



**BEYOND LEATHER**

**FUNCTIONAL  
PROTEINS FOR  
AGRICULTURE AND  
LEATHER  
PROCESSING**



**TRUMPLER**  
SIMPLY GOOD CHEMISTRY

# Environmental Challenges in the Tanning Industry



## Leather production

### Processing:

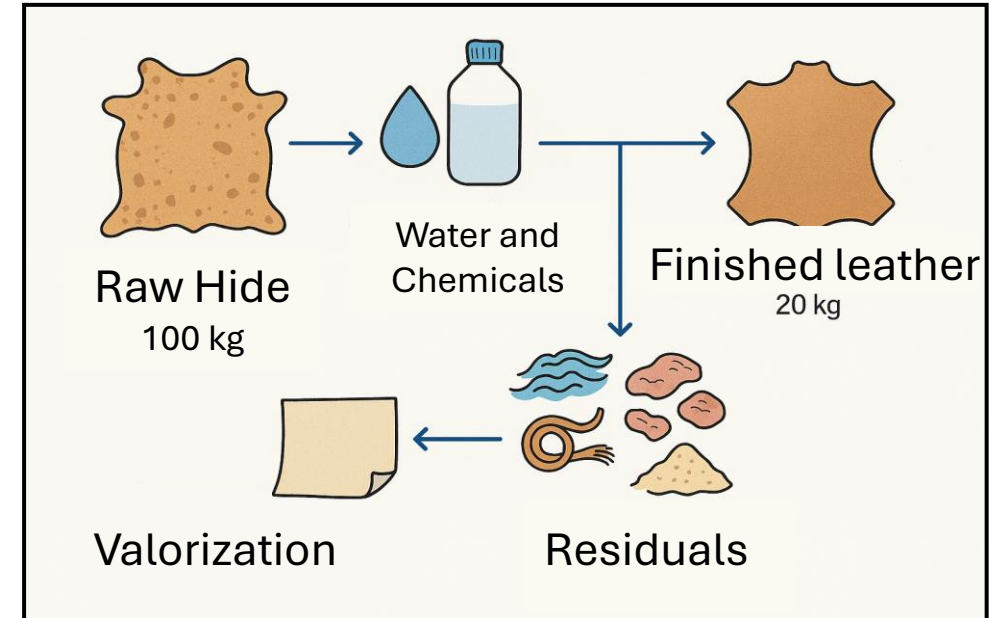
The raw hide is treated using **water and chemicals**, which are essential for preserving the material.

### Main Output:

Per **100 kg raw hide** **20 kg of finished leather**, ready for industrial or commercial use.

### By-products:

residuals can be **valorized**—they can be transformed into **additional products**, such as fertilizers, biopolymers, energy sources, or construction materials.



### Solid Residuals:

For every ton of finished leather, between 500 and 800 kg of solid waste\* can be generated.

- Leather trimmings
- Removed hair
- Fat
- Subcutaneous tissue
- Shavings from the finishing process

\*Industrial Engineering and Technology Institute, 2000, Technical Guide for Tanneries. Lisboa: PNAPRI, p. 102, in Portuguese.

# Chrome Tanning System



**The main leather tanning system today is chrome tanning**, which accounts for approximately **75% of global leather production**. This method is widely used due to its speed, efficiency, and low cost. It produces flexible, water-resistant, and durable leather, ideal for applications such as footwear, upholstery, and fashion.



