

Antimicrobial packaging to improving the safety, shelf life and waste reduction of various types of food

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Why Antimicrobial Packaging

- Antimicrobial packaging is one of multiple interventions to enhance microbial safety, quality, and shelf-life of foods
- When microorganisms attach to food, they may survive after pasteurization/sanitizing steps. Under suitable conditions, they may grow during storage, transportation and marketing before home consumption.
- Antimicrobial packaging provides a final defense system to kill or inhibit pathogenic and spoilage microorganisms in foods

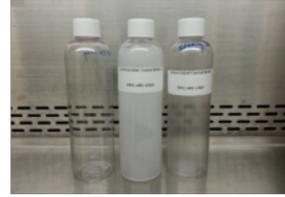
Prototypes Developed and Evaluated in My Lab

- Antimicrobial bottles for liquid food
- Antimicrobial solutions for food surface coating
- Antimicrobial films (bag/pouch) for film packaging
- Antimicrobial patches for releasing gaseous antimicrobials
- Containers with antimicrobial surface
- Antimicrobial packaging + other technologies

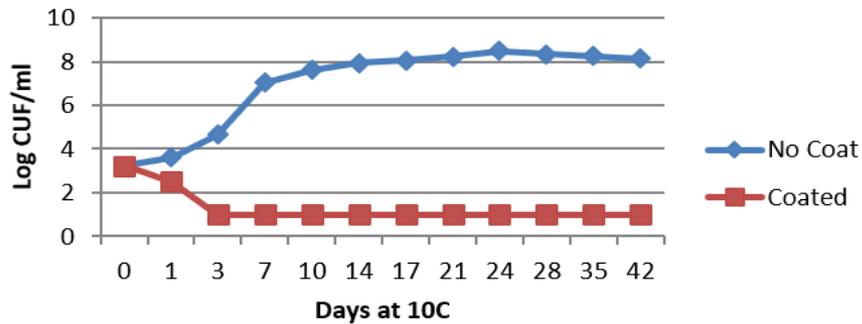
Foods Evaluated

- **Juice/beverage:**
 - Fruit juice/puree
 - Liquid egg
 - Milk
- **Produce:**
 - Apple
 - Banana
 - Cantaloupe
 - Orange
 - Tomato
 - Strawberry
 - Blueberry
 - Spinach
 - Lettuce
 - Broccoli
- **Poultry and meat:**
 - Shell egg
 - Read-to-eat deli meat
 - Roast beef
- **Seafood**
 - Raw and RTE Shrimp
- **Dessert**
 - Cake
- **Dairy**
 - Cheese

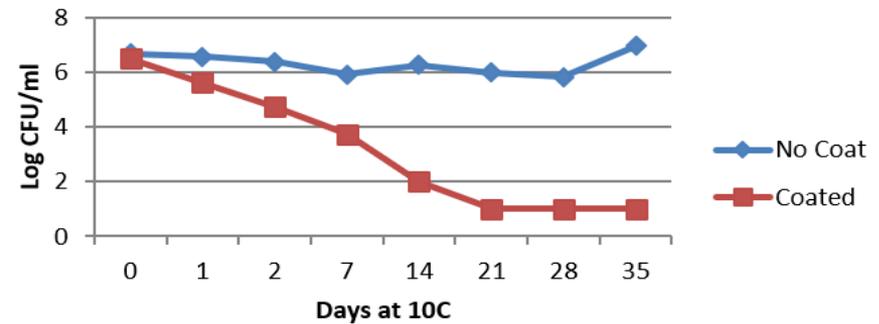
Inactivation of pathogens in bottled juices and beverages



