Biomimetic surfaces inspired by cabbage leaves for *Escherichia coli* biofilm prevention in the food industry

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INTRODUCTION

Biofilms formed by **foodborne pathogens** that occur on food industry equipment are a major problem since they are a frequent source of product contamination, resulting in economic losses for processors and posing serious health concerns for consumers. Safer food production may entail **high cleaning costs** and severe environmental impacts to reduce contamination[1]. One way to reduce the amount of cleaning is to design naturally cleaning surfaces based on **biomimetic designs**[2].

This work aimed to (i) **produce** and **characterize** biomimetic replicates of four self-cleaning cabbage leaves (Tenderheart, Cauliflower, White cabbage and Leek), and (ii) compare the **antifouling performance** of leaves and their artificial replicates through retention assays using *Escherichia coli*.

MATERIAL AND METHODS

Surface production

Original leaves:

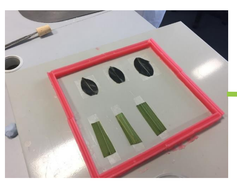
Tenderheart
(Brassica oleracea)

Cauliflower
(Brassica oleracea var. botrytis)

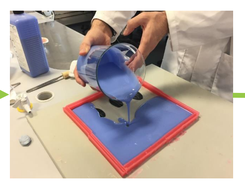
White cabbage
(Brassica oleracea capitate)

Leek
(Allium ampeloprasu)

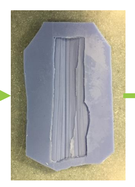
Casting & Moulding:



Leaf fixation



Silicone pouring



Negative silicone

Wax pouring

Biomimetic replicates

Surface characterization

Optical profilometry
- Surface roughness

Contact angle determination
- Surface hydrophobicity

Scanning Electron Microscopy
- Surface morphology

Binding assay

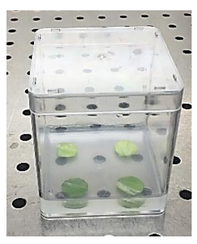
Retention assay

Static incubation in 25 mL of cell suspension for **1 h** at **37 °C**

Final step before biofilm formation

Escherichia coli
NCIB 9484
(5.5×10^7 CFU/mL)

Original leaves, biomimetic surfaces and flat surface (control)

