Emerging Food Safety Challenges

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Outline

• Food safety impacts
• Foodborne illness investigation
• Foodborne illness and disease burden estimates of CDC and EPI
• Emergence of food pathogens and challenges
• Selected research works of mine
Food safety definition

Food safety (food hygiene) involves any practice in processing, preparation or handling of food to ensure it is safe.

Food safety is the state of acceptable and tolerable risks of illness, disease, or injury from the consumption of foods.
Food safety impacts
(risks of unsafe food consumption)

- On human health;
  
  ✔ Short run (hygiene depended) risks;
    ➔ throw-up, food poisoning, etc.

  ✔ Long run (nutrition content, production methods depended) risks;
    ➔ obesity, heart attack, diabetes, immune disorders, cancer, liver disease, GI issues etc.

*FDA estimates that 2-3% of all foodborne illnesses lead to serious secondary long-term illnesses.*
Causes of foodborne illnesses and diseases

Foodborne diseases result from ingestion of a wide variety of foods contaminated with pathogenic microorganisms, microbial toxins, or chemicals.
Foodborne illness investigation
What is a food illness outbreak?

When two or more people get the same illness from the same contaminated food or drink, the event is called a foodborne outbreak (2 or more unrelated cases).

**Case:** an instance of a particular disease

In an outbreak, there should be at least 2 or more unrelated cases reporting illness.

Exception: 1 case of a chemical-related foodborne illness or *Clostridium botulinum* poisoning constitutes an outbreak

**Why investigate?**

➔ Public health officials investigate outbreaks to control them, so more people do not get sick in the outbreak, and to learn how to prevent similar outbreaks from happening in the future.
Foodborne illness investigation

• Foodborne disease is a common reason for people to seek medical care.

• Majority of foodborne illnesses are never reported.

• The outbreak investigation is time consuming process.
Why does it take so long?

Patient eats contaminated food

Patient becomes ill

Stool sample collected

Time to diagnose = 1-3 days

Pathogen or causal agent identified

Time to treat = 1-5 days

Public health lab received sample

Shipping time = 0-7 days

DNA fingerprinting = 1-4 days

Case confirmed

http://www.cdc.gov/foodborneburden
Centers for Disease Control and Prevention. Gather data on foodborne illnesses, investigate foodborne illnesses and outbreaks, and monitor the effectiveness of control efforts in reducing foodborne illnesses. CDC also plays a key role in building state and local health department epidemiology, laboratory, and environmental health capacity to support foodborne disease surveillance and outbreak response.
Foodborne Disease Outbreak Surveillance System

- **Local Health Departments**
  - Patient complaints
  - Laboratory, HCW, CMR reports

- **State Health Departments**
  - Foodborne outbreak reports
  - *Salmonella* serotyping
  - PFGE

- **Federal Health Agencies (CDC and regulatory)**
  - PulseNet and FoodNet
PulsNet (http://www.cdc.gov/pulsenet/)

- PulseNet is a national laboratory network made up of 87 laboratories—at least one in each state.
- PulseNet compares the 'DNA fingerprints' of bacteria from patients to find clusters of disease that might represent unrecognized outbreaks.

PulseNet detects subtypes of *E. coli* O157 and other Shiga toxin-producing *E. coli*, *Campylobacter jejuni*, *Clostridium botulinum*, *Listeria monocytogenes*, *Salmonella*, *Shigella*, *Vibrio cholerae*, and *Vibrio parahaemolyticus*. 
FoodNet is the Foodborne Diseases Active Surveillance Network ([http://www.cdc.gov/foodnet/](http://www.cdc.gov/foodnet/))

- Food Net - Foodborne Diseases Active Surveillance Network (CDC, USDA, FDA).
# Foodborne Illness in the United States


1 in 6 people in the United States get sick from foodborne illness each year. This chart shows the number of illnesses, hospitalizations, and deaths caused by foodborne illness in the United States, classified by the type of foodborne pathogen.