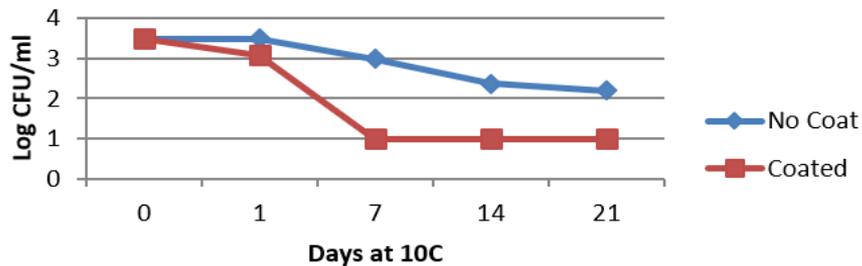
L.monocytogenes in milk



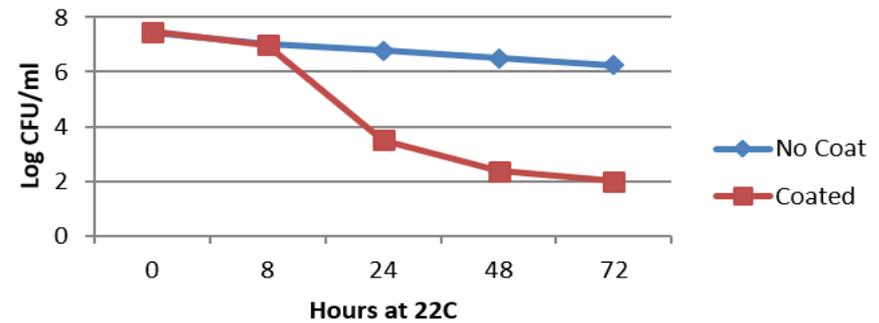
Salmonella in liquid egg white



E.coli O157:H7 in strawberry puree



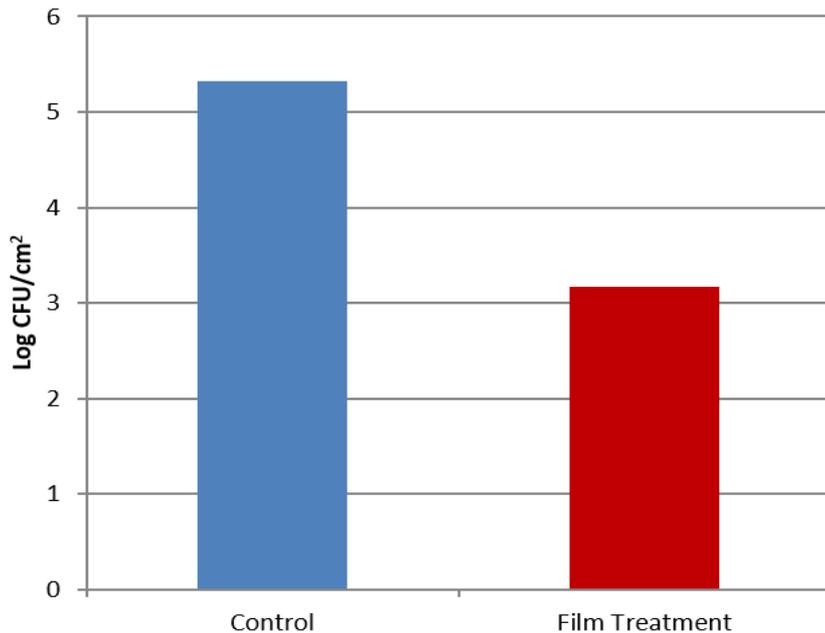
E. coli O157:H7 in orange juice



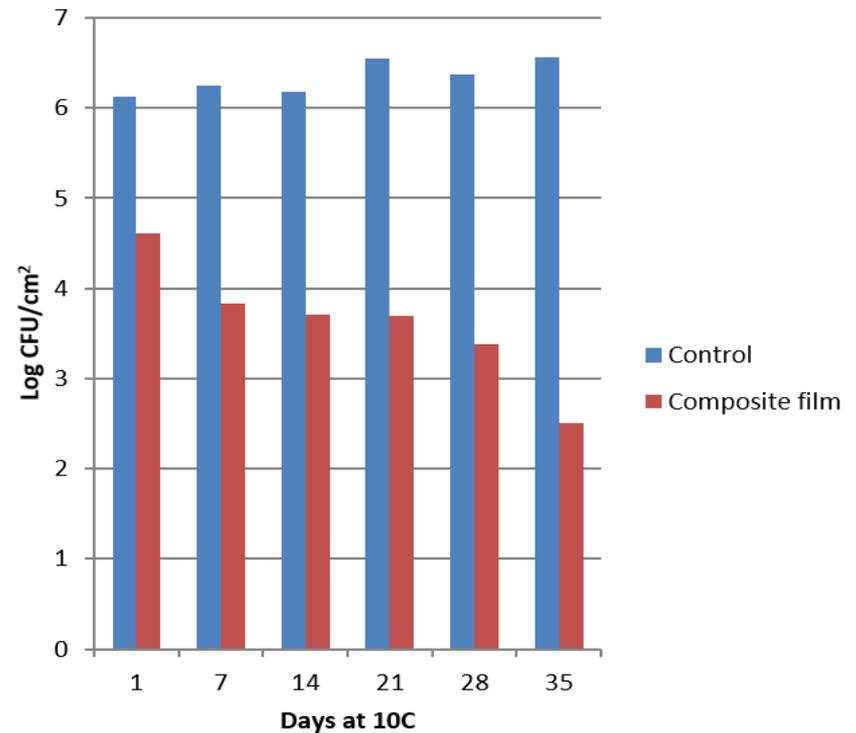
Antimicrobial composite films



Inactivation of *L. monocogenenes* on RTE meat by composite film



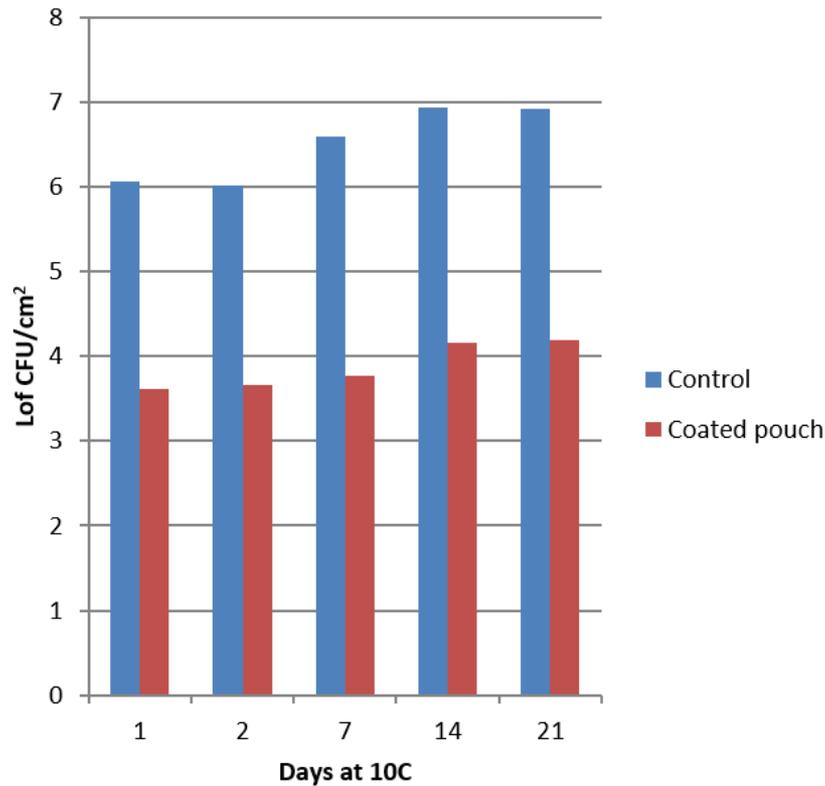
Inactivation of *L. innocua* on RTE meat by composite film



