State of Science
Safety of Fresh Produce

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Status of Science

- **Body of science on produce safety is significant**
- **Current science is inadequate to address all questions on needed production, processing and handling; however,**
- **More applicable published science is available than is currently being transferred into everyday practices**
- **Need for integrated, concentrated, rapid, multidisciplinary approach to ferret out best practices not currently incorporated in industry**
- **Need for strengthened coordination and communication between all sectors – researchers, regulators, and industry on available science and current unpublished data**

Difficulties with Current Science

- Negative scientific data – rarely published but very applicable to safety of produce
  - USDA Microbiological Data Program 2003 Summary >10,700
- Difficulty in funding applied research and microbial surveys
- Speed of publication – many studies by researchers are completed yet not published or available for application
- Duplication – Some duplication needed to confirm findings yet lack of communication and coordination between researchers, regulators and industry leads to unnecessary loss of funds due to duplicative results.
- Lack of science based metrics for monitoring environment and practices – often based on water standards
- How do we solve these dilemmas?

Status of Science: Produce Safety

- Cross over of applicable research between commodities
- Pertinent research spans 60 years
- Research dollars miniscule compared to animal products
- Limited research on the farms – actual production areas

- Interpretive reviews of science status needed
- Goal of prevention of illness and contamination not supported by complete science

Produce Safety Research Areas

- In today's marketplace both domestic and imported important
- Many foci for research – complex questions involving diverse crops, widespread geographical areas, low levels of environmental contamination, microbial ecology and genetics, human and animal/produce proximity.

- Multiple pathogens and pathogen survivability in the environment
  - E. coli O157:H7 West coast, Salmonella – East coast

- Contamination Focus
  - Farm, packinghouses, processing, food service – entire chain
  - Development of Good Agricultural Practices
    - Practices presenting risk: feces, irrigation waters, soil amendments, previous and adjacent land use, etc.
  - Internalization of pathogens - inconclusive
  - Microbial Methods of Analysis
    - Slow analytical methods unacceptable, prompt validation of rapid methods is critical
  - Antimicrobial treatments – basically no 'kill' step available for most produce
    - Washing
    - Prevention of growth in Produce
    - Rapid approval by EPA essential to application of science

Tomato Food Safety Forum

- Forum Nov. 30,2006 Orlando attended by >85% of the U.S. fresh tomato production owners
- Scientific Bibliography – prepared by Drs. Buchanan and Gendel – reviewed > 100 papers
- Presentations on status of science and new research studies shared
- Available documents on GAPs and BMPs
- Initiated coordination and communications between researchers, regulators and industry in 7 eastern states
- All documents available on http://research.ifas.ufl.edu/tomato
- Follow-up Actions requested: Prioritization of research, communication increase, request to AFDO for assistance on Model GAPs

Tomatoes: Challenging “Common Knowledge”

- Tomatoes are an acidic food that do not support the growth of foodborne pathogens
  - Asplund and Nurmi, 1991
    - Small cubes of tomatoes supported growth of *Salmonella enterica* at 22° and 30°C but not at 7°C
  - Beuchat and Brackett, 1991
    - *Listeria monocytogenes* grew on whole cherry tomatoes at 21°C but not at 10°C
    - *L. monocytogenes* declined at 10° and 21°C in chopped tomatoes
  - Wei et al., 1995
    - *Salmonella* Montevideo survived on tomato skins and stem scars and grew in puncture wounds and on tomatoes slices at 20° and 25°C

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Tomatoes: Challenging “Common Knowledge”

- Standard wisdom: Tomatoes are an acidic food that do not support the growth of foodborne pathogens
  - Zhuang et al., 1995
    - *Salmonella* Montevideo grew on surface of tomatoes at 20° and 30°C but not at 10°C
  - Weissinger et al., 2000
    - Growth of *Salmonella* Baildon in diced tomatoes at 21° and 30°C, and slow decline at 4°C
  - Wade and Beuchat, 2003a
    - Chill injury and co-growth of proteolytic yeast enhanced the growth of *Salmonella enterica*
  - Wade and Beuchat, 2003b
    - *Salmonella* grew in puncture wounds at 15° and 25°C
  - Warriner, 2006
    - Variety of *Salmonella* serovars grew at 25ºC in tomatoes that had inoculated by vacuum infiltration

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Antimicrobial Treatments

A number of potential treatments have been evaluated

- Tap water
- Chlorinated water
  - Wei et al., 1995
  - Zhuang et al., 1995
  - Weissinger et al., 2000
  - Bari et al., 2004
  - Yuk et al., 2005
  - Simmons et al., 2006
- Hydrogen peroxide
  - Sapers and Jones, 2006
  - Calcinated calcium
    - Bari et al., 2002
  - Peroxyacetic acid
    - Yuk et al, 2005
  - Chlorine dioxide
    - Yuk et al., 2005
  - Trisodium phosphate
    - Zhuang and Beuchat, 1996