<table>
<thead>
<tr>
<th>Foodborne Agents</th>
<th>Illnesses</th>
<th>%</th>
<th>Hospitalizations</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>31 known pathogens</td>
<td>9.4 million</td>
<td>20</td>
<td>55,961</td>
<td>1,351</td>
</tr>
<tr>
<td>Unspecified agents</td>
<td>38.4 million</td>
<td>80</td>
<td>71,878</td>
<td>1,686</td>
</tr>
<tr>
<td>Total</td>
<td>47.8 million</td>
<td>100</td>
<td>127,839</td>
<td>3,037</td>
</tr>
</tbody>
</table>
Germs (and some foods) responsible for most foodborne illness

<table>
<thead>
<tr>
<th>Germs</th>
<th>Foods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campylobacter</td>
<td>Poultry</td>
</tr>
<tr>
<td>E. coli O157</td>
<td>Ground beef, Leafy greens, Raw milk</td>
</tr>
<tr>
<td>Listeria</td>
<td>Deli meats, Unpasteurized soft cheeses, Produce</td>
</tr>
<tr>
<td>Salmonella</td>
<td>Eggs, Poultry, Meat, Produce</td>
</tr>
<tr>
<td>Vibrio</td>
<td>Raw oysters</td>
</tr>
<tr>
<td>Norovirus</td>
<td>in many foods (e.g., Sandwiches, Salads)</td>
</tr>
<tr>
<td>Toxoplasma</td>
<td>Meats</td>
</tr>
</tbody>
</table>
Causes of illness in outbreaks of single food commodities: 1998-2010

http://www.cdc.gov
Contribution of different food categories to estimated domestically acquired illness and deaths, 1998-2008

*Chart does not show 5% of illnesses and 2% of deaths attributed to other commodities. In addition, 1% of illnesses and 25% of deaths were not attributed to commodities; these were caused by pathogens not in the outbreak database, mainly *Toxoplasma* and *Vibrio vulnificus.*

Aims to ensure the U.S. food supply is safe by shifting the focus from responding to contamination to preventing it.

www.fda.gov/FSMA
Have called US FDA and USDA-FSIS to become more preventative and risk-based

**Need:**
Development of new data and risk-prioritization models to identify high-risk foods and facilities and to inform resource allocation decisions.

*which pairs of foods and microbes present the greatest burden?*
RANKING THE RISKS:
The 10 Pathogen-Food Combinations With The Greatest Burden on Public Health

MICHAEL B. BATZ, SANDRA HOFFMANN AND J. GLENN MORRIS, JR.

Emerging Pathogens Institute
UNIVERSITY of FLORIDA

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Support for this report was provided by a grant from the Robert Wood Johnson Foundation.
Steps in Foodborne Illness Risk Ranking

QALY: Quality Adjusted Life Years (A measure of health related quality of life)
## Annual Burden of Disease Caused by Fourteen Foodborne Pathogens, Sorted by Share of Overall Public Health Impact s (rank in parentheses)

