Mucoadhesion ability of protein and starch from lotus (*Nelumbo nucifera Gaertn.*) seeds, relative to milk casein, gelatine and gum Arabic as well-recognized mucoadhesive biopolymers

Jiaxin Zuo[1], Bukola Onarinde[1], Song Miao[2,3], Xu Lu[2,3,4,5*], Essam Hebishy[1*]

[1]Centre of Excellence in Agri-food Technologies, National Centre for Food Manufacturing, College of Sciences, University of Lincoln, Holbeach, Spalding, PE12 7FJ, United Kingdom
[2]China-Ireland International Cooperation Center for Food Material Science and Structure Design, Fujian Agriculture and Forestry University, 350002 Fuzhou, China
[3]Teagasc Food Research Centre, Moorepark, Fermoy, Co. Cork, Ireland
[4]College of Food Science, Fujian Agriculture and Forestry University, 15 Shangxiadian Road, 350002 Fuzhou, China
[5]Institute of Food Science and Technology, Fujian Agriculture and Forestry University, 18 Simon Pit Road, 350002 Fuzhou, China

Objective

This study aimed to investigate the mucoadhesive properties of different proteins and polysaccharides, described as suitable food models, to systematically investigate their oral processing and their ability to improve saltiness perception. Mucoadhesion ability of such model food systems were studied through In vitro binding with mucin and artificial saliva. The binding was studied studied under varying conditions of biopolymer concentration, pH and ultrasonic treatment. This study presents a novel salt reduction strategy in liquid/semi-solid food formulations with new insights into the interactions of taste perception and the mucus system in the body.

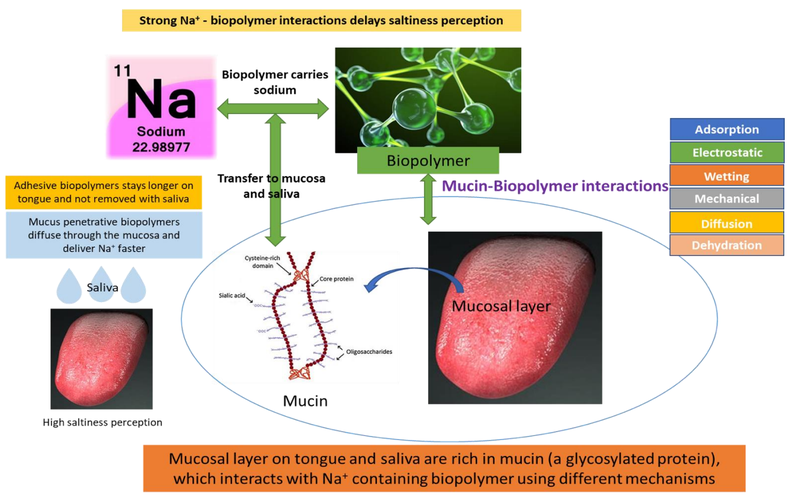
1 Introduction

1.1 Salt reduction

Salt plays an important role in food processing and consumption. In many countries, the current intake of salt exceeds the recommended values established by dietary guidelines and has been linked to the incidence of health problems.

1.2 Mucoadhesion

- Mucoadhesion of biopolymers to mucosa can be through different mechanisms such as adsorption, wetting, electrostatic interaction, amongst others.
- In the pharmaceutical industry, mucoadhesives have been used to deliver drugs by the oral route via buccal and sublingual patches.
- In the food industry, they can alter the perception and release of both tastant and aroma molecules.
- This approach has not been sufficiently exploited by the food industry.
- Mucoadhesives can also be used to reduce salt and sugar in high-salt and high-sugar foods, e.g. sauces, puddings, and cheeses.



1.3 Lotus seeds

- Lotus (*Nelumbo nucifera Gaertn.*) seed is one of the traditional medicinal plants in China.
- Lotus seed has abundant and various proteins, polysaccharides, mineral substances and many nutrients that could benefit the human body. It contains most of the essential amino acids needed by the human body.
- No studies have investigated their role as mucoadhesives.

2 Material and Methods

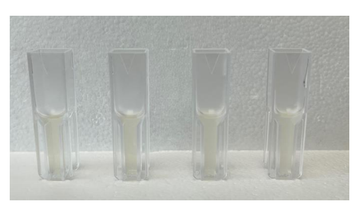
2.1Material

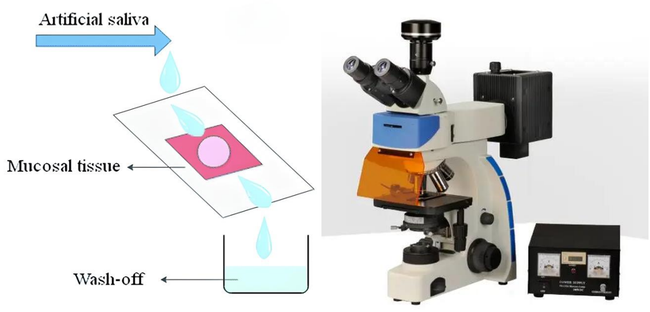
Casein (CA), Gelatin (G), gum Arabic were purchased from Chinese market. Lotus Seeds Protein (LP) and Lotus Seed Starch (LS) were extracted in the lab. Mucin from porcine stomach, artificial saliva, Phosphate Buffer Saline (PBS) and other reagents were sourced from Sigma Aldrich.