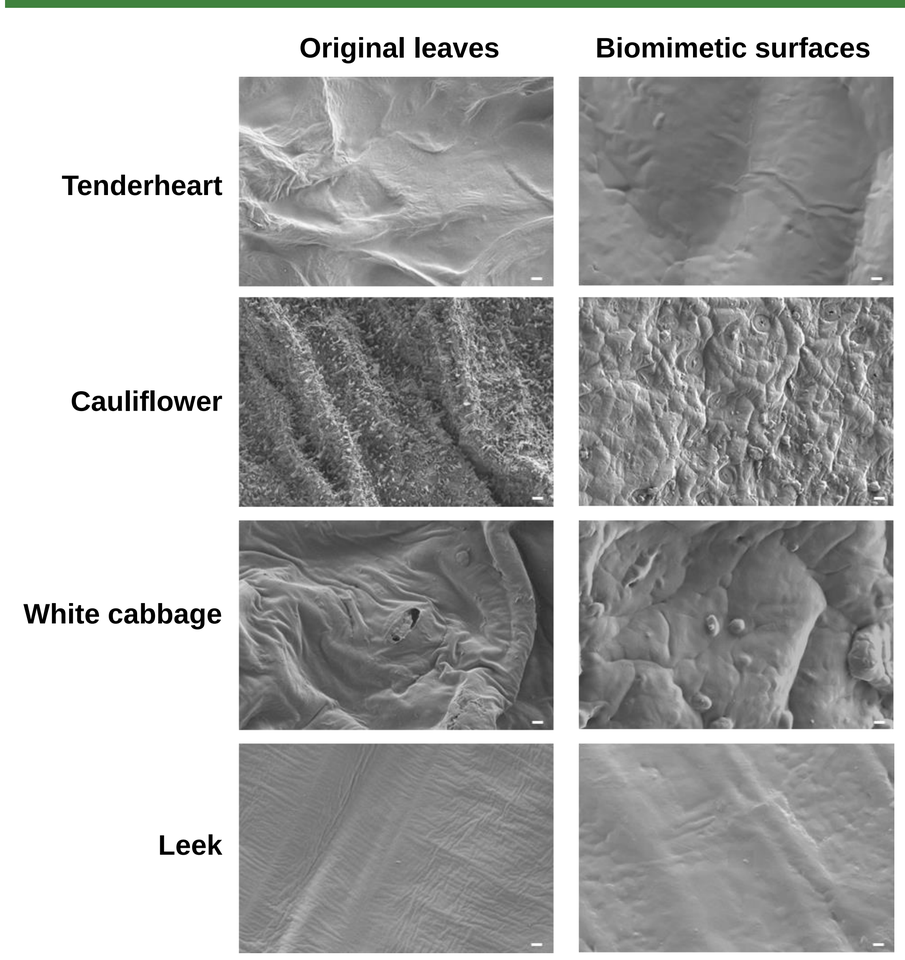


Retention analysis

Colony-forming units (CFU)
- Retained culturable cells

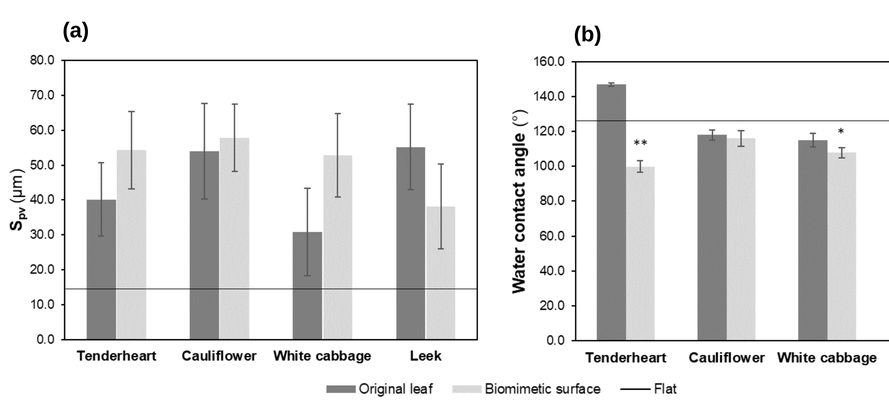
Scanning Electron Microscopy
- Spatial distribution of retained cells

RESULTS



The macro- and micro-topographies of the original leaves were well reproduced in wax

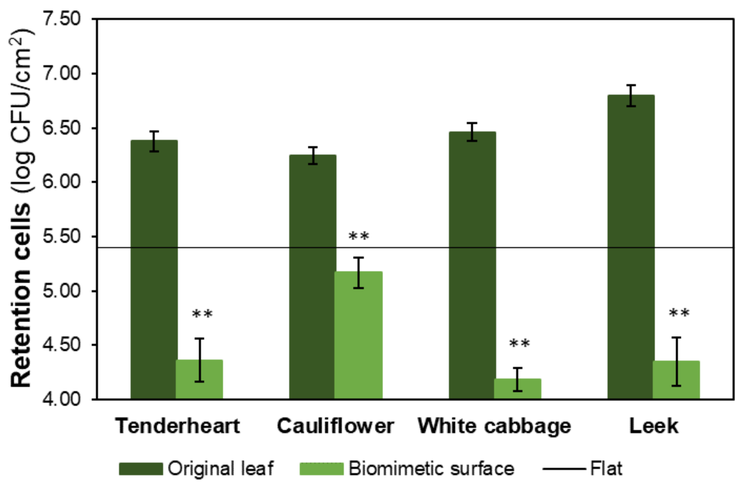
Figure 1. SEM micrographs of the original leaves and biomimetic surfaces. Magnification = 5000×, scale bar = 2 µm.



The natural White cabbage had the lowest roughness values, but its replica is one of the roughest surfaces.

All the surfaces were non-wettable (WCA > 100°).

Figure 2. (a) Peak to valley height (S_{pv}) and **(b)** water contact angles. Asterisks denote significant differences between the original and replicate of the same leaf (* $p < 0.05$ and ** $p < 0.01$). Black lines are the values of the flat control.



The biomimetic surfaces were more efficient at avoiding retention than natural leaves.

The biomimetic replicas of **White cabbage** and **Leek** were the **most promising surfaces** (reductions of ~ 2 Log).

Figure 3. Culturable cells on the original leaf and corresponding biomimetic surface. The means ± SDs for three independent experiments are presented. Asterisks denote significant differences between the original and replicate of the same leaf (** $p < 0.01$). The black line indicates the value of the flat control.

CONCLUSIONS

- These results showed that via a casting approach wax surfaces mimicking the structure of cabbage leaves could be prepared.
- The nano-scale topography and wettability associated with the natural leaves are not essential for bacterial retention in the tested conditions.
- **Biomimetic surfaces inspired by self-cleaning leaves have potential for the development of industrial antifouling surfaces.**

ACKNOWLEDGMENTS:

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