

High-value protein upcycling from chrome leather shavings

By **Dr Jordi Escabrós, R&D, Trumpler Espanola.**

The leather industry is undergoing a profound transformation in recent years, redefining how leather is produced. Through the smart utilisation of collagen-rich waste, what was once a problematic byproduct can now become a valuable solution to other challenges. This approach creates a renewable and circular source of value that can even support other industries, reducing the carbon footprint and lowering dependence on fossil-based raw materials. This breakthrough has the potential to set a new standard for the leather sector.

Collagen is the most abundant protein in the animal kingdom, accounting for about 30% of all proteins in various species, including mammals. It serves as the structural “scaffold” for skin, tendons and bones. But collagen is far more than just “the skin protein”. It is a versatile molecule with unique properties, found in abundance in leather industry residues. Thanks to its biochemical characteristics, collagen can be considered a renewable raw material for multiple industries.

From every ton of chrome-tanned leather shavings, 350-450 kg of high-value hydrolysate can be recovered. This means that a pure protein hydrolysate, which previously ended up in landfills, can now replace products derived from fossil sources or synthetic fertilizers. In short, these proteins can have a second life—one that does not involve disposal.

The starting point: A mountain of chrome shavings
Every year, the global leather industry generates roughly 800,000 tons of chrome-containing waste. Classified as hazardous in many countries, it is expensive to landfill and almost impossible to incinerate cleanly because of the trivalent chrome content. For decades the only “valorisations” were low-value collagen hydrolysates made by harsh acid or alkaline hydrolysis – products that were cheap, smelly and of inconsistent quality.

Trumpler chose a different path. The company created an advanced enzymatic platform that gently unravels the collagen triple helix under mild conditions using food-grade proteases. The outcome is a crystal-clear hydrolysate with peptides mainly in the 500-3000 Da range—precisely the size that plants and leather fibres favour—while maintaining delicate amino-acid side chains that ensure biological activity. Yields reach an outstanding 90% of

the original protein content, and chromium remains in an easily filterable cake ready for recycling.

From dilute hydrolysate to high-value concentrate: The membrane cascade.

Starting at only 2-5% dry matter, raw enzymatic hydrolysate is far too dilute for most industrial processes and uneconomical to ship. A three-stage membrane system solves this challenge, progressively concentrating on the product to meet application and logistics requirements.

1. Ultrafiltration (30 kDa cut-off) removes any remaining large proteins and particles.
2. Nanofiltration (300-500 Da cut off) concentrates the target peptides to 20-30 % dry matter while letting salts pass into the permeate.

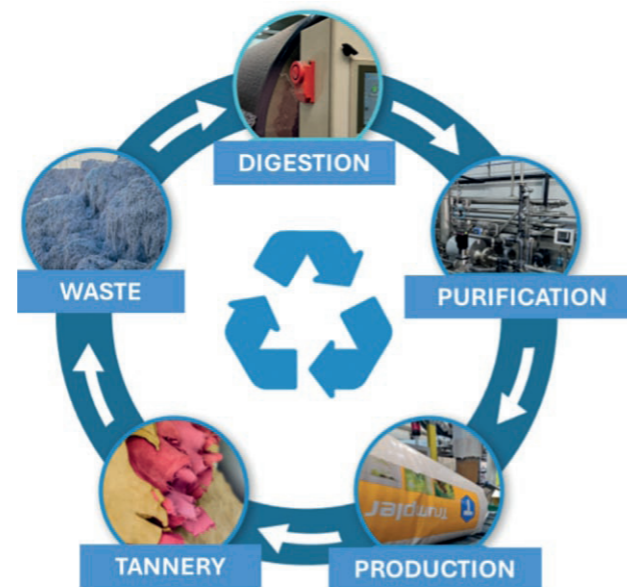


Figure 1: Circular economy, recycle of chrome residuals.



Chrome leather shavings.

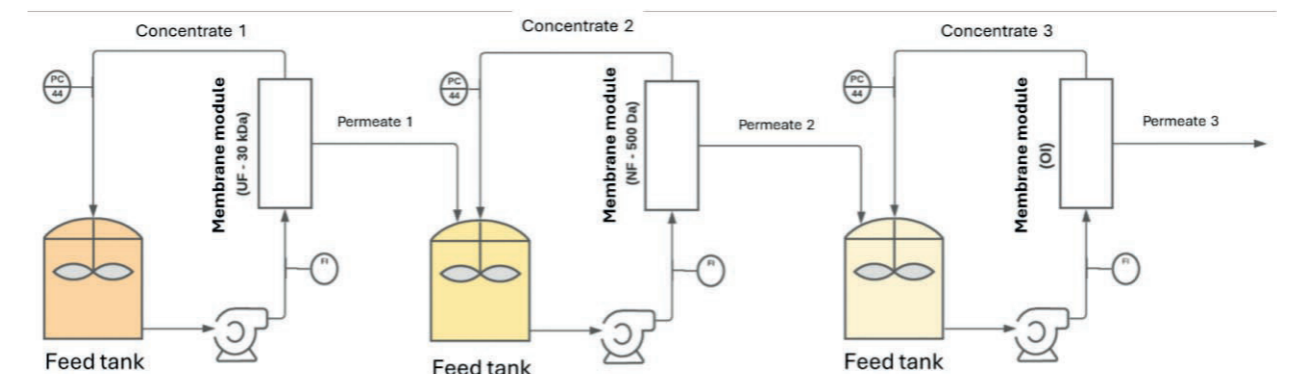


Figure 2: Flow chart for the filtration process.