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Combined Rank*</th>
<th>QALY loss</th>
<th>Cost of Illness ($ mil.)</th>
<th>Illnesses</th>
<th>Hospitalizations</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmonella spp.</td>
<td>1</td>
<td>16,782 (1)</td>
<td>3,309 (1)</td>
<td>1,027,561 (2)</td>
<td>19,336 (1)</td>
<td>378 (1)</td>
</tr>
<tr>
<td>Toxoplasma gondii</td>
<td>2</td>
<td>10,964 (3)</td>
<td>2,973 (2)</td>
<td>86,686</td>
<td>4,428 (4)</td>
<td>327 (2)</td>
</tr>
<tr>
<td>Listeria monocytogenes</td>
<td>3</td>
<td>9,651 (4)</td>
<td>2,655 (3)</td>
<td>1,591</td>
<td>1,455</td>
<td>255 (3)</td>
</tr>
<tr>
<td>Campylobacter spp.</td>
<td>3</td>
<td>13,256 (2)</td>
<td>1,747 (5)</td>
<td>845,024 (4)</td>
<td>8,463 (3)</td>
<td>76 (5)</td>
</tr>
<tr>
<td>Norovirus</td>
<td>5</td>
<td>5,023 (5)</td>
<td>2,002 (4)</td>
<td>5,461,731 (1)</td>
<td>14,663 (2)</td>
<td>149 (4)</td>
</tr>
<tr>
<td>E. coli 0157:H7</td>
<td>6</td>
<td>1,565</td>
<td>272</td>
<td>63,153</td>
<td>2,138 (5)</td>
<td>20</td>
</tr>
<tr>
<td>Clostridium perfringens</td>
<td>6</td>
<td>875</td>
<td>309</td>
<td>965,958 (3)</td>
<td>438</td>
<td>26</td>
</tr>
<tr>
<td>Yersinia enterocolitica</td>
<td>8</td>
<td>1,415</td>
<td>252</td>
<td>97,656</td>
<td>533</td>
<td>29</td>
</tr>
<tr>
<td>Vibrio vulnificus</td>
<td>8</td>
<td>557</td>
<td>291</td>
<td>96</td>
<td>93</td>
<td>36</td>
</tr>
<tr>
<td>Shigella spp.</td>
<td>10</td>
<td>545</td>
<td>121</td>
<td>131,254 (5)</td>
<td>1,456</td>
<td>10</td>
</tr>
<tr>
<td>Vibrio other*</td>
<td>11</td>
<td>149</td>
<td>107</td>
<td>52,228</td>
<td>183</td>
<td>12</td>
</tr>
<tr>
<td>Cryptosporidium parvum</td>
<td>12</td>
<td>341</td>
<td>47</td>
<td>57,616</td>
<td>210</td>
<td>4</td>
</tr>
<tr>
<td>E. coli STEC non-0157</td>
<td>13</td>
<td>327</td>
<td>26</td>
<td>112,752</td>
<td>271</td>
<td>0</td>
</tr>
<tr>
<td>Cyclospora cayetanensis</td>
<td>14</td>
<td>10</td>
<td>2</td>
<td>11,407</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>63,375</strong></td>
<td><strong>14,120</strong></td>
<td><strong>8,914,713</strong></td>
<td><strong>53,678</strong></td>
<td><strong>1,322</strong></td>
</tr>
</tbody>
</table>

* Combined rank is average of QALY loss rank and COI rank.
+ includes *Vibrio parahaemolyticus* and other non-choleric *Vibrio* species

EPI, Univ of Florida
The top 10 pathogen-food combinations in terms of annual disease burden, by combined rank

