2025 IULTCS Young Leather Scientist Grant

Identification: YLSG_2026_applicantname

COMPLETE APPLICATION FORM (click application area)

☐ Basic Research ☐ Environmental/Sustainability ☐ Machinery/Testing

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By submitting this application, I commit to develop the project as outlined in the attached Research Project Plan and to complete a written report by February 28, 2027 with the following items:

1) Introduction
2) Materials and Methods
3) Results and Discussion
4) Conclusion
5) Suggestion for Future Work
6) References

2) Research Project Plan outline – Maximum 3 pages

Title: EPOXIDIZED FLESHING WASTE OIL: A SUSTAINABLE ALTERNATIVE TO CONVENTIONAL CHAMOIS TANNING AGENTS

Introduction

Leather remains one of the most valued biomaterials in global trade, admired for its durability, breathability, and aesthetic versatility. Among its various categories, chamois leather occupies a unique position owing to its characteristic softness, high water absorbency, and washability. Traditionally, chamois leather is produced through oil tanning, a process that relies on the oxidation of unsaturated oils particularly marine or fish oils to generate aldehydic compounds capable of crosslinking with collagen fibres (Suparno, 2010). These oxidation products bind to amino and hydroxyl groups in collagen, forming a porous, hydrophilic network that gives chamois leather its distinctive properties for example high flexibility, non-abrasive feel, and the capacity to absorb several times its own weight in water (Ramesh et al., 2025).

However, the conventional chamois tanning process faces serious economic, environmental, and ethical limitations in a way that Fish and marine oils used in oil tanning possess high iodine values (160 - 190) that make them ideal for oxidative crosslinking, but they are expensive, scarce, and prone to producing persistent fishy Odor that reduce consumer acceptance (Wainaina et al., 2019). Additionally, the oxidation process is slow in conventional oil tanning, usually requiring 2 to 9 weeks for full polymerization, which increases energy consumption and raises manufacturing costs (Ongarora et al., 2019).

In previous years, alternative plant-based oils from sources such as rubber seed, linseed, castor, jatropha, or corn oil have been investigated as substitutes for fish oil. While more renewable, most of these have disadvantages such as poor penetration, formation of surface residues, and inadequate reactivity, yielding uneven tanning and poorer mechanical properties (Ongarora et al., 2019). Modified derivatives such as methyl esters or polyethylene glycol (PEG) esters process more quickly but still can have Odor, toxicity, or fibre damage due to chemical accelerators like hydrogen peroxide (Alam et al., 2025).

At the same time, the leather industry itself produces high volumes of organic solid wastes during beam-house operations were about 50-60% of such wastes include fleshing wastes (Kowalska et al., 2024). This waste contains valuable proteins and 4-18% fat content, yet it is largely disposed of in open dumps or landfills, contributing to Odor nuisance, methane emissions, and groundwater contamination. Valorising this waste into useful by-products represents an important step toward sustainable and circular leather manufacturing. Recent studies for example, (Mekuria, 2024; Wainaina et al., 2019) have shown that oil extracted from fleshing waste can be utilized for fat liquoring, softening and oil tanning, however, its low iodine value (55-60) restricts its oxidative tanning potential and therefore, this challenge opens the opportunity for chemical modification to enhance its reactivity.

One promising route is epoxidation, a reaction that converts the unsaturated double bonds (C=C) in fatty acids into reactive oxirane (epoxy) rings (Esposito & Marzocca, 2022). These epoxy groups can directly react with the amino (–NH_2) and hydroxyl (–OH) functionalities of collagen to form covalent bonds, achieving tanning without the need for prolonged oxidation (Mekonnen, 2021). Such a mechanism has been successfully demonstrated with epoxidized rubber seed oil and

epoxidized castor oil, both of which produced leathers with improved softness, tensile strength, and wash resistance compared to their unmodified counterparts (Alam et al., 2025; Sudha et al., 2017). Unlike oxidative tanning, which depends on aldehyde intermediates, epoxidized oils achieve rapid and direct collagen crosslinking, leading to faster processing and Odor-free products (Sahu et al., 2022).

