ADVANCING CLEANER PRODUCTION

Towards Sustainable Leather Sector in Pakistan

Leather is one of the major pillars of Pakistan's economy, standing as the third-largest export sector and contributing approximately four per cent to the national GDP. While leather production utilizes hides and skins (a byproduct of the meat industry), it is not immune to environmental and social risks.

Modern methods of production demand a modern solution to the persisting ecological burden. Cleaner production offers a smart way forward, tackling the issue at source. It is a sustainability driven approach that aims to lessen environmental harm proactively by preventing pollution at the source rather than dealing with it later. As global industries modernize through cleaner technologies, it is only imperative that Pakistan follows suit.

Advantages of advancing cleaner production

Embracing cleaner production is a necessary step for local businesses as it:

Lowers the negative environmental impact of the manufacturing process

Reduce operational costs through resource and energy efficiency

Increases worker safety as the risk of exposure is minimised

Improves compliance with the production regulations and lowers the liability

Provides an edge in the market in today's time of pursuing sustainability

Pathways to cleaner production

• Resource efficiency and circularity

Cleaner production begins by improving resource efficiency throughout the manufacturing cycle. For example, water recycling and reuse can significantly reduce freshwater demand. Similarly, the use of other raw materials, such hides and chemicals, can be optimized. Moreover, by adopting circular economy models, which aim to keep materials in use for as long as possible, industries can reduce their dependency on virgin resources.

• Process optimization

Enhancing operations by employing upgraded equipment, regular maintenance, and control devices reduces waste and emissions and helps achieve cleaner production goals.

• Waste minimization

Cleaner production methodologies prioritize preventive measures that reduce waste at source instead of depending on end-of-pipe management solutions. Industries can significantly lessen their environmental impact through waste management at source and even by incorporating it into the production process.

• Green chemical transition

Substituting chemicals with environmentally friendly alternatives helps automatically reduce adverse environmental impact. Use of bio-degradable chemicals encourages compliance with sustainability standards as well.

• Energy management

Improving energy management, upgrading energy-efficient systems, and integrating renewable energy solutions help reduce operational costs and carbon emissions.

What we did and how it advances cleaner production

One of the major steps in leather manufacturing is degreasing. This is the effective removal of natural fats and grease from hides and skins to ensure uniform dyeing, finishing quality, and long-term product durability. Conventionally, degreasing involves the extensive use of chemicals, including petrochemical solvents and synthetic surfactants. These degreasers not only contribute to high raw material consumption, but also to elevated pollution loads, higher treatment costs, and greater occupational exposure risks. To address this issue and provide a greener solution, an enzymatic alternative was introduced: Lipases. Under controlled conditions, they offer targeted fat removal with a safer working environment and reduced toxic chemical usage.

In collaboration with Pakistan Council of Scientific and Industrial Research (PCSIR), this pilot focused on locally producing the lipase enzyme tailored for leather degreasing application through solid-state fermentation (SSF).

Indigenous lipase production through solid-state fermentation: process overview

STEP 1: Fungal cultivation and lipase induction

The fungal strain of *Aspergillus niger* is cultivated on agriculture residue (rice husk and corn meal), with olive oil and Tween-80 (1:1 ratio) introduced to encourage production. This acclimatized microorganisms to lipid rich conditions and enhanced lipid-responsive enzyme expression.

STEP 2: Post extraction stabilization and fermentation

After the extraction of the crude enzyme, it is stabilized using a composition of skimmed milk powder, Maltodextrin, refined glycerol concentrations, and food grade preservatives. Vacuum drying is conducted post stabilization, resulting in a thick paste suitable for industrial application.

STEP 3: Testing against commercial standard

Enzyme performance is determined using a titrimetric olive oil emulsion assay under controlled conditions (pH 7.0, 37°C). The final product showed satisfactory performance when compared with commercial enzyme.

STEP 4 : Application in real leather processing conditions

The resultant enzyme is tested under controlled degreasing conditions (pH 7.0, 37°C) with a 10-20% dosage based on skin weight and three to six hours reaction time. The enzymatic hydrolysis converted triglycerides into emulsifiable free fatty acids and glycerol, facilitating improved fat removal during subsequent washing and emulsification steps.

This application establishes compatibility with existing leather processing stages, which can allow for successful integration without any major infrastructure changes.

Environmental and Economic Value

Lipase enzyme induces hydrolysis reducing the dependency on solvent-based degreasing agents, which ultimately lessens the chemical load in wastewater streams. This targeted fat breakdown also supports easier emulsification and removal, resulting in an improved effluent profile. This pilot decreases reliance on other outsourced degreasers and strengthens industrial biotechnology capacity within Pakistan. This option contains very strong potential for cost-controlled scaling.

Disclaimer: The UK Government funds this pilot activity of cleaner production as part of the project "Pakistan Leather Sector: Traceability, Cleaner Production and Circularity" through UK International Development and SMEP Programme; however, the views expressed do not necessarily reflect the UK Government's official policies.