



**intralytix**  
SAFETY BY NATURE™

# Bacteriophages: Gently Modifying Food Microflora to Improve Food Safety

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# Foodborne Illness – Causes

- Chemical, parasitic, viral
- Bacterial
  - Salmonella
  - Shigella
  - E. coli
  - Campylobacter
  - Listeria

## Foodborne Illness – Costs

- In the US, 48 million people / year are sickened
  - 128,000 are hospitalized
  - 3,000 die
- \$6.9 billion annually
- Reducing foodborne illnesses by 10%:
  - Prevent ~5 million foodborne illnesses
  - Save \$700 million



# Current antimicrobial methods

- Irradiation
- Ultrasonic processing
- Thermal treatment
- Modified atmosphere
- Chemicals

## Drawbacks

- Not natural
- Not environmentally friendly
- Affect organoleptic qualities
- BROAD-SPECTRUM

# Natural bacterial populations

	Aerobic bacteria (average CFU/g)	<i>E. coli</i>	<i>Salmonella</i>	<i>Listeria</i>
Fresh-cut vegetables	1E+07	11.4%	1.7%	-
Whole vegetables	8E+05	7.1%	-	-
Fresh-cut fruit	6E+03	-	-	-
Sprouts	8E+07	40%	-	-



# Phages are common in foods

- Fresh ground beef
- Canned corned beef
- Fresh pork sausage
- Fresh chicken meat
- Delicatessen meat
- Farmed freshwater fish
- Oil sardines
- Cheese and raw milk

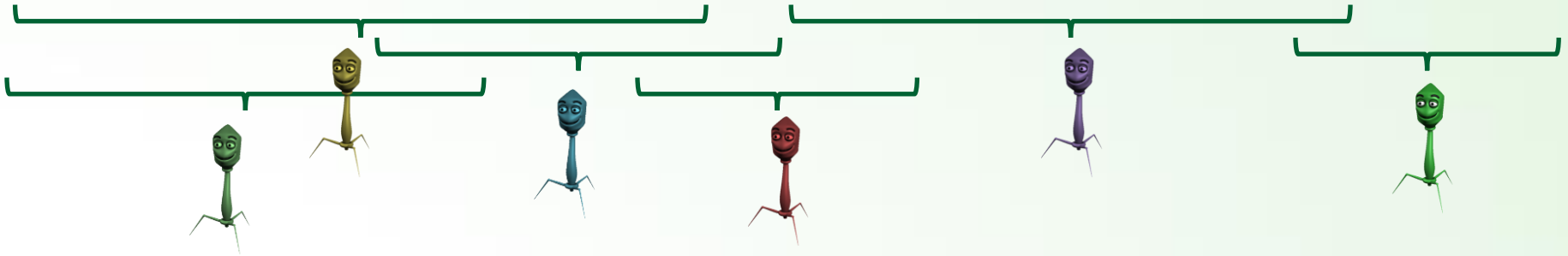
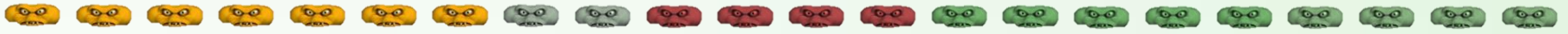
Levels ranged:

- $4 \times 10^{10}$  PFU/100g fresh chicken and pork
- $3 \times 10^{10}$  PFU/100g roast turkey breast
- Up to  $10^9$  PFU/mL of yogurt and cheese whey



# Phages and Safety

- Used to prevent and treat infectious diseases
- Therapeutic applications
- Potential applications for improving food safety  
recent trend