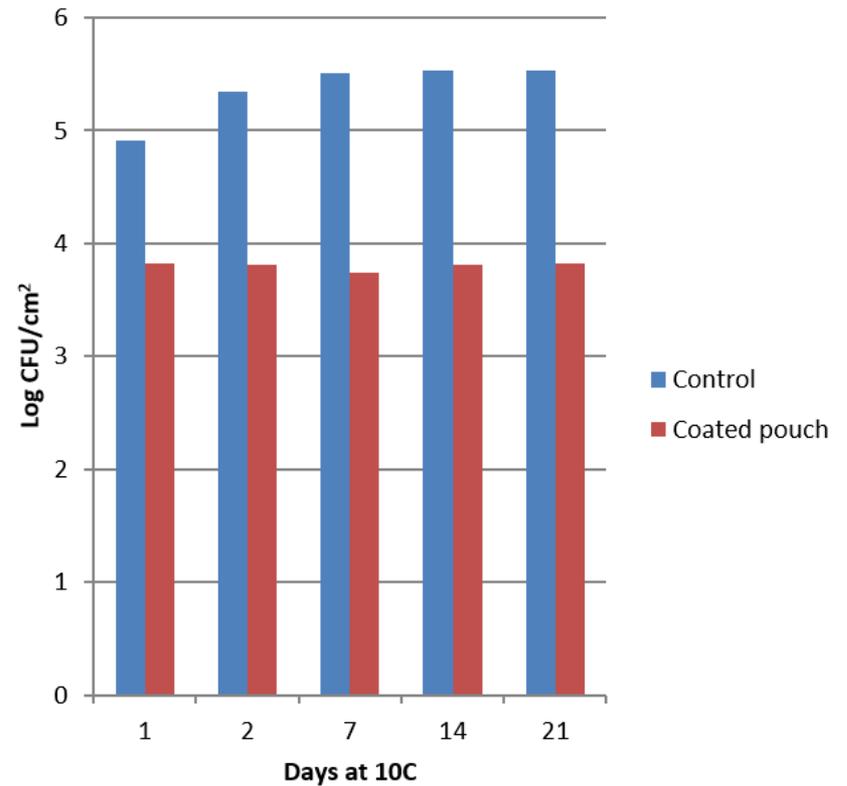
Antimicrobial coated pouch



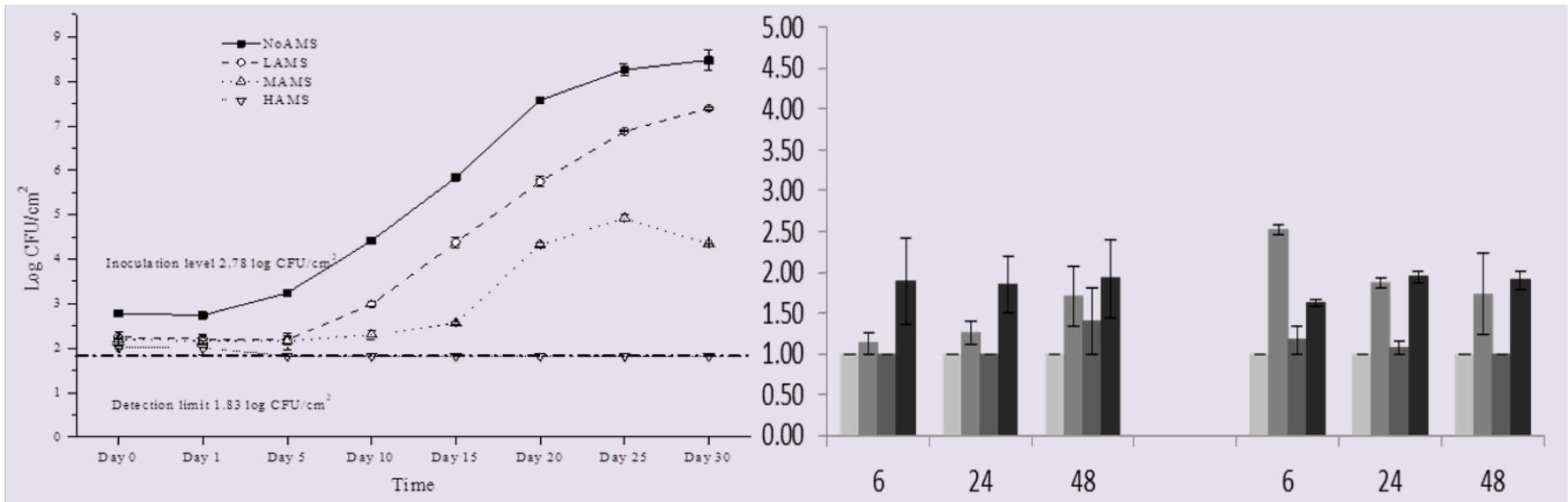
Inactivation of *L.monocytogenes* in RTE meat by coated pouch



Inactivation of *S.Typhimurium* in RTE meat by coated pouch



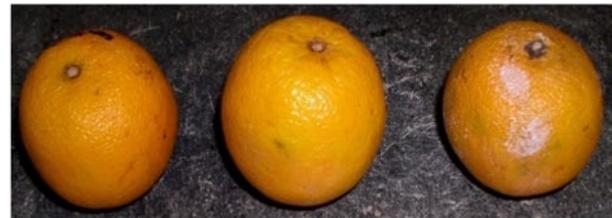
Antimicrobial solutions used for coating or marinate for beef



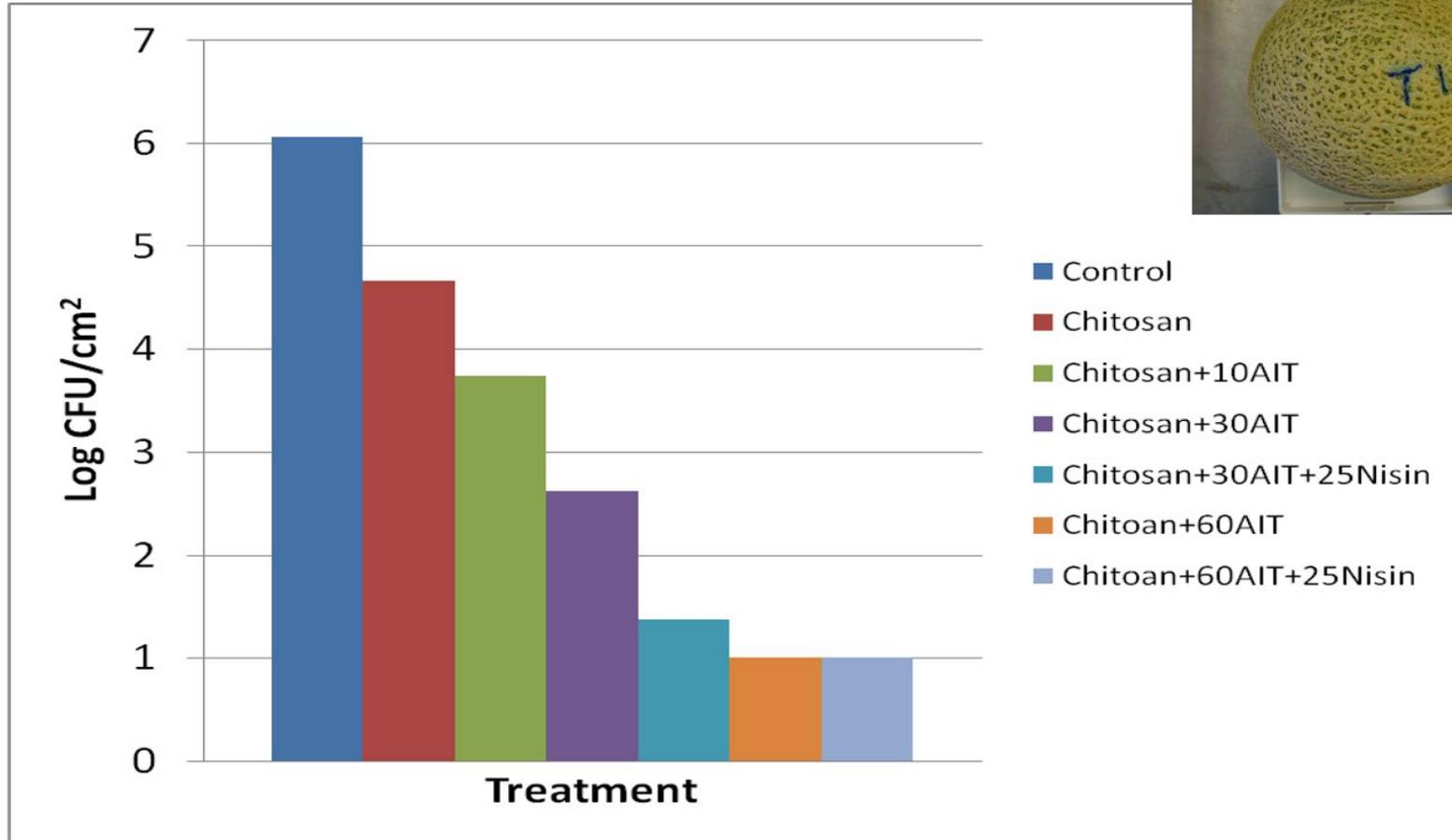
Effects of different concentrations of antimicrobial solution on *Listeria* cocktail on roast beef

Survived *Escherichia coli* O157:H7 cocktail after raw beef being marinated by antimicrobial solution