<table>
<thead>
<tr>
<th>Pathogen-Food Combinations</th>
<th>Combined Rank</th>
<th>QALY Loss</th>
<th>Cost of Illness ($ mil.)</th>
<th>Illnesses</th>
<th>Hospitalizations</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campylobacter – Poultry</td>
<td>1</td>
<td>9,541</td>
<td>1,257</td>
<td>608,231</td>
<td>6,091</td>
<td>55</td>
</tr>
<tr>
<td>Toxoplasma – Pork</td>
<td>2</td>
<td>4,495</td>
<td>1,219</td>
<td>35,537</td>
<td>1,815</td>
<td>134</td>
</tr>
<tr>
<td>Listeria – Deli Meats</td>
<td>3</td>
<td>3,948</td>
<td>1,086</td>
<td>651</td>
<td>595</td>
<td>104</td>
</tr>
<tr>
<td>Salmonella – Poultry</td>
<td>4</td>
<td>3,610</td>
<td>712</td>
<td>221,045</td>
<td>4,159</td>
<td>81</td>
</tr>
<tr>
<td>Listeria – Dairy products</td>
<td>5</td>
<td>2,632</td>
<td>724</td>
<td>434</td>
<td>397</td>
<td>70</td>
</tr>
<tr>
<td>Salmonella – Complex foods</td>
<td>6</td>
<td>3,195</td>
<td>630</td>
<td>195,655</td>
<td>3,682</td>
<td>72</td>
</tr>
<tr>
<td>Norovirus – Complex foods</td>
<td>6</td>
<td>2,294</td>
<td>914</td>
<td>2,494,222</td>
<td>6,696</td>
<td>68</td>
</tr>
<tr>
<td>Salmonella – Produce</td>
<td>8</td>
<td>2,781</td>
<td>548</td>
<td>170,264</td>
<td>3,204</td>
<td>63</td>
</tr>
<tr>
<td>Toxoplasma – Beef</td>
<td>8</td>
<td>2,541</td>
<td>689</td>
<td>20,086</td>
<td>1,026</td>
<td>76</td>
</tr>
<tr>
<td>Salmonella – Eggs</td>
<td>10</td>
<td>1,878</td>
<td>370</td>
<td>115,003</td>
<td>2,164</td>
<td>42</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>36,915</strong></td>
<td><strong>8,151</strong></td>
<td><strong>3,861,128</strong></td>
<td><strong>29,830</strong></td>
<td><strong>765</strong></td>
</tr>
</tbody>
</table>

EPI, Univ of Florida
Disease Burden by Food Category, Summed Across Pathogens, by Combined Rank

<table>
<thead>
<tr>
<th>Food Category</th>
<th>QALY Loss</th>
<th>Cost of Illness (Million $)</th>
<th>Illnesses</th>
<th>Hospitalizations</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poultry</td>
<td>14,744</td>
<td>2,462</td>
<td>1,538,468</td>
<td>11,952</td>
<td>180</td>
</tr>
<tr>
<td>Complex foods</td>
<td>7,518</td>
<td>2,078</td>
<td>3,001,858</td>
<td>11,674</td>
<td>189</td>
</tr>
<tr>
<td>Pork</td>
<td>7,830</td>
<td>1,894</td>
<td>449,322</td>
<td>4,334</td>
<td>201</td>
</tr>
<tr>
<td>Produce</td>
<td>6,171</td>
<td>1,404</td>
<td>1,193,970</td>
<td>7,125</td>
<td>134</td>
</tr>
<tr>
<td>Beef</td>
<td>5,766</td>
<td>1,338</td>
<td>760,799</td>
<td>4,818</td>
<td>131</td>
</tr>
<tr>
<td>Deli/Other Meats</td>
<td>5,065</td>
<td>1,338</td>
<td>204,293</td>
<td>1,889</td>
<td>129</td>
</tr>
<tr>
<td>Dairy products</td>
<td>5,410</td>
<td>1,232</td>
<td>297,410</td>
<td>2,933</td>
<td>114</td>
</tr>
<tr>
<td>Seafood</td>
<td>2,762</td>
<td>921</td>
<td>642,860</td>
<td>2,937</td>
<td>97</td>
</tr>
<tr>
<td>Game</td>
<td>2,551</td>
<td>651</td>
<td>46,636</td>
<td>1,106</td>
<td>69</td>
</tr>
<tr>
<td>Eggs</td>
<td>2,252</td>
<td>428</td>
<td>170,123</td>
<td>2,472</td>
<td>45</td>
</tr>
<tr>
<td>Baked goods</td>
<td>988</td>
<td>273</td>
<td>462,399</td>
<td>1,833</td>
<td>25</td>
</tr>
<tr>
<td>Beverages</td>
<td>403</td>
<td>94</td>
<td>146,577</td>
<td>606</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>61,461</strong></td>
<td><strong>14,114</strong></td>
<td><strong>8,914,713</strong></td>
<td><strong>53,678</strong></td>
<td><strong>1,322</strong></td>
</tr>
</tbody>
</table>