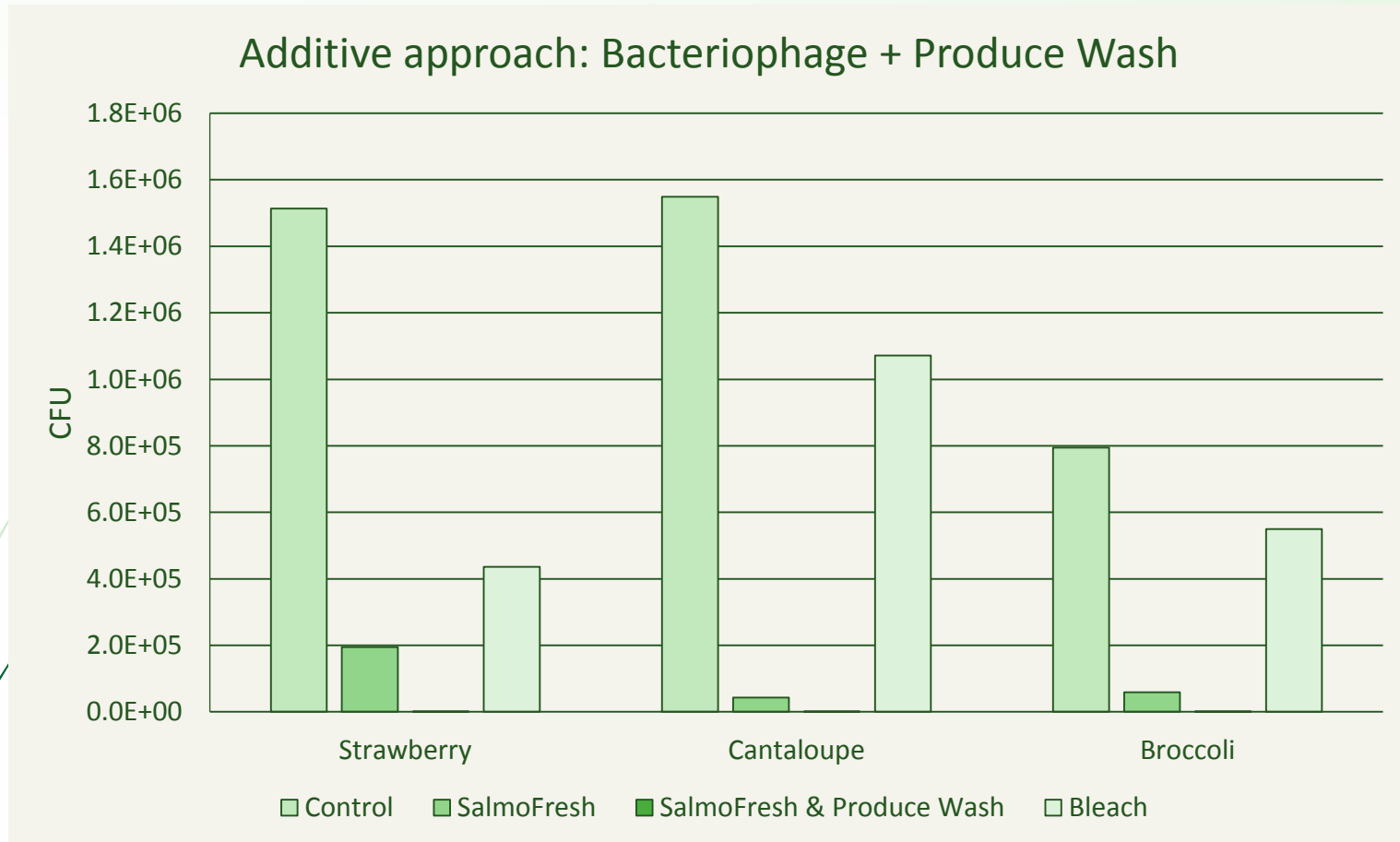
# Food safety applications

- Pre-harvest interventions
- Environmental decontamination
- Direct food applications

# Food safety regulatory approvals

Date	Agency	Phage preparation	Target application
2006, August	FDA, 21 CFR 172.785	ListShield	RTE meats
2006, October	FDA, GRN 198	Listex	cheese
2007, January	USDA, FSIS Directive 7120.1	E.coli O157:H7 targeted	hides of livestock
2007, March	USDA, FSIS Directive 7120.1	Salmonella-targeted	hides of livestock
2007, June	FDA, GRN 218	Listex	foods, generally
2008, July	USDA, FSIS Directive 7120.1	Salmonella-targeted	feathers of live poultry
2010, September	Health Canada	Listex	RTE meat, dairy, fish
2011, February	FDA, FCN 1018	EcoShield	ground beef
2012, August	FSANZ	Listex	meat, seafood, cheese, RTE foods
2013, February	FDA, GRN 435	SalmoFresh	Poultry, fish, fruits, vegetables
2013, December	FDA, GRN 468	Salmonex	Pork and poultry
2014, August	Health Canada	SalmoFresh	Poultry, fish, fruits, vegetables
2014, August	Israel Ministry of Health	SalmoFresh	Poultry, fish, fruits, vegetables
2014, August	Israel Ministry of Health	ListShield	RTE meats
2014, August	Israel Ministry of Health	EcoShield	ground beef
2014, December	FDA, GRN 528	ListShield	fruits, vegetables, dairy, fish