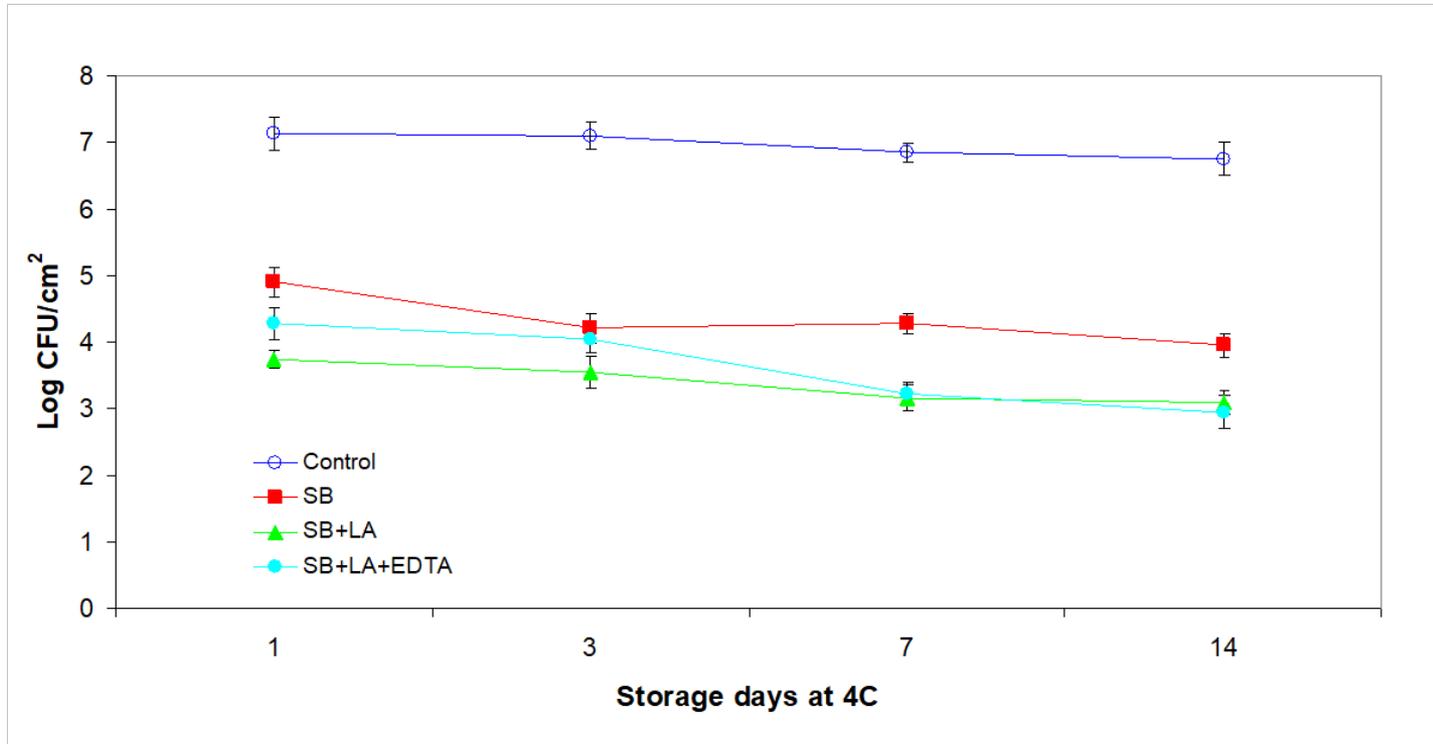
Edible and non-edible food surface coatings (direct coating)



Survival of *Salmonella* on cantaloupe surfaces as affected by the application of antimicrobial coatings.



Inactivation of *Salmonella* stanley on apple surface by antimicrobial PLA coating



SB: Sodium benzoate; LA: Lactic acid

Coating Treatment of Apples and Stored at Room Temperature



4 Mons

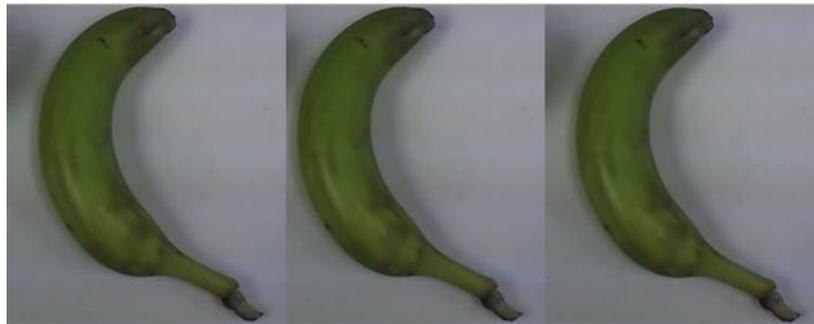


Control
without
solvent

7 Mons

PLA + solvent coating only

Coating Treatment of Banana and Stored at Room Temperature



0 week



1 week



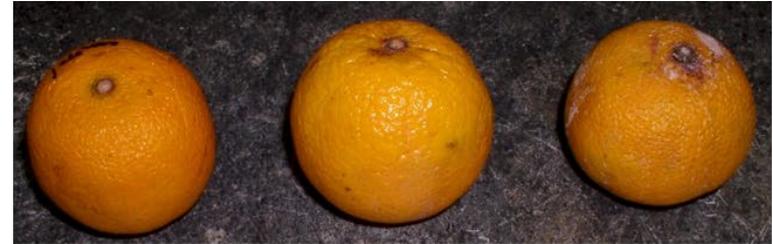
2 weeks

Control; solvent; PLA+solvent

Coating Treatment of Orange & Stored at Room Temperature



1 week



2 weeks



3 weeks



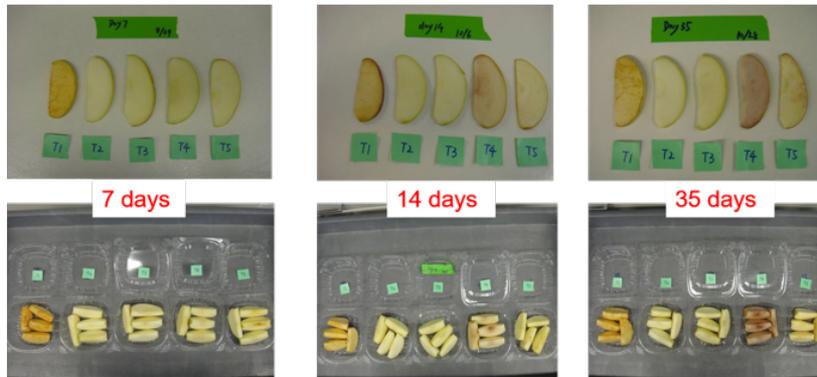
4 weeks



5 weeks

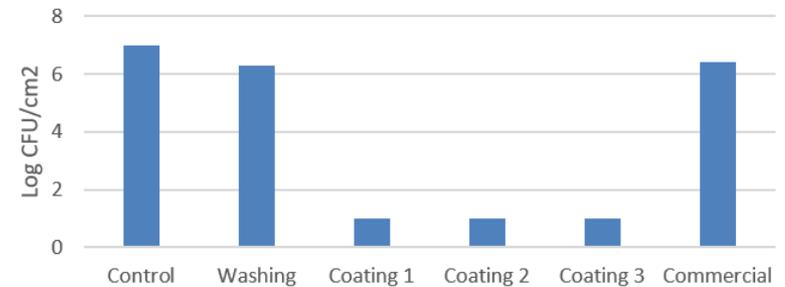
Control; PLA+solvent; PLA+solvent+sodium benzoate

Antimicrobial coating keeps fresh-cut apple fresher and safer.

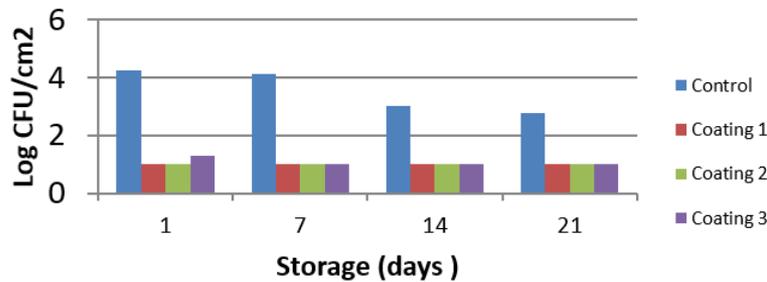


T1: Control; T2: Coating 1; T3: Coating 2; T4: Coating 3; T5: Commercial product

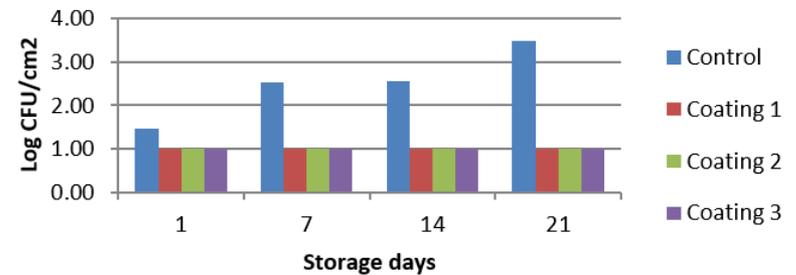
Survival of Salmonella on apple slices after treatments



