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Valorizing Agro-Industrial Waste: Exploring Antimicrobial Peptides Prepared from Feather Keratin

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Introduction

Microbial colonization on surfaces contributes to infections, imposing significant health and economic burdens. Biobased alternatives to commercial antimicrobial coatings are increasingly sought after for sustainable solutions. Antimicrobial peptides (AMPs), biomolecules found in various natural sources, are known for effectively inhibiting microbial growth.

The goal of this project is to explore keratin-based AMPs from feather waste, a sustainable and abundant source, to produce contact-killing coatings for self-disinfecting surfaces.
Various extraction and purification strategies were employed to generate a wide range of AMP candidates with optimal bioactivity.

Keratin structure

Feathers are mainly composed of keratin,
a mechanically strong structural protein, insoluble in water, and resistant to degradation.

To break down this protein into a mixture of peptides, different types of bonds must be broken :

- Disulfide (S-S) bonds that contribute to the strength of keratin
- Some peptide bonds that constitute the backbone of this molecule, but not all of them.

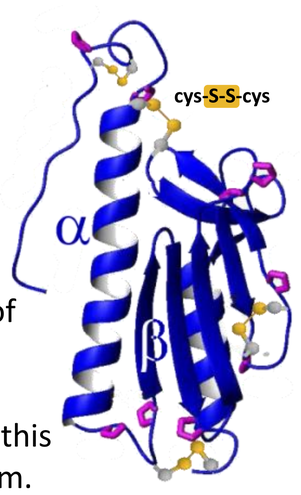

Figure 3. Simplified protein structure.

From feathers to antimicrobials

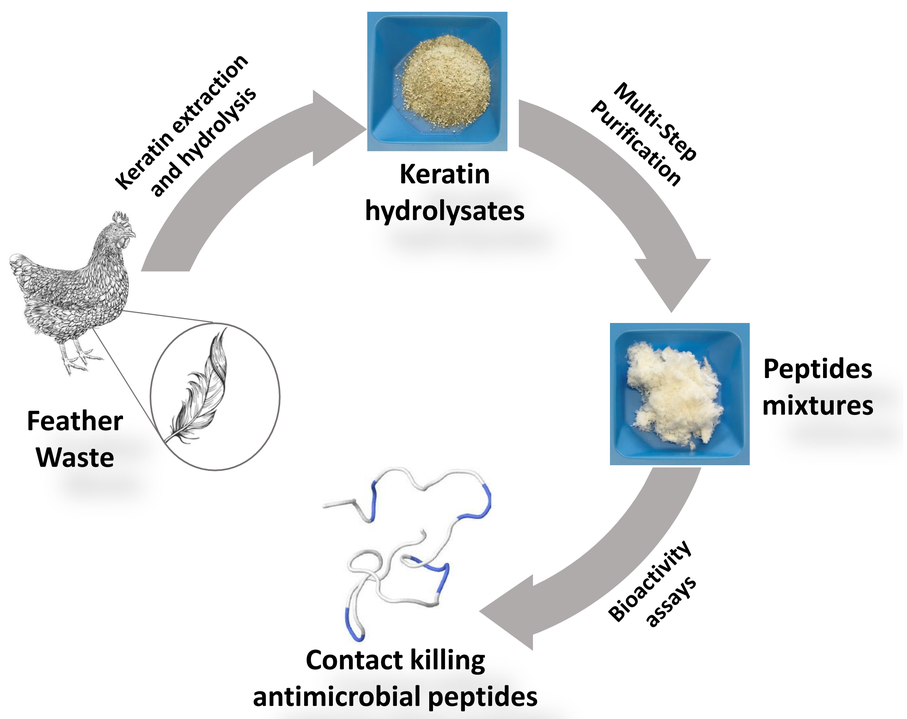

Figure 1. Overview of our global UF approach.

Peptides extraction

Bioactivity of peptides are associated with their structural characteristics.
Therefore, our strategy was to generate a large pool of antimicrobial candidates, by a large screening of various preparation methods, combining sometimes several hydrolysis approches

