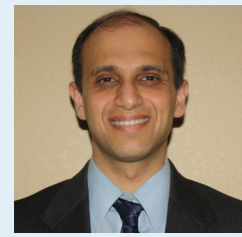


Bio-based antimicrobial coatings for reducing risk of cross-contamination during harvesting



Contact

Nitin Nitin, PhD
University of California, Davis
nnitin@ucdavis.edu

Authors

Jiyeon Yi, Yue Ma, Glenn M. Young (Co-PI), Gang Sun (Co-PI), Nitin Nitin (PI)

Project funding dates

January 1, 2021 – December 31, 2022

Acknowledgements

Thanks to the industry members for providing samples of diverse food contact surfaces, including conveyor belts and packaging tabletop.

Summary

Food contact surfaces are one of the major routes for cross-contamination of fresh produce. To address this issue, the project is developing bio-based antimicrobial coatings on various food contact surfaces and evaluating them for reducing cross-contamination between the coated surfaces and fresh produce. For hydrophobic plastic surfaces, yeast-derived particles (Bio-Mos) were deposited using beeswax coatings to form surface-bound chlorine. These coatings showed effective antimicrobial activity under simulated processing conditions and reduced cross-contamination of fresh produce. Furthermore, a soy protein-based hydrogel, with promising active chlorine capacity (>400 ppm), stability, and rechargeability, has been successfully developed, exhibiting great potential in antimicrobial and antifouling applications. The coating compositions developed in the project could be applied to existing food contact surfaces and enhance food safety.

Objectives

1. Develop approaches for rapid and uniform deposition of antimicrobial food ingredient-based coatings on [surfaces]...
2. Demonstrate antimicrobial effectiveness of the food ingredient-based coatings against a diversity of pathogens and evaluate the prevention of cross-contamination of fresh produce upon contact with coated surfaces as well as the overall quality of the produce upon contact.
3. Field-test the coating approach to demonstrate effectiveness on harvesting knives, and estimate costs of implementing this solution for harvesting knives and harvester conveyors.

Methods

Preparation of bio-based antimicrobial coatings: Polypropylene plastic coupons were coated with a Bio-Mos/beeswax coating solution using a 10-s dip coating at 70°C. The coated plastic coupons were charged with chlorine for 1 h to form N-halamine compositions. The level of surface-bound chlorine was enhanced by encapsulating ε-poly-L-lysine into Bio-Mos.

Evaluation of the coatings under simulated processing conditions: The antimicrobial activity was tested against *Escherichia coli* O157:H7 after water immersion or in the presence of organic matter. Cross-contamination of fresh produce was simulated using baby spinach.

Preparation of a soy protein-based hydrogel: Soy protein hydrogels were prepared using cooked soy protein isolates (SPI) in combination with [2-(methacryloyloxy)ethyl]dimethyl-(3-sulfopropyl)ammonium hydroxide (SBMA) monomers. Using simple mixing, SPI-SBMA hydrogels were readily formed via a free radical polymerization reaction.

Results to Date

Rapid and uniform deposition of bio-based antimicrobial coatings on plastics: Surface-bound chlorine concentration was 262.50–700.00 nmol/cm² (Figure 1a).

Enhanced stability and antimicrobial activity under processing conditions: The antimicrobial coating resulted in >4 log reduction in 2 min. The coating compositions were stable in water or the presence of COD (Figure 1b, 1c). These coatings reduced cross-contamination of baby spinach (>2 log reduction) (Figure 2).

Characterization of SPI-based hydrogel: Porous structure with SPI encased in SPI-SBMA hydrogels was formed (Figure 3d, 3e) and validated using spectroscopy (Figure 3f).

Antimicrobial and antifouling functions of SPI-based hydrogel: The chlorinated 10% SPI-SBMA hydrogel (Figure 4a–d) inactivated 7 log CFU of *E. coli* within 5 min of contact (Figure 4e) and reduced biofouling (Figure 4f).

Benefits to the Industry

The bio-based coatings developed with food-grade components and/or food contact polymers in this project would enable stable and rapid deposition of antimicrobial agents on existing food contact surfaces and reduce the risk of cross-contamination of fresh produce. Success in this project will address the unmet needs to develop novel approaches for continuous sanitation of harvest equipment using food-grade ingredients combined with an approved sanitizer.