2.2 Methods

- Samples were treated with thermal treatment (H, 85^{o}C/30 min), ultrasounds (US, 50% amplitude at 40^{o}C/30 min) or heating followed by ultrasounds (H+US) to study the impact of such treatments on the mucoadhesion ability of proteins.
- Samples were prepared in 0.1% PBS solution at different pH values from 1.2 to 6.8.

Turbidity increase during 6 h of interaction (mucin 1:1 mixed with protein)



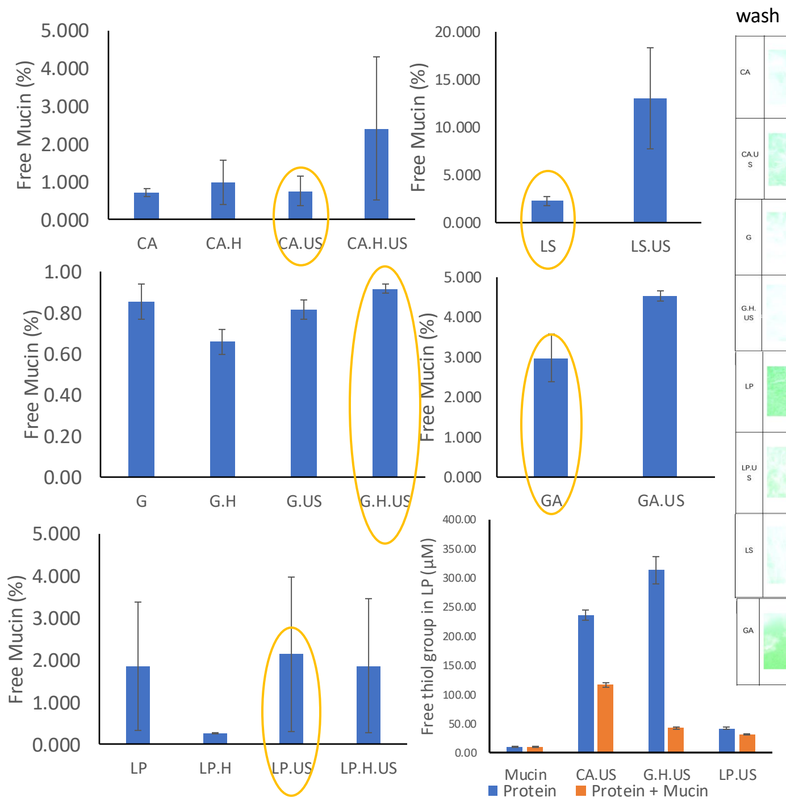


Ex vivo mucosal retention of sodium with porcine tongue
(Using the fluorescence sodium)

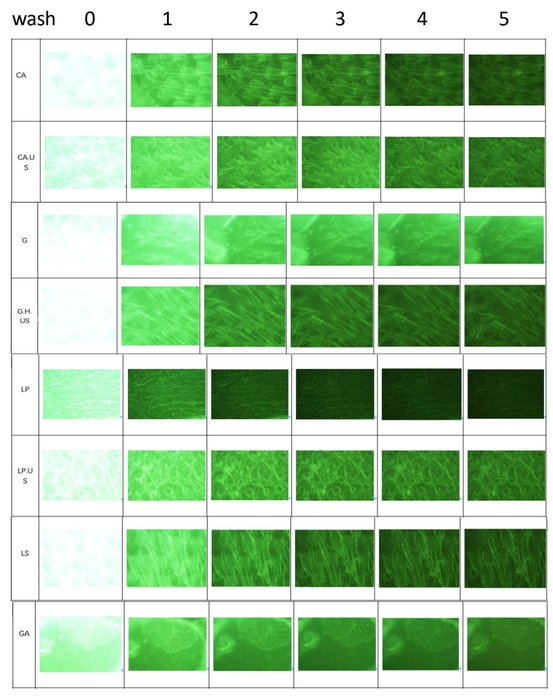
Force of Bioadhesion test
(Mixing proteins with artificial saliva to simulate the oral environment)

3 Results

Mucin absorption test of gelatin with different treatments



Ex vivo Sodium retention of different treatments



Free thiol group of the best treatment of different protein solution

4 Discussion and Conclusion

- The optimal treatment was identified through a series of biopolymer-mucin interaction experiments (turbidity, mucin absorption, and force of bioadhesion). For CA and LP, sonication was the best; for G, heating followed by sonication was optimal; and the two polysaccharides were best untreated.
- The results of the above experiments demonstrate that the treatment significantly impacts the binding of biopolymer-mucin. The disruption of the biopolymer structure following treatment results in a reduction in functional groups that bind to mucin and the capacity to entangle with mucin chains. (e.g. hydrogen bonding, van der Waals forces)
- Above all, gelatine is more mucoadhesive than other biopolymers. In future work, more *In vivo* testing should be carried out to confirm chemical tests.

5 Reference

- Cook, S. L., Bull, S. P., Methven, L., Parker, J. K., & Khutoryanskiy, V. V. (2017). Mucoadhesion: A food perspective. *Food Hydrocolloids*, *72*, 281–296.
- Li, Y., Wan, Z., & Yang, X. (2019). Salt reduction in liquid/semi-solid foods based on the mucopenetration ability of gum arabic. *Food Funct.*, *10*(7), 4090–4101.

Acknowledgments

The authors are grateful to The Royal Society of Chemistry for funding this research under the International Exchanges 2022 Cost Share (NSFC) (Grant Number: IEC\NSFC\223188).