Survival of Salmonella on apple slide during storage at 4C



Mold and yeast on apple slide during storage at 4C



Another Challenge

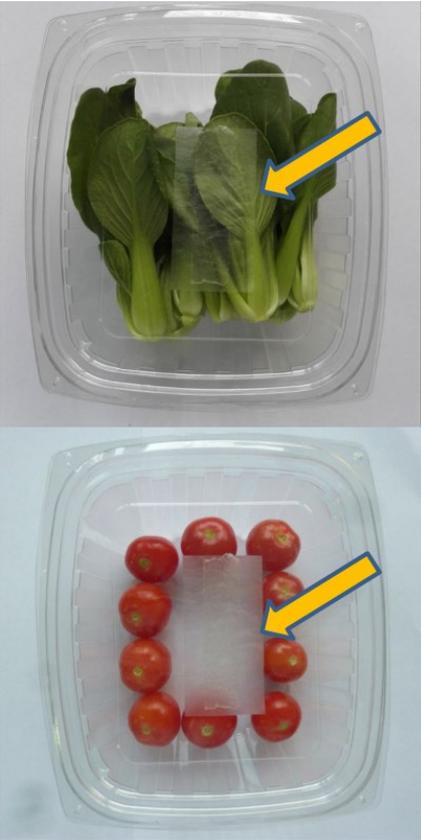
- Although surface coating is better than liquid washing, there are some limits, such as product shape, product type, or crack and crevice, causing slow penetration and lower efficacy.



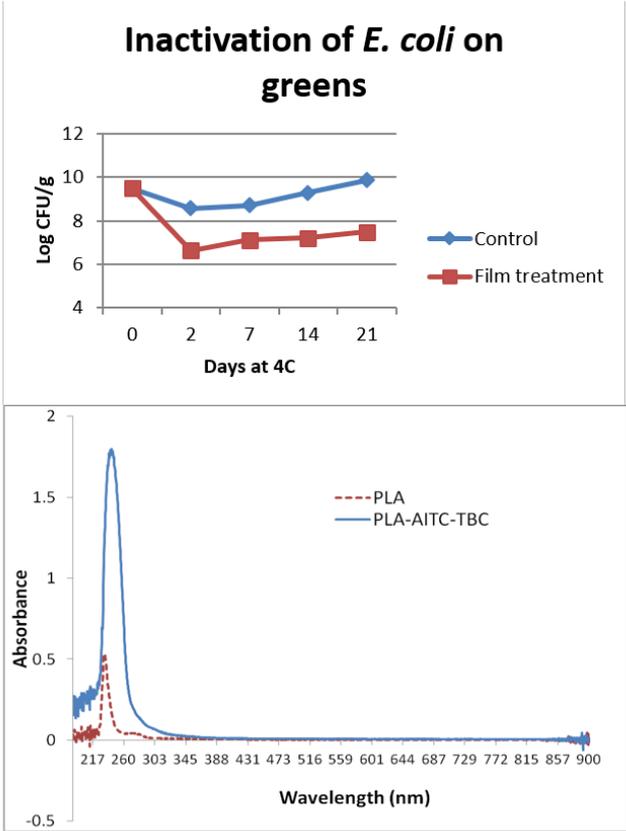
Approach 2: Gaseous Sanitizers

- Gaseous/volatile antimicrobials have rapid penetration and penetrate/diffuse to any hole or pore in food, not limited to product shape or product type.

Self release antimicrobial Film

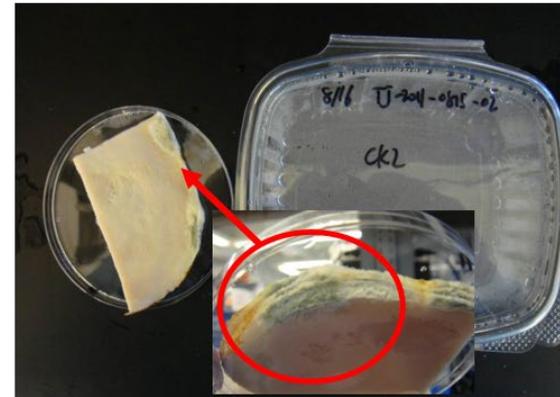
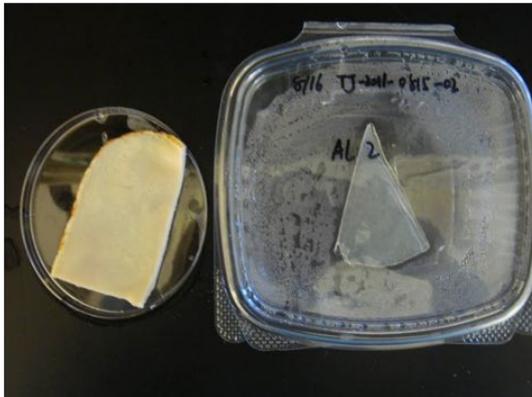
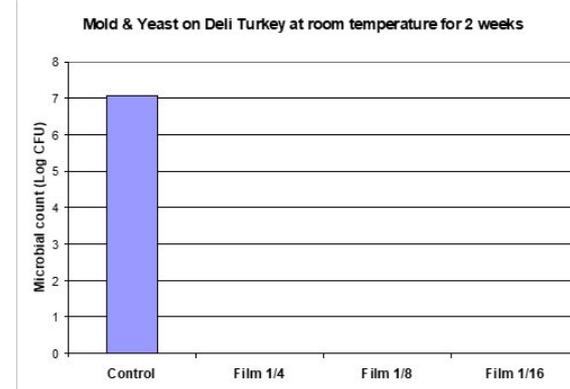
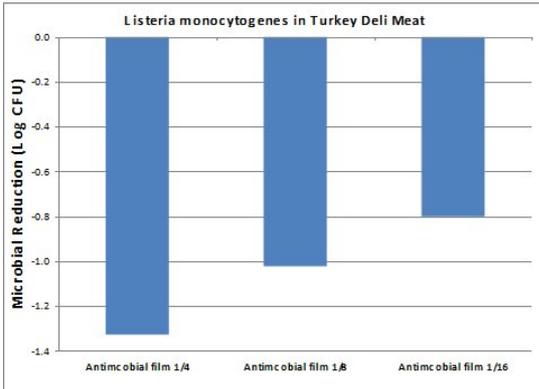