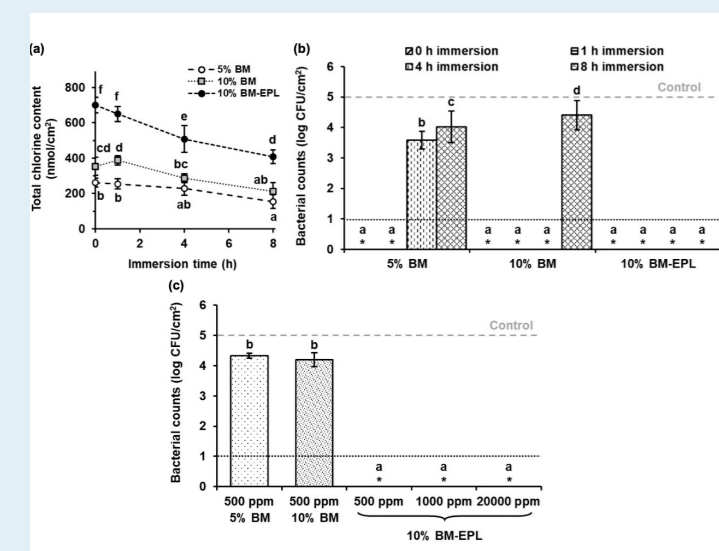


Figure 1. Evaluation of the Bio-Mos/beeswax coatings under simulated processing conditions: (a) chlorine stability and (b) antimicrobial activity after water immersion; (c) antimicrobial activity in the presence of organic matter at different chemical oxygen demand (COD) levels. 5% BM: coupons coated with a 5% Bio-Mos solution. 10% BM: coupons coated with a 10% Bio-Mos solution. 10% BM-EPL: coupons coated with a 10% solution of Bio-Mos encapsulated with ε-poly-L-lysine.

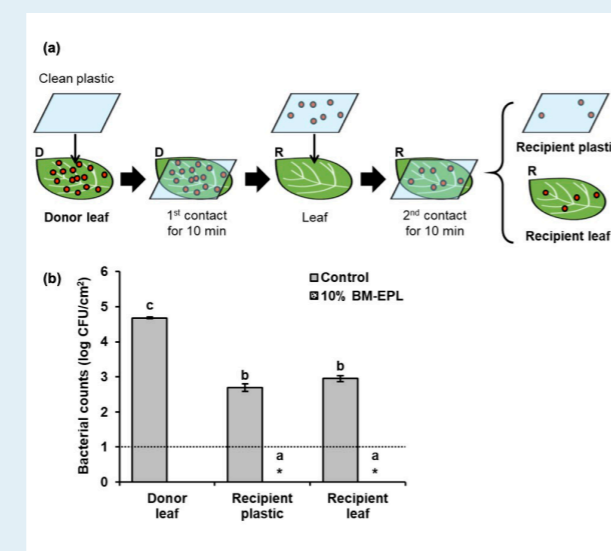


Figure 2. Effect of the Bio-Mos/beeswax coatings on reducing cross-contamination of fresh produce. (a) A schematic diagram of the simulated cross-contamination process. (b) Bacterial counts recovered from the selected samples (donor leaf, recipient plastic/leaf).

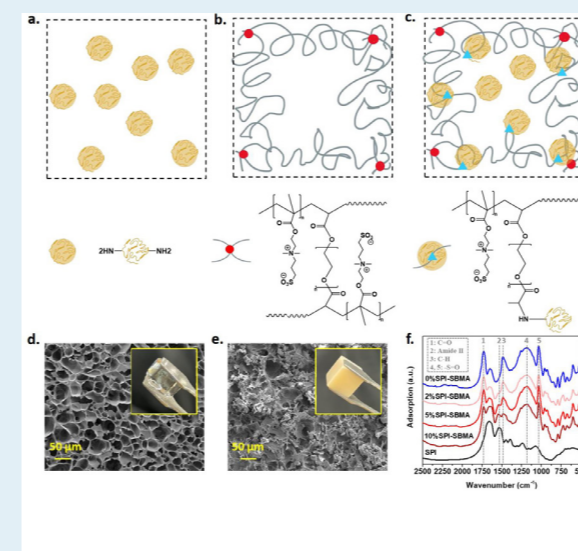


Figure 3. Scheme of (a) cooked soy protein isolate suspension, (b) PEGDA crosslinked polymerized SBMA gel, and (c) SPI-SBMA semi-interpenetrating gel with potential chemical crosslinking via PEGDA. SEM images and optical images of (d) 0% SPI-SBMA hydrogel and (e) 10%SPI-SBMA hydrogel, respectively; (f) FT-IR spectra of SPI and SPI-SBMA hydrogels with different SPI contents.

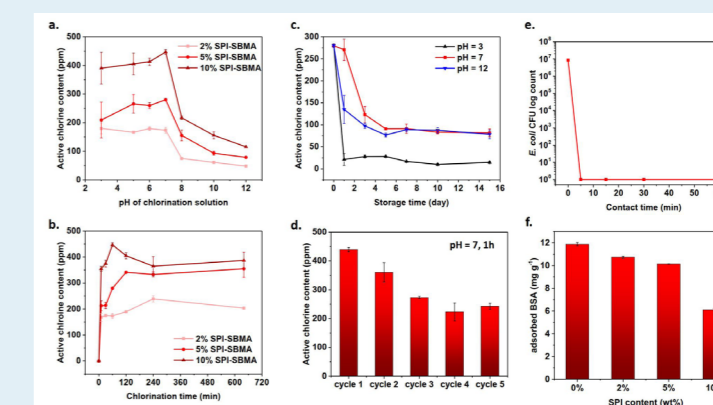


Figure 4. Active chlorine contents of SPI-SBMA hydrogels as a function of (a) pH chlorination solutions and (b) chlorination time. (c) Active chlorine stability of the chlorinated 10% SPI-SBMA hydrogel stored in different pH conditions. (d) Active chlorine contents of 10% SPI-SBMA hydrogel with 5 chlorine charging–quenching cycle tests. (e) Time-dependent biocidal activities of the chlorinated 10% SPI-SBMA hydrogel against *E. coli*. (f) BSA protein adsorption capacities of the SPI-SBMA hydrogels with different SPI content.