## Solid Residual

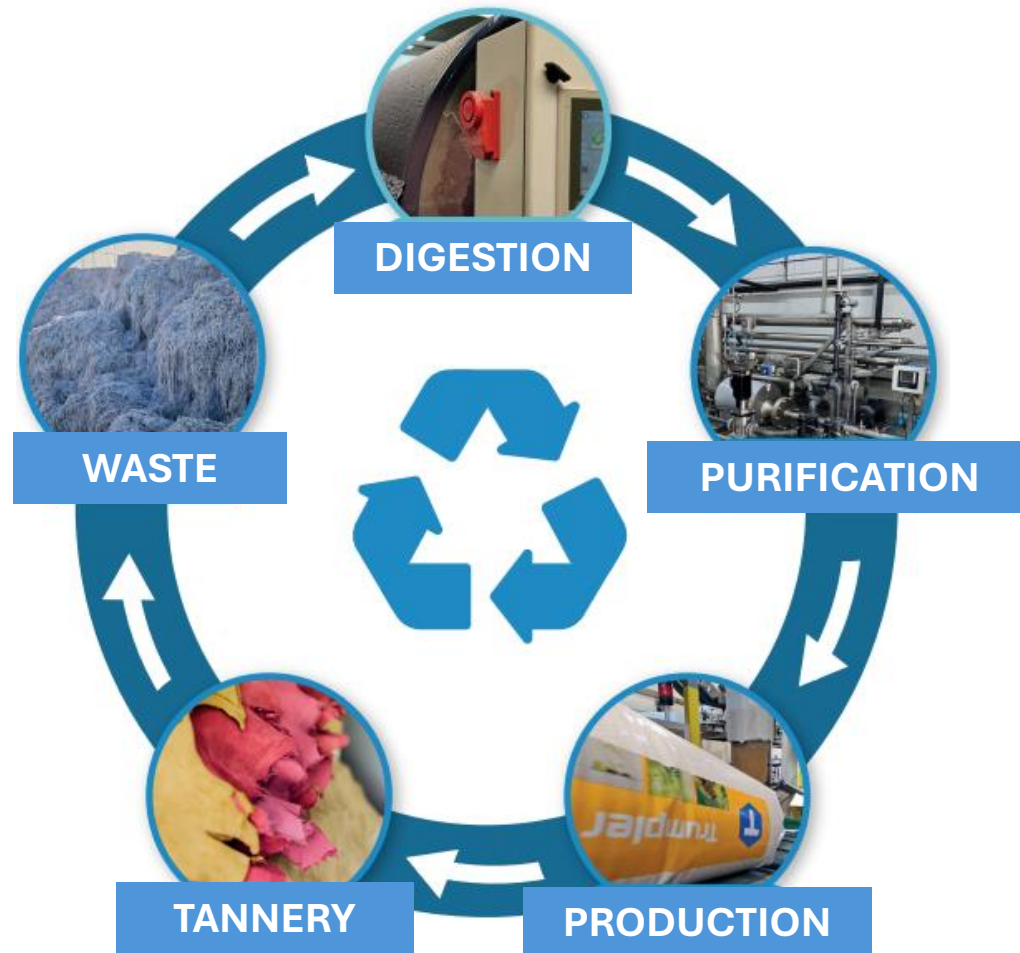
- Chromed solid residual:** Includes scraps and shavings of tanned leather, as well as sludge from treatment plants. These contain high levels of chromium and must be recycled.



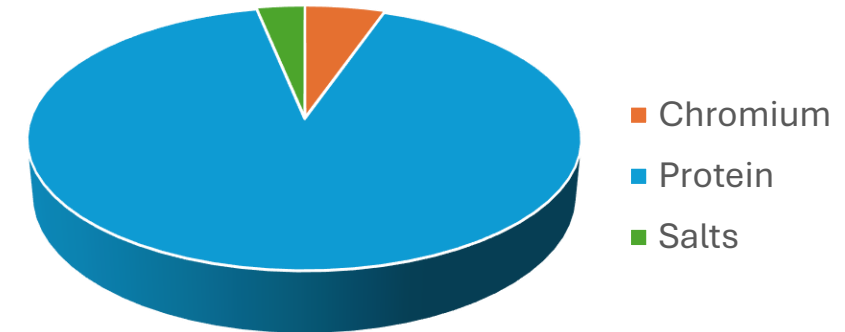
# Circular Economy- Recycle of Chrome Residuals