EPI, Univ of Florida

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Decrease</th>
<th>Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campylobacter</td>
<td>-14%</td>
<td>14%↑</td>
</tr>
<tr>
<td>Listeria</td>
<td>-6%↓†</td>
<td>6%↓†</td>
</tr>
<tr>
<td>Salmonella</td>
<td>-3%↑†</td>
<td>3%↑†</td>
</tr>
<tr>
<td>Shigella</td>
<td>-13%↓†</td>
<td>13%↓†</td>
</tr>
<tr>
<td>STEC* O157</td>
<td>-10%↓†</td>
<td>10%↓†</td>
</tr>
<tr>
<td>Vibrio</td>
<td></td>
<td>43%↑</td>
</tr>
<tr>
<td>Yersinia</td>
<td></td>
<td>6%↓†</td>
</tr>
</tbody>
</table>

% change compared with 2006–2008

*Shiga toxin-producing Escherichia coli
†Not statistically significant
# Food Safety Progress Report for 2012

<table>
<thead>
<tr>
<th>Disease Agents</th>
<th>2012 Rate per 100,000 Population</th>
<th>2020 Target Rate per 100,000 Population</th>
<th>CDC Estimates That...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campylobacter</td>
<td>14.30</td>
<td>8.5</td>
<td>For every Campylobacter case reported, there are 30 cases not diagnosed</td>
</tr>
<tr>
<td>Escherichia coli O157</td>
<td>1.12</td>
<td>0.6</td>
<td>For every E. coli O157 case reported, there are 26 cases not diagnosed</td>
</tr>
<tr>
<td>Listeria</td>
<td>0.25</td>
<td>0.2</td>
<td>For every Listeria case reported, there are 2 cases not diagnosed</td>
</tr>
<tr>
<td>Salmonella</td>
<td>16.42</td>
<td>11.4</td>
<td>For every Salmonella case reported, there are 29 cases not diagnosed</td>
</tr>
<tr>
<td>Vibrio</td>
<td>0.41</td>
<td>0.2</td>
<td>For every Vibrio parahaemolyticus case reported, there are 142 cases not diagnosed</td>
</tr>
<tr>
<td>Yersinia</td>
<td>0.33</td>
<td>0.3</td>
<td>For every Yersinia case reported, there are 123 cases not diagnosed</td>
</tr>
</tbody>
</table>

For more information, see [http://www.cdc.gov/foodnet/](http://www.cdc.gov/foodnet/) Preliminary FoodNet 2012 Data
Needs of food safety management

Quick and accurate identification of hazards, ranks and the hazards by level of importance

Identifying microbial control approaches of greatest impact on reducing hazards, including strategies to address emerging hazards

Institute of Food Technologists
Emerging hazard or risk

It is a new risk which is in the process of being understood and quantified

- risks that have no track record which can be used to estimate likely probabilities and expected losses

- risks that are expected to grow greatly in significance

Emerging food safety risk: The new risk emerging to different kinds of foods
Emerging foodborne pathogens

→ Those causing illnesses that have only recently appeared or been recognized in a population

and also

→ those that are well recognized but are rapidly increasing in incidence or geographic range
Emerging foodborne bacteria

- *Salmonella* (multidrug resistant strain)
- *Campylobacter jejuni*
- *E. coli* O157:H7 and non O157
- *Listeria monocytogenes*
- *S. aureus* MRSA
- *Vibrio vulnificus*
- *Yersinia enterocolitica*
- *Arcobacter* spp.
- *Mycobacterium paratuberculosis*
Why do pathogens emerge?
Factors leading to pathogen emergence
Examples of recent emerging diseases
Food pathogens emerge mainly due to

- Newly identified host or pathogenicity
- Known pathogens spreading to new geographical areas or populations
- ‘Old’ disease re-emergence
Key issues on the horizon

