fine powder for efficient extraction

4.3 Extraction of Vegetable Tannins

Tannins were extracted using hot water extraction methods under controlled temperature and pH conditions. The extracts were filtered and concentrated for further analysis.

4.4 Characterization of Extracts

The extracted tannins were evaluated for various physical and chemical parameters, including color, pH of a 10% solution, total solids, tannin content, non-tannin content, volatile matter, total soluble matter, and total ash, using standard test methods as prescribed in IS 5466.

4.5 Application in Leather Tanning

The extracts were applied to pickled or pre-tanned hides/ skins following standard vegetable tanning procedures.

4.6 Evaluation of Tanned Leather

The tanned leathers were tested for

 Cross-sectional through and through penetration of the tanning agent

 Shrinkage temperature

 Fullness and softness

 Colour and grain characteristics

 Results were compared with leather tanned using imported vegetable tannins.

5. Results and Discussion

The tannin extracts obtained from Indian agro-industrial by-products showed high polyphenolic content and effective collagen-binding capacity. Cashew and areca husk extracts exhibited tanning characteristics comparable to conventional vegetable tanning agents. Leathers tanned with these extracts showed satisfactory shrinkage temperature, good fullness, and acceptable mechanical strength. The tanning process resulted in proper penetration and fixation of tannins within the collagen matrix. Minor variations in colour and texture were observed, which can be improved through process optimization or blending with conventional tannins.

The results indicate that indigenous agro-waste-based tannins can effectively replace a portion of imported vegetable tannins, thereby reducing cost and environmental impact.

6. Conclusion

The study confirms that tannin-rich by-products from Indian agro-industries can serve as viable and sustainable alternatives to imported vegetable tannins. The utilization of areca husk fractions and cashew husk extracts supports eco-friendly leather processing, waste valorization, and self-reliance in raw materials.

With further research, standardization, and industrial-scale trials, these indigenous resources can significantly contribute to the sustainable development of the Indian leather industry, aligning with environmental regulations and national sustainability goals.

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