33%

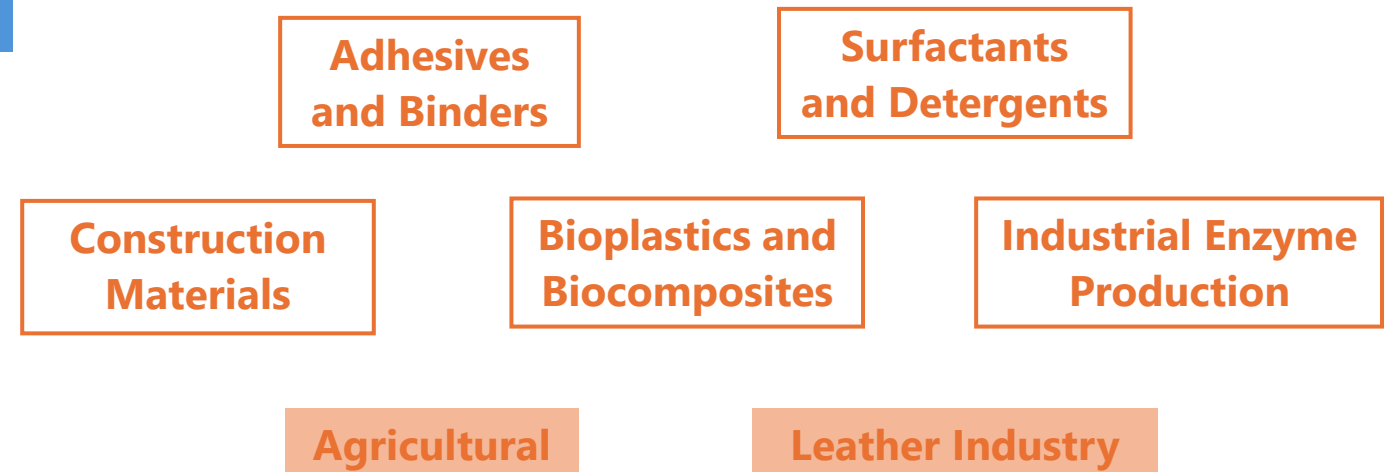
TRUMPLER SPAIN products  
coming from Chrome Shavings



## CHROME SHAVINGS



## PROTEIN RECOVERY INDUSTRIAL APPLICATIONS

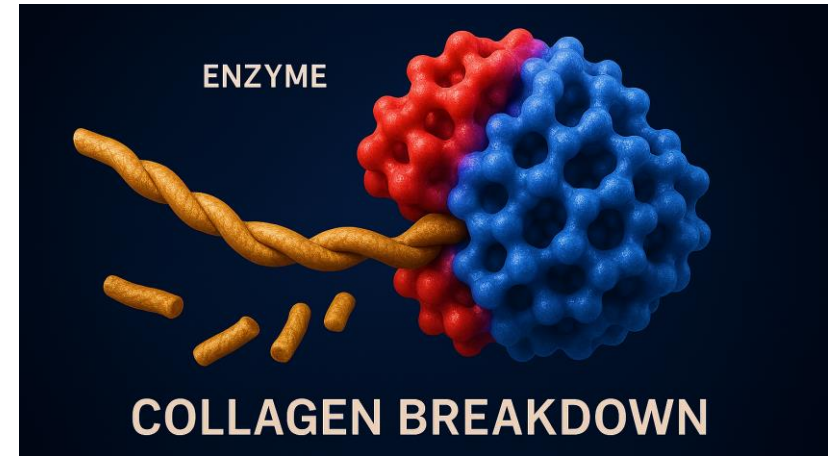




## Enzymatic Processing

**Controlled Molecular Weight:** Enzymes enable precise control over peptide size, essential for applications in leather, and agricultural.

**Mild Processing Conditions:** The process operates under gentle temperature and pH conditions, preserving sensitive amino acids and minimizing unwanted by-products.



## Nanofiltration Step:

Nanofiltration membranes separate peptides by molecular weight. This allows concentration of desired bioactive peptides and removal of salts or small unwanted molecules.