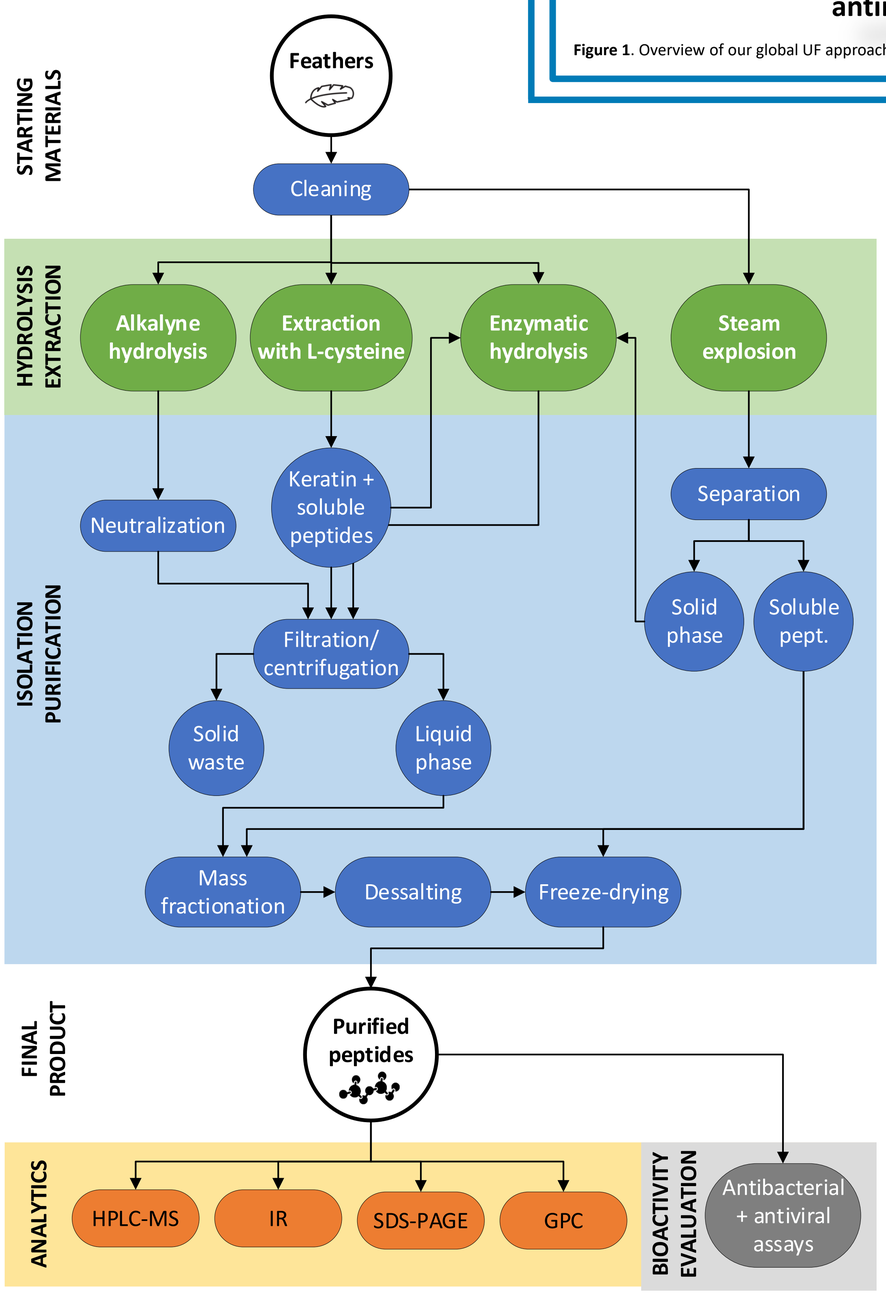

Figure 2. Studied pathways for keratin hydrolysis and peptides purification and characterization.

Peptides size also matters.
That's why ultrafiltration has been used not only as a purification methods, but also in a way of separating peptides mixtures into fractions of several mass intervals.

Results and outlooks

Screening of peptides preparation methods
In accordance with the process flow delineated on the left, more than 50 distinct samples encompassing various keratin peptide fractions were produced, in quantities ranging from a few milligrams to over 1 gram.

Antimicrobial activity
Preliminary analyses have shown promising antimicrobial activity of keratin-derived peptides in solution, particularly against viruses and Gram-negative bacteria.

Process scale-up
Production has been scaled-up 20 x for one of the most bioactive peptides samples, revealing different technical challenges, in particular for the work-up stages, but generating yields very close to the equivalent small scale experiments (around 40% of purified peptides regarding the mass of feather feed).

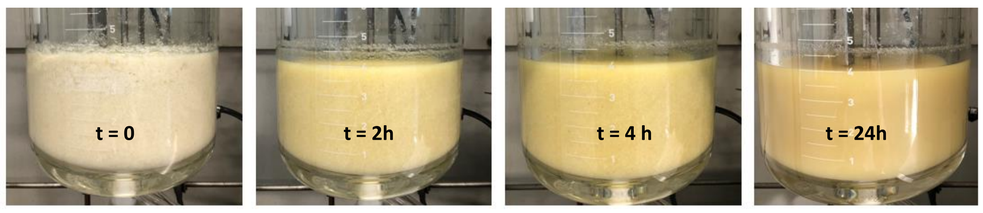

Figure 4. Scale-up of alkaline hydrolysis in a 5 L reactor – Appearance of the reaction mixture over time.

Surface functionalization
The project now advances to the next phase: coupling keratin-based antimicrobial peptides with nanoparticles, which will be applied to surfaces via cold atmospheric plasma deposition to create self-disinfecting materials.

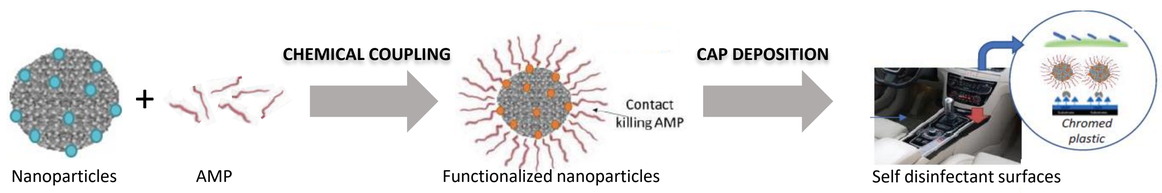

Figure 5. Surface functionalization by cold atmospheric plasma deposition of antimicrobial nanoparticles.

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