PLA+AIT film



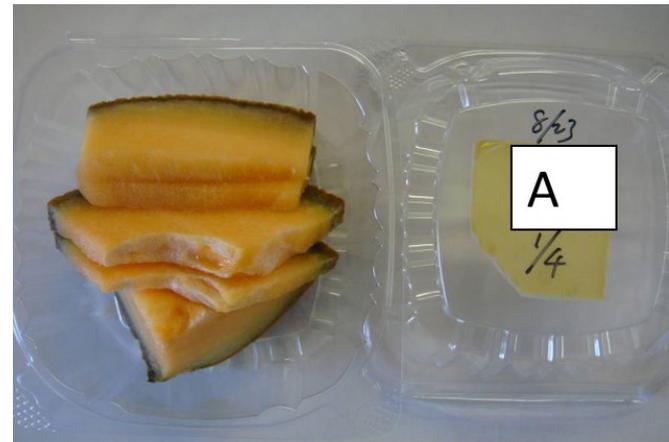
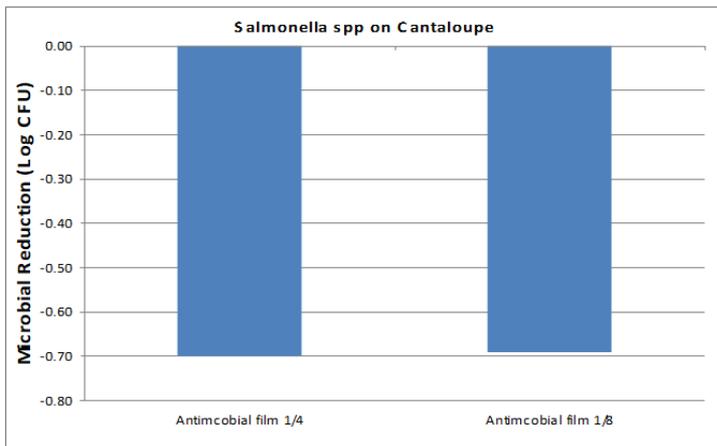
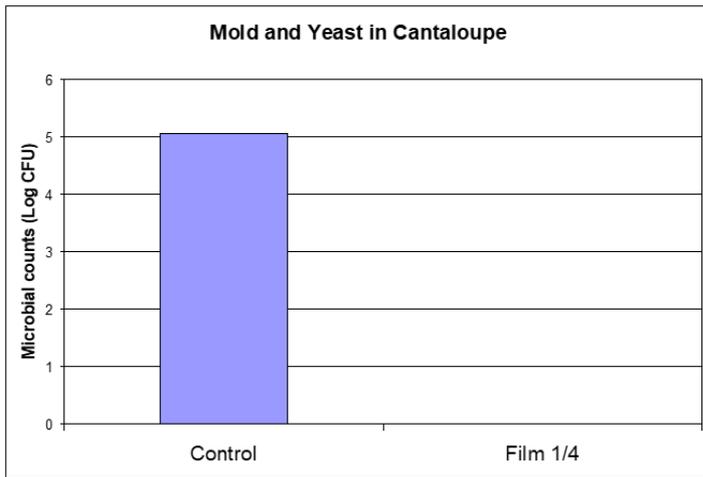
Gao et al. 2018. Inter J. Food Sci. Tech. 53, 1983-1991;
Gao et al. 2017. J. Food Control. 73:1522-1531.

Self release film for deli meat

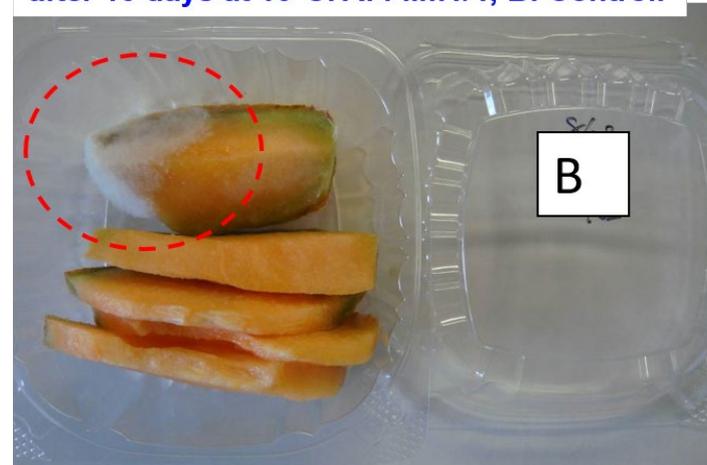


Appearance changes of deli meat in boxes with antimicrobial films after 14 days at room temperature

Self release film for fresh-cut cantaloupe

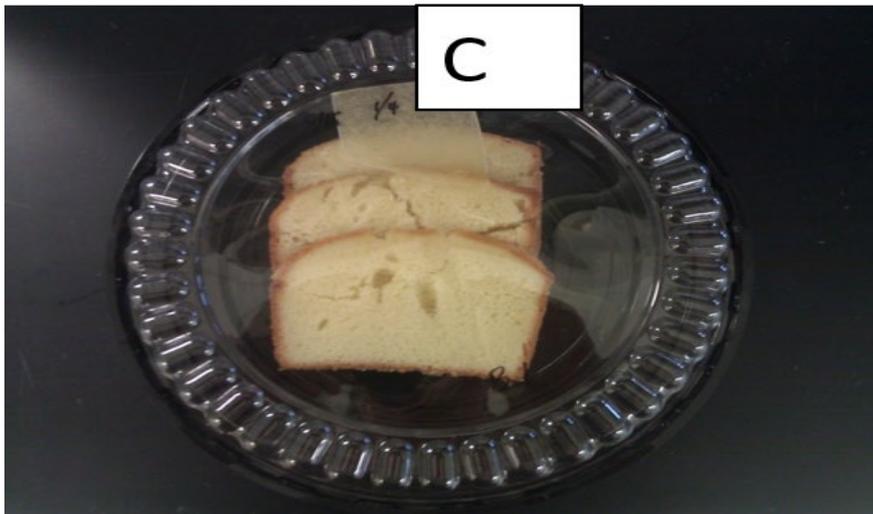


after 10 days at 10°C. A: Film1/4; B: Control.



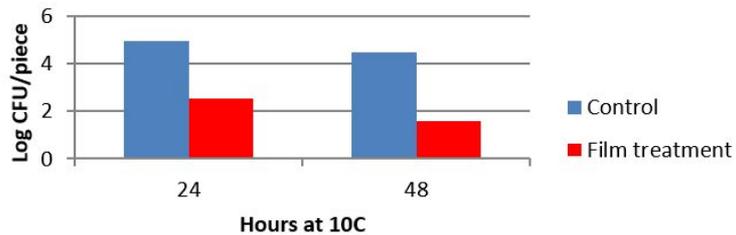
Self release antimicrobial film for cake

- Appearance changes of cake in boxes with antimicrobial films after 17 days at room temperature. A: Film1/4; B: Control; C: in cake box