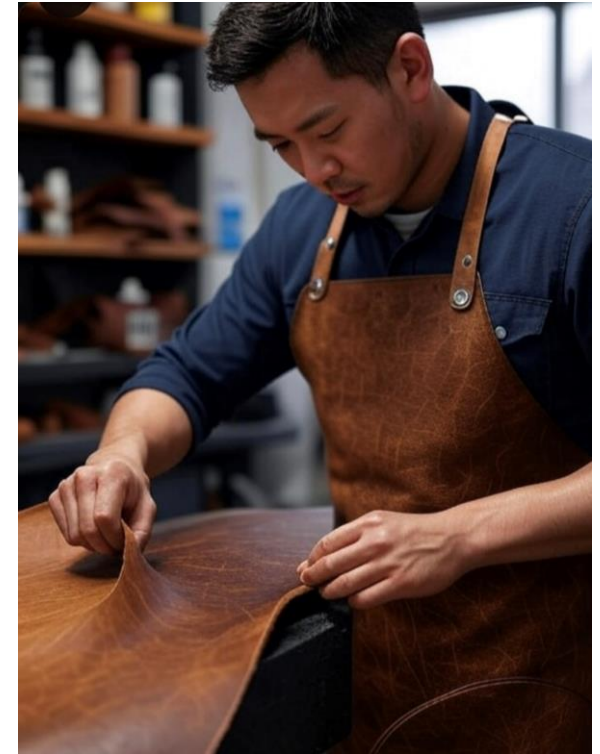
**Biotechnological process** supported using **renewable energy** coming from photovoltaic solar arrays and biomass-based thermal energy.

# Functional Proteins for Agriculture and Leather processing



## Leather Industry Applications:

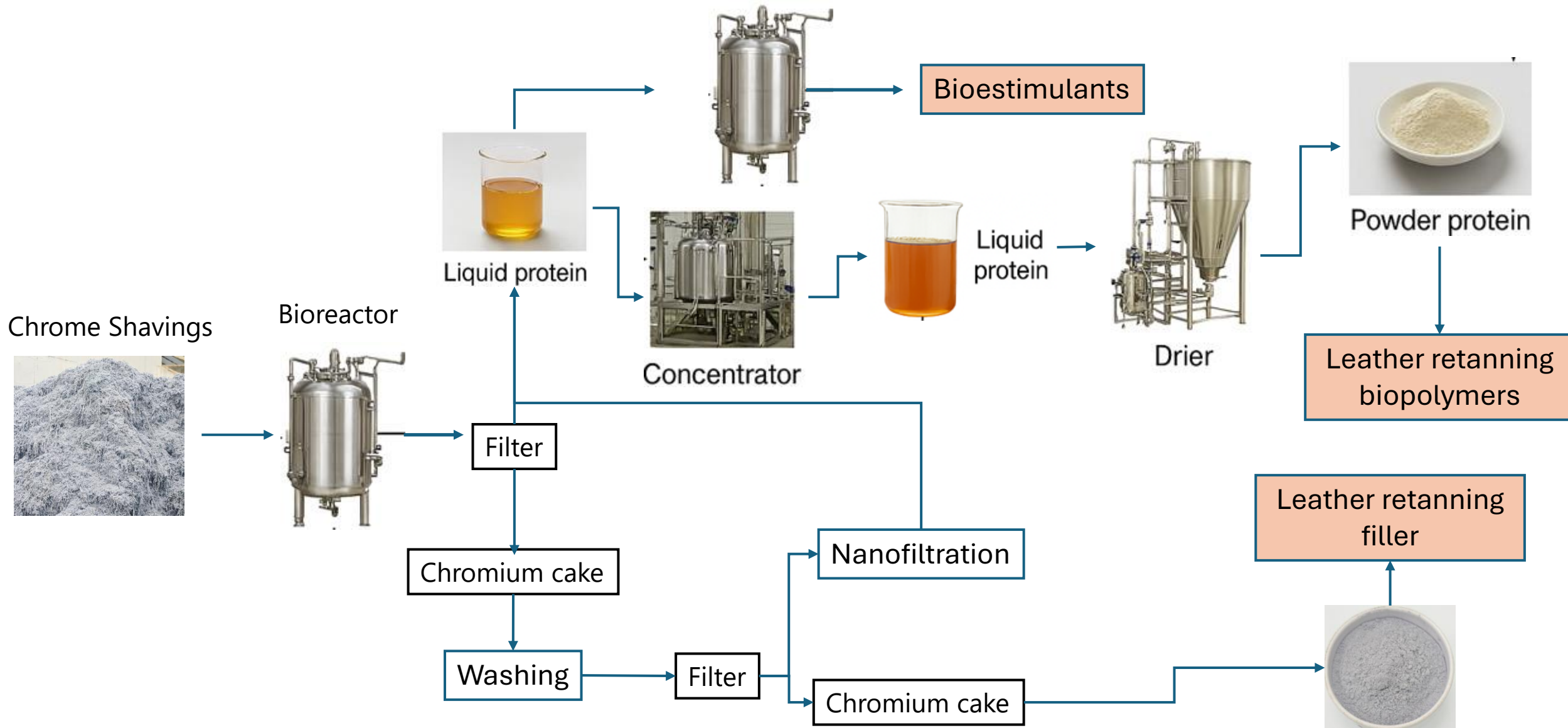
- Eco-Friendly retanning Agent:** Collagen hydrolysate can replace traditional chemical retanning agents, offering a more sustainable and less toxic alternative (**bisphenol free**).
- Improved Leather Quality:** Enhances softness, flexibility, and durability of leather products.
- Valorization:** Utilizes animal by-products, reducing environmental impact and promoting circular economy practices.