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Antimicrobial Treatments

A number of potential treatments have been evaluated

- Electrolyzed alkaline water (GC-100X)
  - Kwon et al., 2003
- Electrolyzed acidic water
  - Bari et al., 2003
- Electrolyzed neutral water
  - Deza et al., 2003
- Acidified sodium chlorite
  - Yuk et al., 2005
  - Organic acids
    - Ibarra-Sanchez et al., 2004
    - Yoon et al., 2004
  - Hydroxypropyl methylcellulose (HPMC) coating
    - Zhuang et al., 1996
  - Electron beam irradiation
    - Schmidt et al., 2006

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Primary Production

- Guan et al., 2005
  - Foodborne pathogens can survive in many pesticide solutions for at least 48 h
  - *Salmonella* Enteritidis and *E. coli* O157:H7 survived on leaves for up to 56 days, but only for 45 hr on tomato skins
- Rathinasabapathi, 2004
  - 3-log reduction of *Salmonella* Montevideo on tomato leaves and green tomatoes after 48 h at 60% RH but no reduction 100% RH
  - *Salmonella* Montevideo was unaffected by exposure of green tomatoes to ethylene

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JIFSAN/UF/IFAS
Tomato Safety Research Needs Workshop
February 21-22, 2007, College Park, MD

- Major goals of the workshop
  - to prioritize research needed to solve the problem of *Salmonella* and other human pathogens in tomatoes and
  - to begin the process of developing a platform for on-going communication and coordination.
  - Forty invited scientists across the U.S. representing academia, government, producers and trade groups participated.
  - http://www.jifsan.umd.edu/tomato_wkp2007.htm

Tomato Food Safety Priorities Identified

- **Are there alternate processing technologies (particularly ‘dry’ processing systems that can be used to reduce either the presence of spread of microbiological contamination?**
- **Are specific seasons, microclimates, or weather events associated with contamination of tomatoes in the field?**
- **What vectors and vehicles are important in transmitting pathogens to tomato plants and fruits? What is the mechanism of pathogen movement?**
- **What is the relative importance of internalization vs. surface contamination of tomatoes in the field?**
- **Are there specific microbial serotypes or genotypes associated with tomatoes? Are certain varieties of tomato more likely to carry pathogens?**

Tomato Research Priorities Cont'd

- **Are there effective approaches that can be used to inactivate internalized or attached pathogens? What interventions will reduce the risk of contamination.**
  How long can pathogens persist in tomato fields, in plant waste, chemical sprays, etc?

- **Are bodies of water in close proximity to tomato fields significant reservoirs for pathogen contamination of tomatoes?**

- **What are the cooling and cold chain requirements needed to prevent growth of pathogens on tomatoes?**

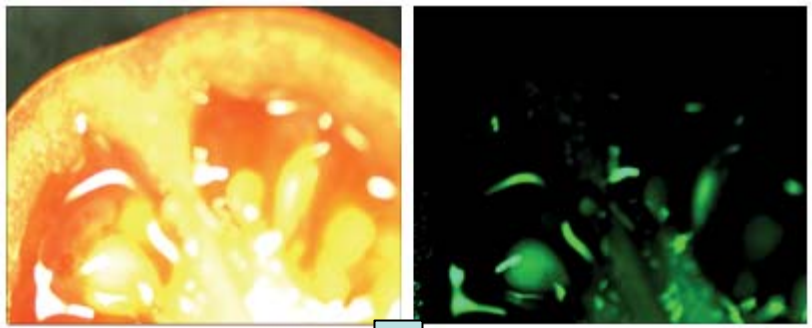
- **What proportion of tomato producers have implemented GAPs and to what extent? What are the barriers to GAPs implementation?**

Summary of Research Projects UF/IFAS

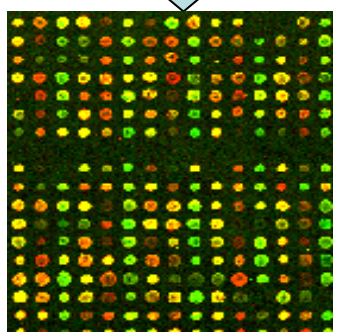
- **Microbiology Department**
  - **Internalization**
- **Soil and Water Science Dept.**
  - **Survivability of Salmonella in the environment, biofilm formations**
- **Plant Pathology Department**
  - **Post harvest treatments – antimicrobials**
- **Food Science and Human Nutrition Dept.**
  - **Sanitizers, chlorine levels, effects of ethylene, infiltration, storage, Round vs Roma**

How does *Salmonella* survive in tomatoes?

Construct *Salmonella* “promoter trap” library



Screen the library in tomatoes



Sort and identify tomato-specific *Salmonella* genes by hybridizing trapped promoters to a microarray

Knowledge will lead to development of targeted BMPs that can disrupt ability to colonize in produce

Teplitski, 2006-7
Soil & Water Science

Summary: Science Status

- Current science is expanding yet is inadequate to address all questions on needed production, processing and handling.
- Much more applicable science is available than is being utilized
- Need for rapid funding and completion of identified research priorities for all produce
- Need for integrated, concentrated, rapid, multidisciplinary approach to ferret out best practices not currently incorporated in industry
- Need for strengthened coordination and communication between all sectors – researchers, regulators, and industry
- Need to identify and communicate available science and current unpublished data and ongoing studies
- Need for critical review and creative long range thinking about the science available