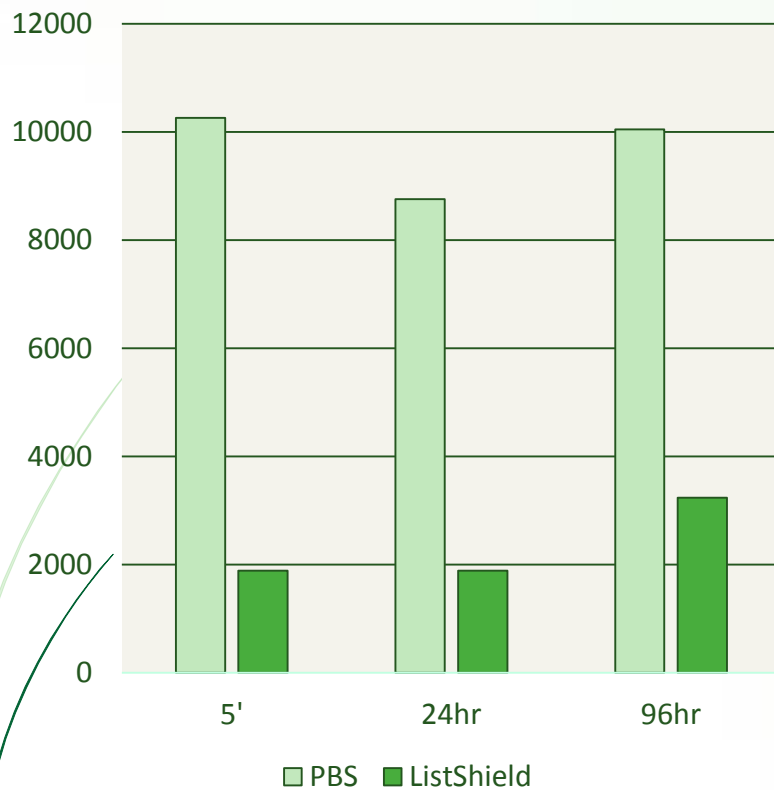
# Fruits and Vegetables



Magnone et al (2013). *J Food Prot*, 76(8),

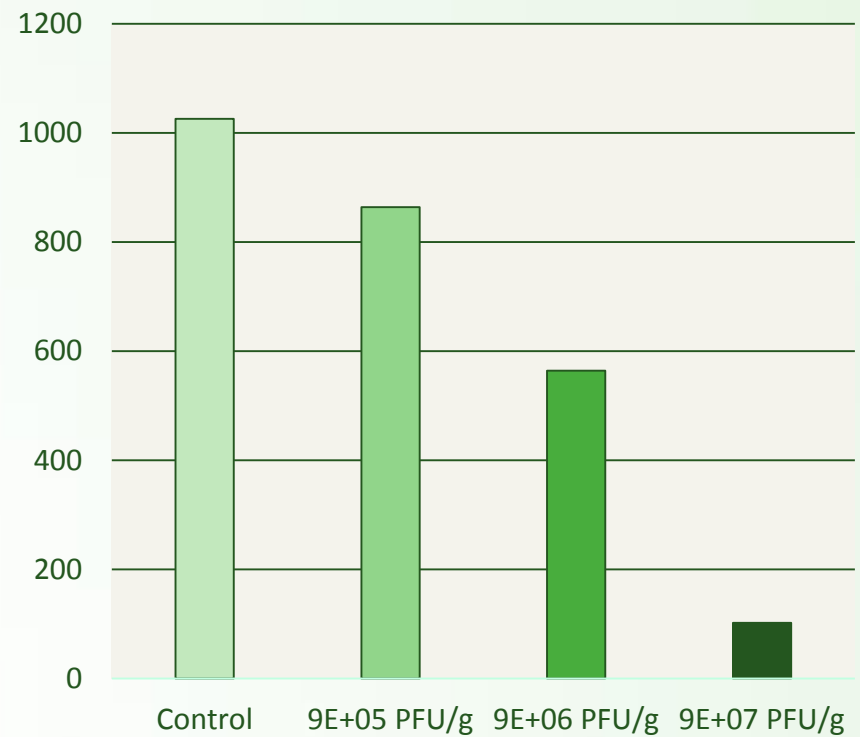
# Dairy

## ListShield on cheese



Perera et al (2015). *Food Microb*, 52:42-48

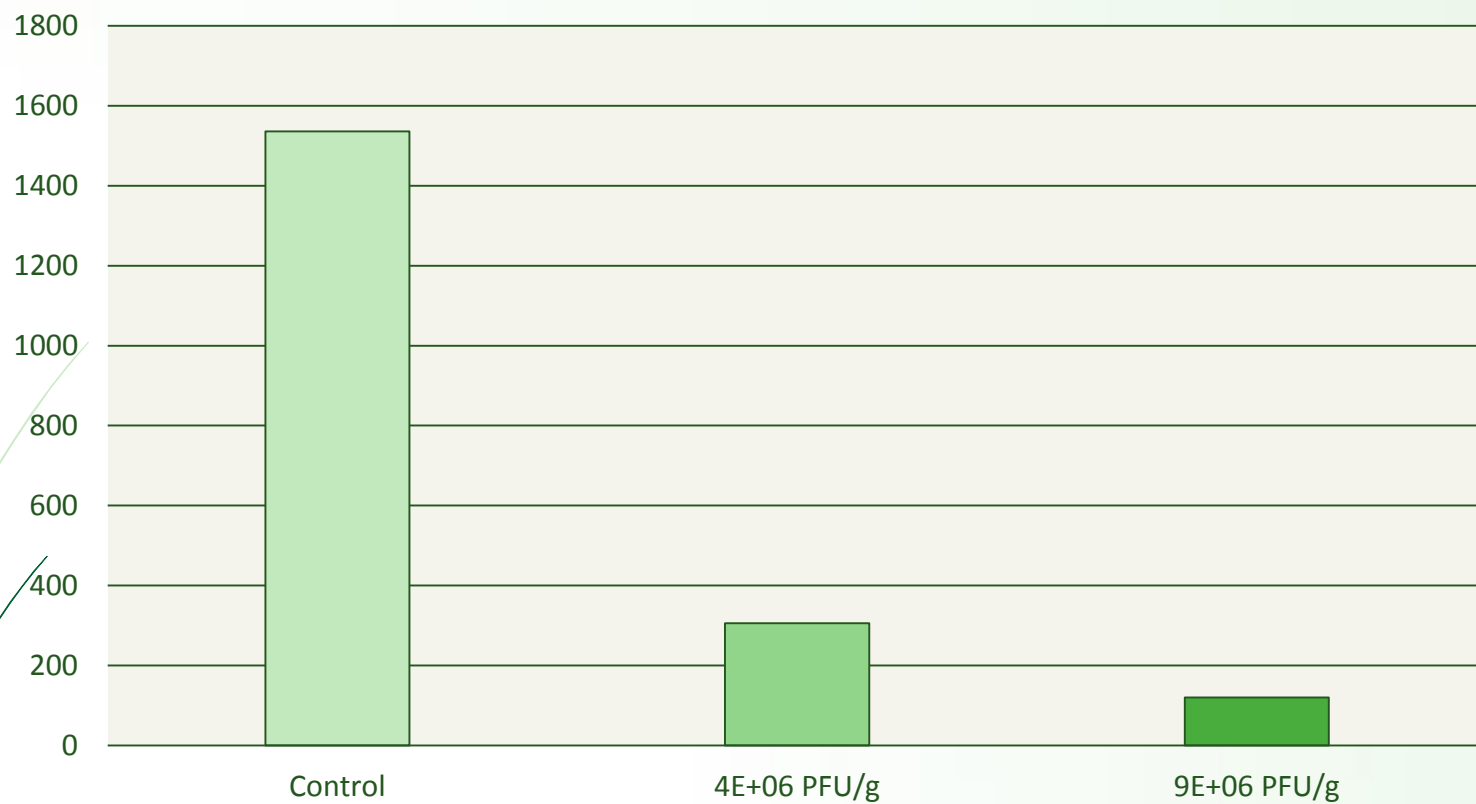
## ShigActive in yogurt



Unpublished

# Fish

## SalmoFresh on sushi-grade tuna

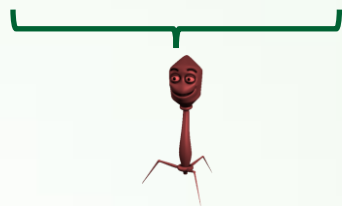
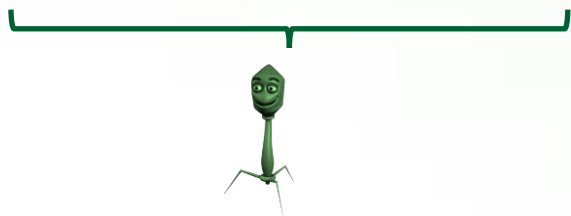
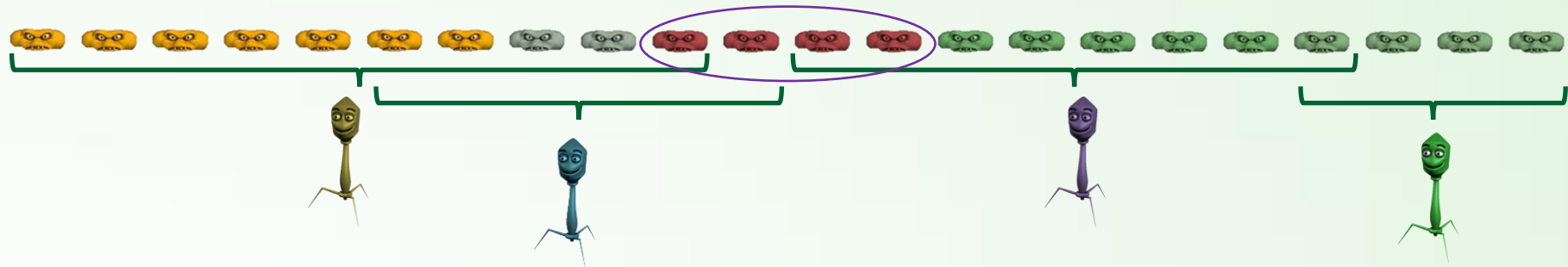


# Organoleptic testing

- ListShield™
  - oven roasted sliced turkey breast
  - cooked ham
  - meat bologna
  - roast beef
- No definitive identification
- No significant difference

## Effect of phage on gut microbiota

- Orally administered *E. coli*-specific phage T4 did not affect fecal counts
- No adverse effects upon volunteers
  - Bruttin & Brussow, 2005
- Orally administered *L. monocytogenes*-specific cocktail did not alter normal diversity of mouse GI tract microbiota
- No adverse effects upon mouse health
  - Mai et al, 2010






# Phages: Safety by nature

## Pros

- Environmentally-friendly, green
- Safe and effective
- Do not affect taste, appearance, smell of food
- Do not alter organic, Halal, or Kosher designations
- No adverse impact on normal microflora
- Flexibility to address bacterial resistance
- Target specific bacterial pathogens



***“Indeed, it’s this exquisite selectivity that makes them so appealing to food scientists. Find the right phage, and it will knock out the food poisoner of concern. And nothing else.”***

www.sciencenews.org, July 2010

## Phages: Cons

- Only effective against targeted pathogen
- Commonly used disinfectants may also inactivate
- Require refrigerated storage
- Acceptance
  - Food producer
    - Cost
    - Efficacy
    - Application method
  - Consumer
    - Food additives unpopular
    - Virus
    - Education



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