## Agricultural Applications:

- Biofertilizer:** Rich in amino acids and peptides, collagen hydrolysate improves soil fertility and promotes plant growth.
- Soil Conditioner:** Enhances soil structure and water retention.
- Plant Stimulator:** Boosts resistance to stress and improves nutrient uptake.

# Flow Chart Process

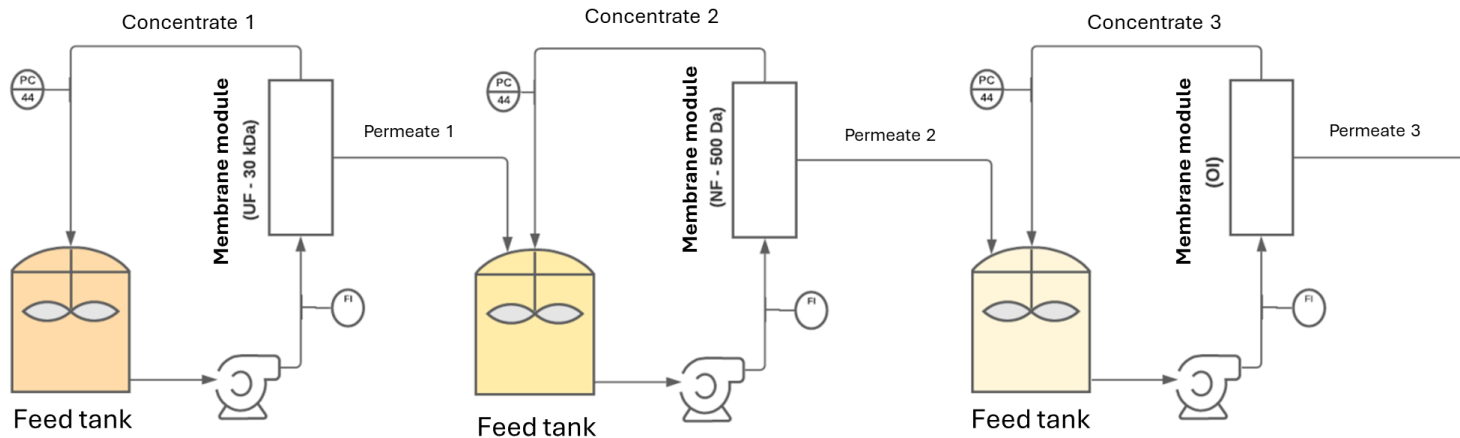
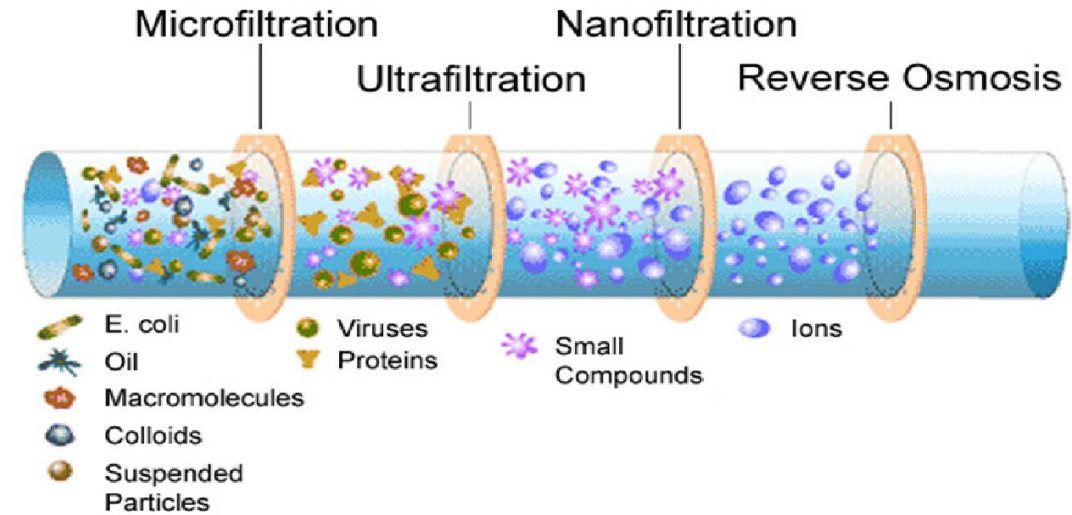