In this context, epoxidized fleshing waste oil (EFO) presents a novel and sustainable tanning alternative for Chamois, however, to the best of my knowledge, no research has been done on its application as a tanning agent. Additionally, by transforming a problematic tannery by-product into a functional oil-based tanning material, this research directly supports the goals of waste valorisation, cleaner production, and resource circularity in the leather sector. The proposed study therefore aims to extract oil from tannery fleshing waste, epoxidize it under optimized conditions, and apply it in the tanning of chamois-type soft leather. The expected result is a leather that exhibits the desirable softness, flexibility, and hydrophilicity of traditional chamois while eliminating Odor, shortening processing time, and reducing reliance on imported or non-renewable oils.

Therefore, this research seeks to demonstrate that epoxidized fleshing waste oil can serve as a viable, eco-friendly tanning agent turning a significant solid waste stream into a high-value input for sustainable leather production.

Objectives

Main objective

To develop and evaluate epoxidized fleshing waste oil (EFO) as a sustainable and effective tanning agent capable of producing soft, absorbent, and odor-free chamois-type leather, thereby replacing conventional fish or marine oils used in chamois tanning.

Specific objective

- To extract and characterize oil from tannery fleshing waste, determining its physicochemical properties.
- To convert the extracted fleshing oil (FO) into epoxidized fleshing oil (EFO)
- To characterize and compare the chemical and physical properties of the raw fleshing oil (FO) and the epoxidized product (EFO) using FTIR.
- To apply EFO in the tanning of chamois-type soft leather, following standardized oil tanning procedures, and to evaluate the resultant leather's mechanical, thermal, and physicochemical properties.

Materials and Methods:

The process will begin with pretreatment: limed fleshing will be delimed and washed using 2% ammonium sulfate and 200% water for 2 hours, followed by grinding into fine particles to facilitate extraction (Mekuria, 2024). Key characteristics such as pH, moisture content, density, viscosity, acid value, and iodine value of the pretreated material will be evaluated using standard methods.

Oil extraction will be performed via Soxhlet method using hexane at varying volumes (250–350 mL) and temperatures (55–75°C) for 2–4 hours. The extracted fleshing oil (FO) will then undergo in-situ **epoxidation** in a three-neck reactor using hydrogen peroxide and formic acid as oxygen carriers, with sulfuric acid as catalyst. A Central Composite Design

(CCD) with three factors (reaction time: 3–6 h; temperature: 50–70°C; H_2O_2:oil ratio: 1.1:1–1.7:1) and 20 experimental runs will optimize the process through Response Surface Methodology. The epoxidized fleshing oil (EFO) yield will be assessed by oxirane oxygen content (AOCS Cd 9-57), conversion percentage, and selectivity.

Both FO and EFO (20% offer each) will be applied in oil tanning of goat and sheep skins following pickling, pretanning with synthetic agent (Relugan GT50), fat liquoring, 9-day oxidation, and finishing processes to produce FO-tanned leather (FOTL) and EFO-tanned leather (EFOTL). The resulting chamois leathers will be characterized for physicochemical properties (shrinkage temperature, oil content, moisture, ash, pH, water absorption, and vapor permeability), mechanical properties (tensile strength, elongation, tear strength, and softness), and functional performance.

Fourier Transform Infrared Spectroscopy (FTIR) will confirm successful oil incorporation into collagen structure. Scanning Electron Microscopy (SEM) will reveal fiber separation and surface morphology. Antimicrobial activity of EFOTL and FOTL against selected microorganisms will be tested using the disc diffusion method.

Hypothesis/Expected Results:

Epoxidized fleshing oil (EFO) will revolutionize chamois leather production by introducing reactive oxirane rings that rapidly form stable covalent crosslinks with collagen's amino groups, completely eliminating the prolonged 2–9-week secondary oxidation required when using raw fleshing oil. This direct crosslinking is expected to yield superior chamois leather with enhanced durability, flexibility, washability, and hygroscopicity while resolving traditional problems such as poor oil penetration, surface residues, and unpleasant odors. By converting 50–60% of hazardous tannery fleshing waste into a high-performance, cost-effective, and eco-friendly tanning agent, the process will significantly shorten production time, reduce environmental impact, and promote a circular economy in leather manufacturing.

Research benefit for the local or global leather industry (one sentence only):

This research will transform hazardous tannery fleshing waste into a high-performance, cost-effective epoxidized tanning agent, enabling the global and local leather industry to produce superior, eco-friendly chamois leather with shorter processing time, reduced chemical dependency, and significant environmental and economic benefits.

Literature:

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