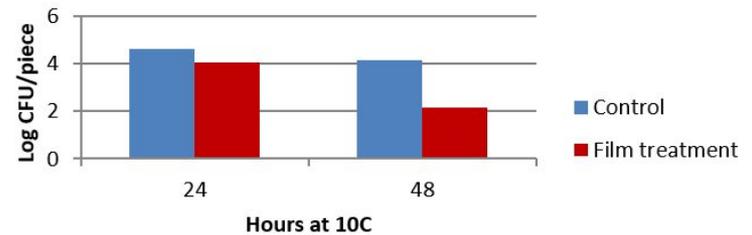


Self activated antimicrobial film – triggered by food

Inactivation of *Listeria* on tomato stem scar



Inactivation of *E. coli* on tomato stem scar

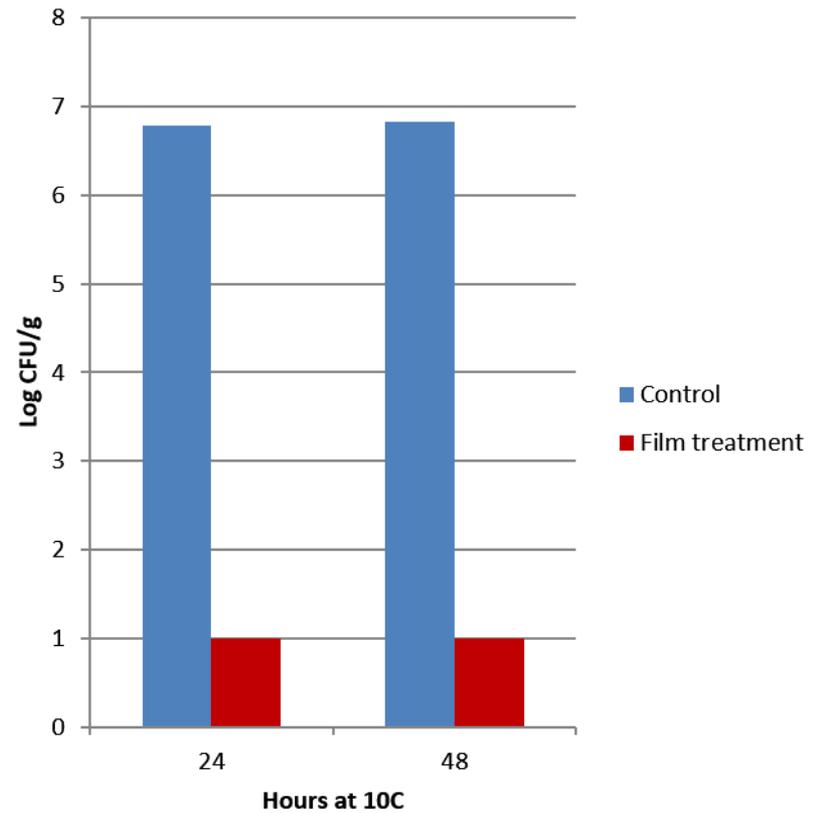


(after 60 days at 4C)

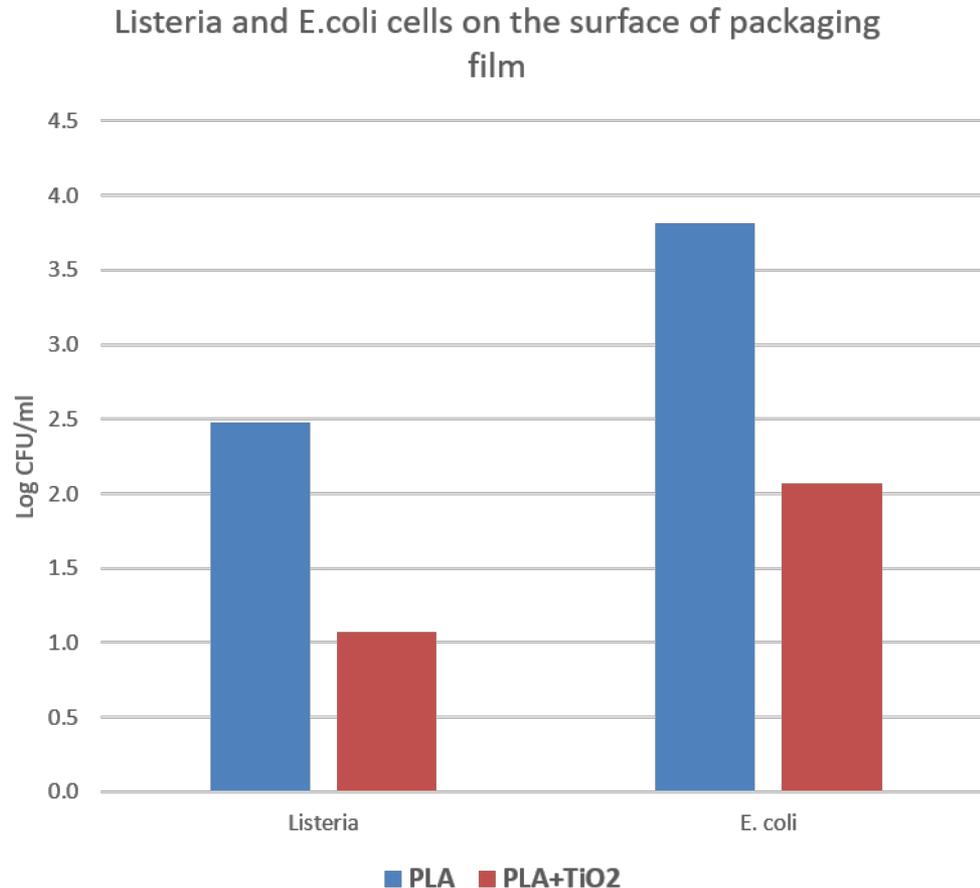
Inactivation of *E.coli* in broccoli



Inactivation of *E. coli* in broccoli



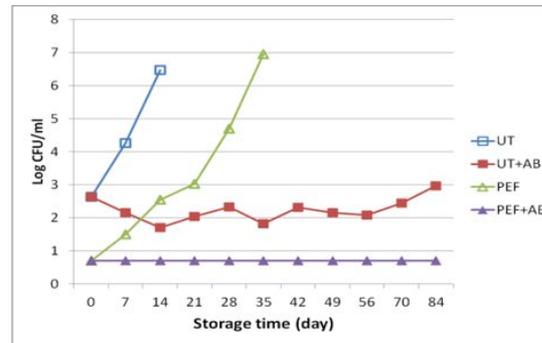
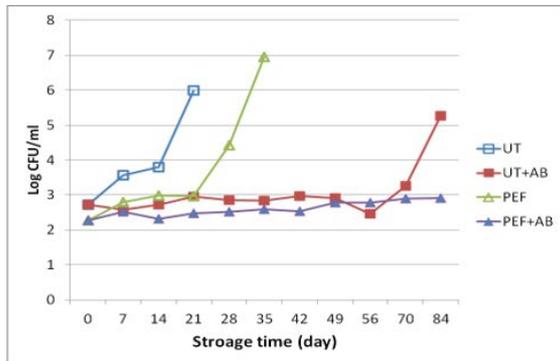
Package Materials with Antimicrobial Surface



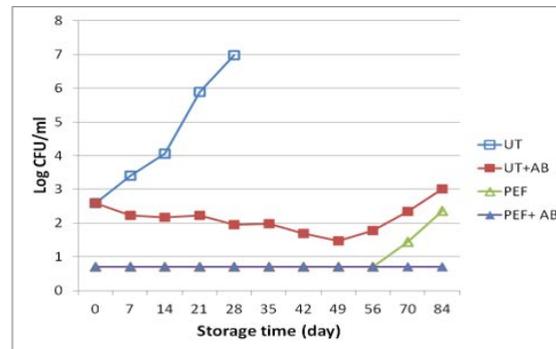
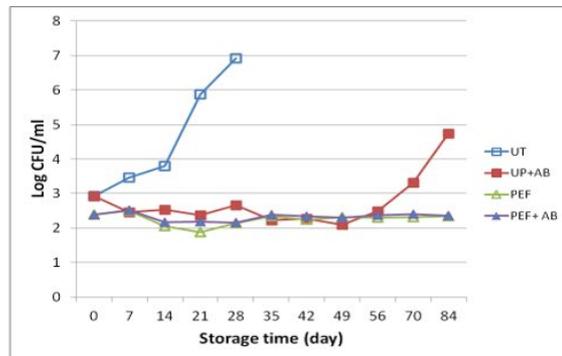
Polylactic acid (PLA) films with TiO₂ nanoparticles had significantly lower survivals of Listeria and E.coli cells on the surfaces than those without TiO₂ nanoparticles.