# Protein Nanofiltration



- **Ultrafiltration (30 kDa):** Effectively removed high-molecular-weight impurities with ~95% permeate recovery, preparing the sample for further concentration.

- **Nanofiltration (300–500 Da):** Successfully concentrated collagen to 20–30% dry matter. The concentrate showed high retention of collagen peptides and nutrients, while the permeate had significantly reduced organic load and mineral content.

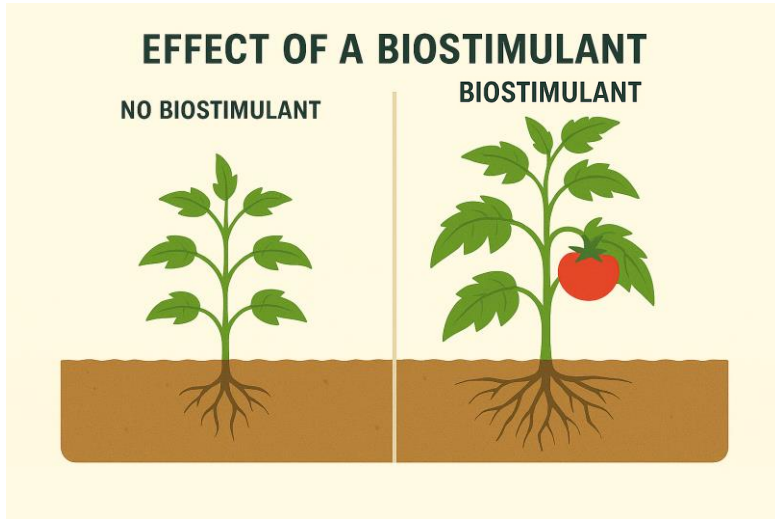


- **Reverse Osmosis:** Purified the nanofiltration permeate by removing low-molecular-weight solutes, yielding a stream suitable for reuse or safe discharge.

- **Overall Process:** Enabled selective separation and concentration of collagen with minimal waste, supporting scalability and valorization of protein hydrolysates.