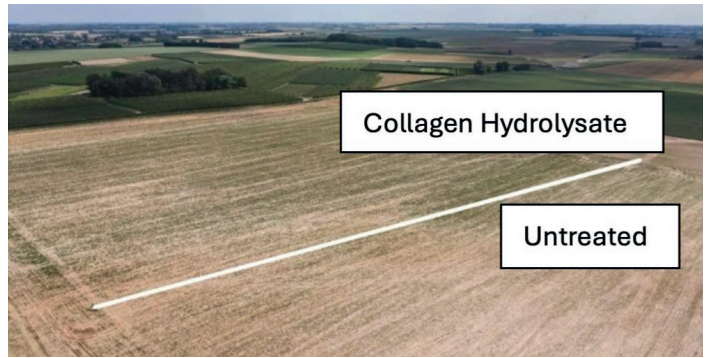
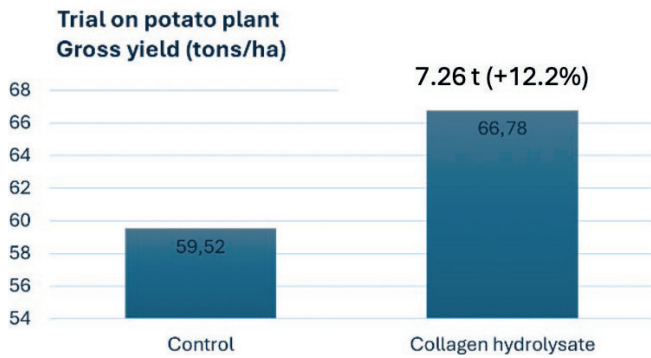


Figure 3: Trial on potato plant.

3. Reverse osmosis polishes the permeate, producing water clean enough to be recycled inside the factory.

The plant is designed as a zero-liquid-discharge (ZLD) loop. Photovoltaic panels on the factory roof and a biomass boiler keep Scope 1 and 2 emissions very low. Early Life Cycle Assessment (LCA) data show a carbon footprint lower than conventional chemical hydrolysis.

The nanofiltration step proved to be the key performer in the process. Despite the sticky, amphoteric nature of collagen peptides, well-chosen membranes achieved volume concentration factors of 10-15 times with acceptable flux and only moderate fouling.

Back to leather: A truly eco-friendly retanning solution

Part of the concentrated hydrolysate returns to the tannery floor as a biobased retanning and filling polymer. Because molecular-weight distribution is tightly controlled, the product behaves predictably: it penetrates quickly, fixes excellently on chrome, glutaraldehyde and vegetable tanned leather, and gives a round, tight grain with excellent dye uniformity. It is naturally formaldehyde-free, readily biodegradable (OECD 301F >90 % in 28 days), and shows zero skin sensitisation – advantages that resonate strongly with brands chasing “clean” chemistry credentials.

Tanneries testing the material report replacement of synthetic retanning agents without loss of physical properties and in many cases, an improvement in tear strength and softness.

Out into the fields: Biostimulants for modern agriculture

Part of the output is directed to agriculture for use as a foliar and soil-applied biostimulant. Collagen peptides are natural signalling molecules. Plants recognise certain sequences (especially glycine-proline-hydroxyproline repeats) as “damage” signals and react by switching on protective pathways: more antioxidants, better osmotic regulation, stronger cell walls. The result is measurable stress tolerance and higher marketable yield.

Field experience validates the actual performance of products under real conditions. In different crops and regions, the use of collagen hydrolysate as a foliar treatment is showing very promising results. In tomatoes grown in Zhejiang (China), three applications at 0.3% on top of the usual fertilisation increased yield by 10% to 16%, with more numerous and heavier fruits. In potatoes (Belgium), six treatments of 3 L/ha added to the standard fertilisation boosted commercial yield by more than seven tons per hectare (+12.2%), with tubers of larger size. Even in plum trees (Spain), treated trees developed 25% more leaves in the first weeks after bud break. Most interestingly, no phytotoxicity was observed in any of the trials, which reinforces the product’s safety.

Farmers and agronomists particularly appreciate that the product is ecologically certified, has an amino-acid profile close to high-quality hydrolysate, and is stable in tank mixes with most crop-protection products.

Global outlook and its impact on the leather industry

Today, tanneries are judged not only by the quality and beauty of the leather they produce but also by how they manage every gram of material that enters their facilities. Leveraging renewable chemical solutions derived from processes that transform complex and costly waste into low-carbon, sustainable products can significantly ease the challenge of managing raw materials—an issue increasingly constrained by global regulations such as REACH, California Proposition 65, ZDHC Roadmap to Zero and the Leather Working Group standards.

The leather industry is entering a new era where waste is no longer seen as a burden but as a valuable resource. What once accumulated as chrome shavings behind factories is now converted into high-value products, advanced retanning agents, and agricultural biostimulants that reduce reliance on synthetic fertilisers and enhance food security in a time of climate stress.

This is the essence of a true circular economy: transforming challenges into opportunities and shaping a sustainable future for leather. |

Biography



Dr Jordi Escabrós, who holds a PhD in Chemistry from the University of Barcelona, has been part of Trumpler Spain for more than 17 years, contributing to Research and Development activities. He has been working in development and optimisation of advanced chemical solutions for wet-end

processing and leather finishing, while also working on the recovery of waste from the tanning industry to create innovative and sustainable products. In addition, Dr Escabrós has driven strategic sustainability initiatives, including carbon footprint calculation, comprehensive life cycle assessments, and the implementation of the ISCC certification system.