- Globalization of the Food Supply
- Alternative Processing Technologies and Novel Foods
- Increases in Organic Foods
- Changes in Food Consumption
- At-Risk Subpopulations
- Pathogen Evolution
- Consumer Understanding
- Integrated Food Safety System
Key issues on the horizon

- Globalization of the Food Supply
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- Pathogen Evolution
- Consumer Understanding
- Integrated Food Safety System
Global travel of food

“We live in a global village”
Global travel and trade

**FOOD MILES**
What are they and how do they affect our world?

Time + distance from the point & time where food is **grown** to where it is **consumed**. The smaller the better!

American food travels an **average** of 1,500 to 2,500 miles from farm to table.

Growing food closer to **home** allows us to have fresher foods, and more varieties of foods.

Food miles are among the fastest-growing sources of greenhouse gas emissions **worldwide**.
Global travel and trade

A personal footprint is a measure of how a person’s lifestyle contributes to climate change.

CO₂e: Carbon dioxide equivalents

Note: Based on the average global footprint per capita in carbon dioxide equivalents. Figure excludes capital, government and land use change emissions. In 2010 the average personal footprint is estimated to be about 5.0 t CO₂e/capita.

Sources: Hertwich & Peters 2009, WRI
Population and food security

By 2050

➢ World’s population → 9-10 billion (34% higher than today)

➢ Increased urbanization from 49% today to 70%
  • Food production must increase by 70%
  • Annual cereal production must rise from 2.1 billion tons today to 3 billion
  • Annual meat production must rise to 470 million tons from 200 million tons today.
Key issues on the horizon

- Globalization of the Food Supply
- Alternative Processing Technologies and Novel Foods
- Increases in Organic Foods
- Changes in Food Consumption
- At-Risk Subpopulations
- **Pathogen Evolution**
- Consumer Understanding
- Integrated Food Safety System
Microbial evolution

Environmental and ecological changes

- Selection/evolution
- Adaptation to extreme temperatures, pH
- New hosts or vectors

Antimicrobial resistance
An infectious disease emergence framework

Grey areas between existing and emerging disease events

1. A species jump involving a **new host** very similar to the original host with an infection generating identical clinical signs can hardly be called a species jump.
2. Most changes in the infection process, such as virulence fluctuation, are not real **new traits** and are common also in existing diseases.
3. A geographic invasion of a **new area** at a local scale may not be distinct from the geospatial dynamics displayed by an existing disease.

i = Intermediates between the 3 emergence categories (see main text)
Microbial evolution

Antimicrobial usage

In the United States, antibiotic-resistant infections are responsible for an estimated $20 billion in excess healthcare costs, $35 billion in societal costs, and 8 million additional hospital days. CDC
How Antibiotic Misuse on Factory Farms Can Make You Sick

1. Factory farms use feed that's pre-mixed with antibiotics to promote faster animal growth and prevent infections.

2. Giving low doses of antibiotics to groups of animals over extended time periods fuels the development of antibiotic-resistant (AR) bacteria.

3. AR bacteria in the waste continue to reproduce and share genes with other bacteria in soil, streams, ponds and groundwater, creating "reservoirs of resistance."

4. AR bacteria in livestock can spread to farmers, farmworkers, meat plant workers and the general population.

5. Consumers encounter AR bacteria while handling raw meat and eating undercooked meat.

6. AR bacterial infections have become increasingly common. Doctors are concerned that some antibiotics no longer work to treat sick people.

www.foodandwaterwatch.org
Examples of How Antibiotic Resistance Spreads

- Animals get antibiotics and develop resistant bacteria in their guts.
- Drug-resistant bacteria can remain on meat from animals. When not handled or cooked properly, the bacteria can spread to humans.
- Fertilizer or water containing animal feces and drug-resistant bacteria is used on food crops.
- Drug-resistant bacteria in the animal feces can remain on crops and be eaten. These bacteria can remain in the human gut.
- George gets antibiotics and develops resistant bacteria in his gut.
- George stays at home and in the general community. Spreads resistant bacteria.
- George gets care at a hospital, nursing home or other inpatient care facility.
- Resistant germs spread directly to other patients or indirectly on unclean hands of healthcare providers.
- Resistant bacteria spread to other patients from surfaces within the healthcare facility.
- Patients go home.