# Collagen-Based Biostimulants for Plants



## Nitrogen transport and assimilation

Stimulation of vegetative growth, biomass production, flowers and fruits

Induction of secondary metabolism and plant resistance to stress

Direct or mediated influence of soil bacteria on molecular signalling processes

## Crops Studied

- Tomato (*Solanum lycopersicum*)
- Potato (*Solanum tuberosum*)
- Plum Trees (*Prunus domestica*)

## Methodology

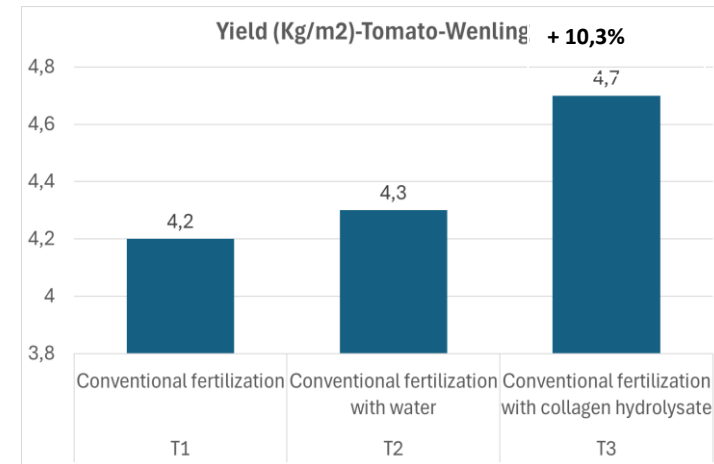
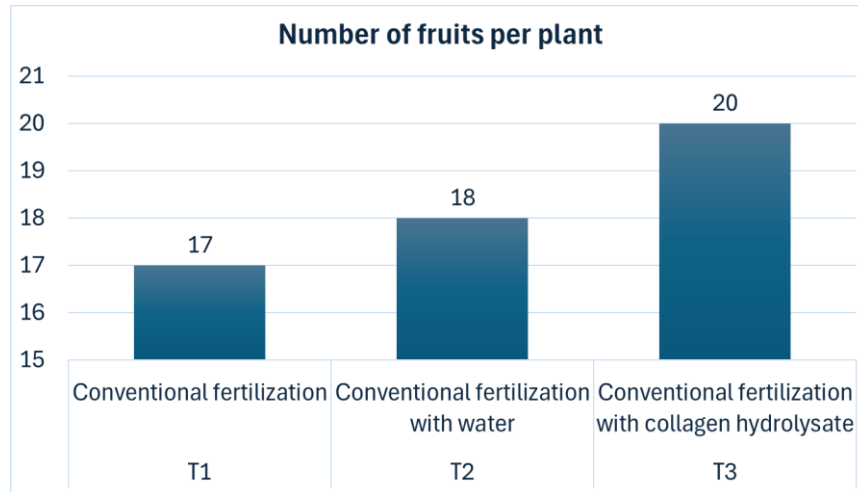
Field trials under real cultivation conditions.  
Use of amino acid-based and foliar biostimulant formulations.

## Key agronomic parameters:

Vegetative growth  
Plant health  
Fruit yield and quality

## Key Findings

Significant improvements in crop performance.  
Enhanced fruit quality.  
Increased economic viability of agricultural systems.