Integration of Antimicrobial Packaging with Other Technologies

Combination of pulsed electric field processing and antimicrobial bottle - pomegranate juice



Lab Scale



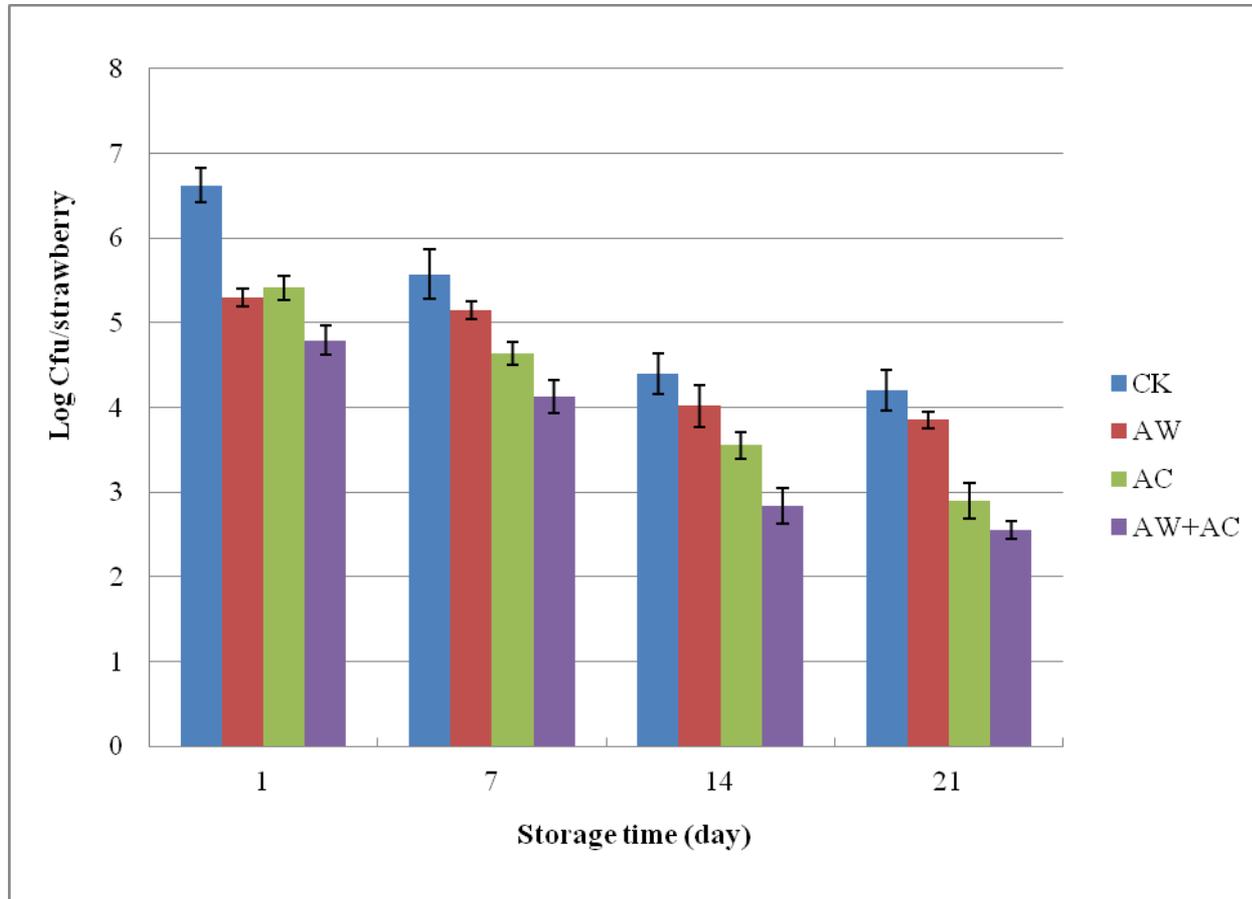
Pilot Scale

total aerobic bacteria

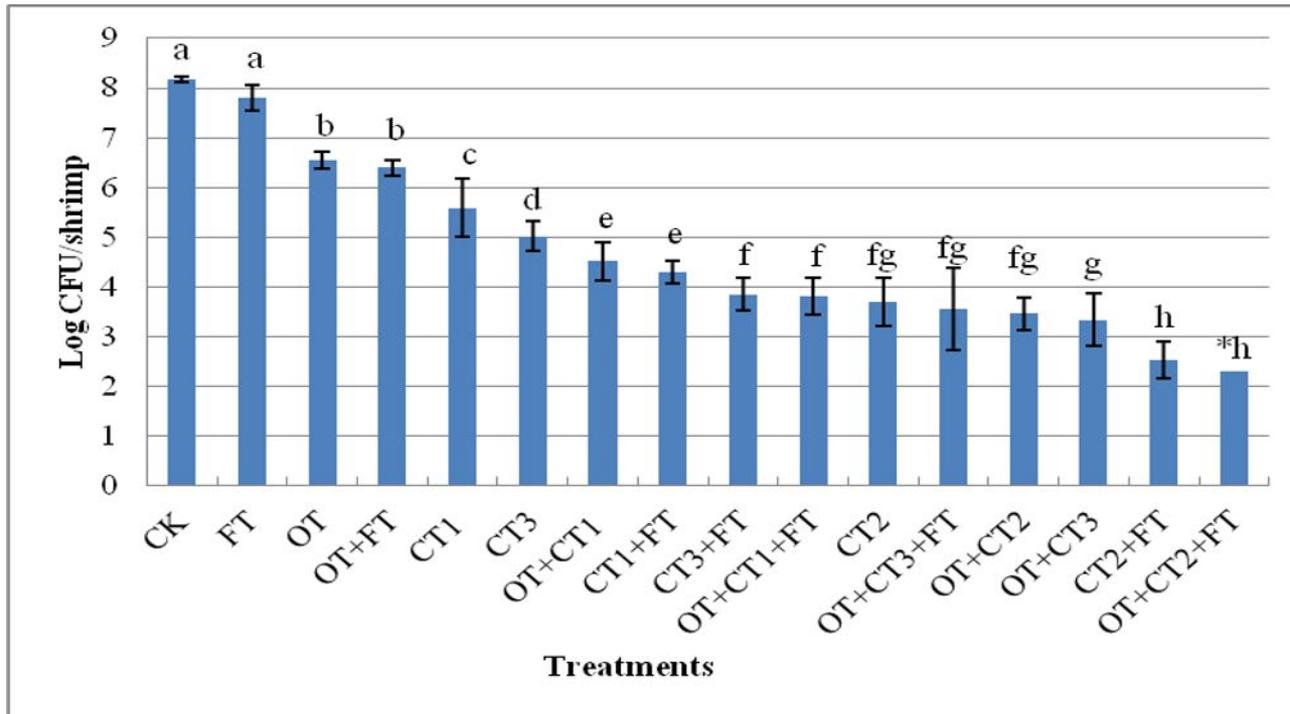
molds and yeasts

UT: untreated; UT+AB: untreated and packaged in antimicrobial bottle; PEF: PEF processed; PEF+AB: PEF processed and packaged in antimicrobial bottle

Combination of antimicrobial coating (AC) and washing (AW) on survival of E.coli O157:H7 and Salmonella on strawberries



Combinations of antimicrobial coating (CT) with Ozone (OT) and Cryogenic freeze (FT) on *L. innocua* in shrimp



Antimicrobial Packaging

- Increase of antimicrobial efficacy by
 - increasing relative higher concentration on food surface
 - keeping constant concentration of antimicrobials on surface by controlled release
 - increasing surface contact time
- Use of less amount of antimicrobials to achieve the same effect, or
- Use of the same amount of antimicrobials to achieve better effect

Summary and Conclusion

- Multiple prototypes developed for various food
 - Simple and easy to use
 - For homes, stores, warehouses, manufacturers, etc.
- Antimicrobial packaging/container is a unique and effective approach to:
 - reduce foodborne pathogens
 - Extend shelf life
 - Reduce waste
 - Maintain quality

THANK YOU!