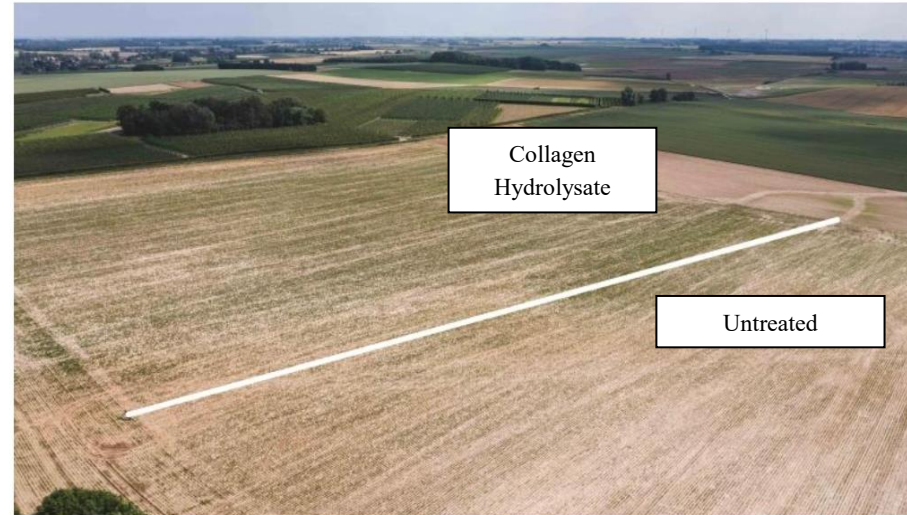
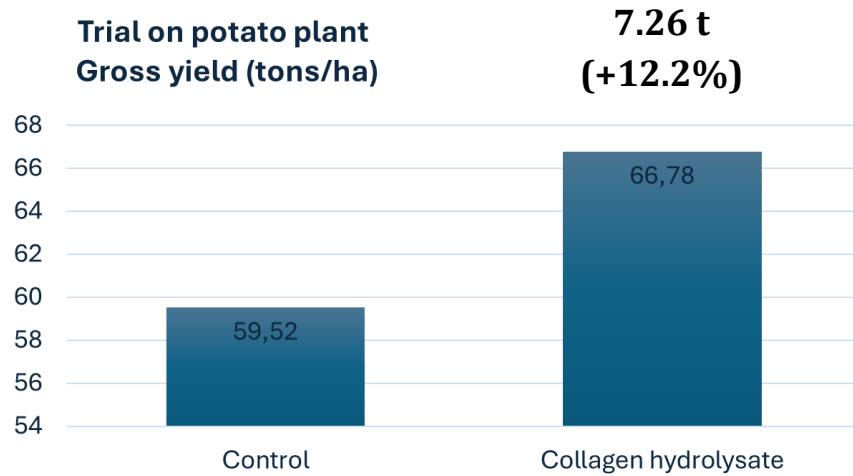
- Treatment groups:

- T1:** Conventional fertilization

- T2:** Conventional fertilization + water spray (control for foliar application)

- T3:** Conventional application +collagen hydrolysate fertilizer (0,3% dilution), applied three times during the growing season.

# Potato Bioassays



The potato variety used was Fontane (28–35 mm).

All treatments received a base fertilization consisting of: 170 kg N from animal manure (equivalent to 102 kg active N), 400 kg of 13-0-17 fertilizer, 200 kg of Greenhouse 27, 17 applications of 2.3N from spray urea.

**Treatment Groups Control (Untreated):** Standard fertilization only.

**Collagen Hydrolysate Treatment:** Standard fertilization + six applications of 3 L/ha Collagen Hydrolysate,

# Conclusions

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**Biotechnological process** for recovering functional proteins using membrane filtration.

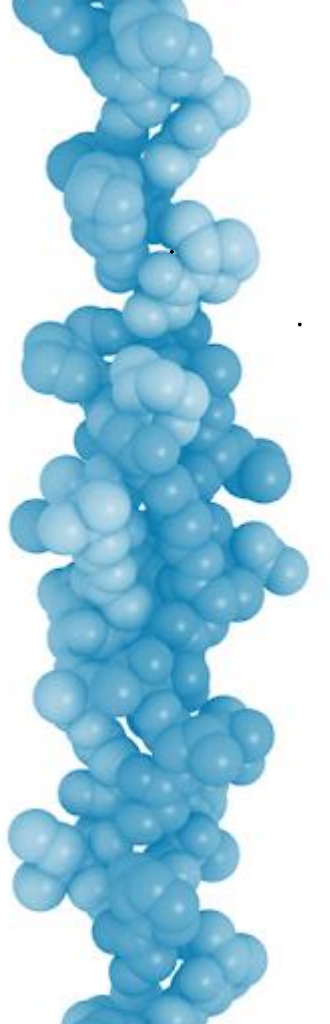
**Three-stage process:** Ultrafiltration (UF), Nanofiltration (NF), and Reverse Osmosis (RO).

**Nanofiltration is the key step**, enabling high-quality concentration with energy efficiency.

**Potential applications:** Leather retanning and agriculture, supporting a circular economy.

**Positive agronomic results:** Improved yield in tomato and potato trials, with no phytotoxic effects.

This process efficiently recovers collagen, reduces **leather industrial residues**, and promotes **sustainable** practices in leather and agriculture, aligned with **green chemistry principles**







THANKS FOR YOUR ATTENTION!



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