Simply using antibiotics creates resistance. These drugs should only be used to treat infections.

http://www.cdc.gov/drugresistance/threat-report-2013/
Microbial evolution

Antimicrobial resistance

- Vancomycin-resistant enterococci (VRE)
- Salmonella Typhimurium DT 104
- Campylobacter jejuni and C. coli
- S. aureus (30-40% MRSA)
- Mycobacterium tuberculosis (15% MDR)
CDCs four core actions to fight antibiotic resistance

1. Preventing Infections, Preventing the Spread of Resistance

2. Tracking Resistance Patterns

3. Improving Use of Today’s Antibiotics (Antibiotic Stewardship)

4. Developing New Antibiotics and Diagnostic Tests

http://www.cdc.gov/drugresistance/threat-report-2013/
Summary
Food safety challenges

- The emergence and spread of new microbes, new hosts
- The globalization of travel and food supply
- The rise of drug-resistant pathogens

http://www.cdc.gov/foodborneburden
Managing emerging pathogens

- Recognition
- Investigation
  - Diagnosis and surveillance
  - Applied epidemiological and ecological research
- Education/knowledge transfer
- Information/communication
- International/interdisciplinary interventions
7 OUT OF 10 CONSUMERS ARE CONFIDENT IN THE SAFETY OF THE U.S. FOOD SUPPLY

BREAKDOWN OF ALL RESPONSES:

- 55% Somewhat Confident
- 23% Not too Confident
- 6% Not at all Confident
- 1% Not Sure
- 15% Very Confident

70% of consumers are VERY or SOMEWHAT confident in the safety of the U.S. food supply.

SOURCE: 2013 IFIC Foundation Food & Health Survey www.foodinsight.org
5 YEARS OF FOOD SAFETY SUCCESS

More Americans are taking basic food safety precautions when cooking, preparing, or consuming food.

<table>
<thead>
<tr>
<th>Action</th>
<th>2009</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wash my hands with soap and water.</td>
<td>87%</td>
<td>97%</td>
</tr>
<tr>
<td>Wash cutting board with soap and water or bleach.</td>
<td>77%</td>
<td>89%</td>
</tr>
<tr>
<td>Properly store leftovers within 2 hours of serving.</td>
<td>69%</td>
<td>81%</td>
</tr>
<tr>
<td>Separate raw meat, poultry, and seafood from ready-to-eat products.</td>
<td>63%</td>
<td>77%</td>
</tr>
<tr>
<td>Cook to required temperature (such as 165°F for poultry).</td>
<td>71%</td>
<td>77%</td>
</tr>
<tr>
<td>Use different or freshly-cleaned cutting boards for each product (such as raw meat, or poultry or produce).</td>
<td>50%</td>
<td>67%</td>
</tr>
<tr>
<td>Use a food thermometer to check the doneness of meat and poultry items.</td>
<td>25%</td>
<td>36%</td>
</tr>
</tbody>
</table>

SOURCE: 2013 IFIC Foundation Food & Health Survey www.foodinsight.org
There's light at the end of every tunnel, keep moving.
My research work
Research Note

Screening of Commercial and Pecan Shell–Extracted Liquid Smoke Agents as Natural Antimicrobials against Foodborne Pathogens

ELLEN J. VAN LOO,1,2,3 D. BABU,1,2,* PHILIP G. CRANDALL,1,2 AND STEVEN C. RICKE1,2

1Department of Food Science and the Center for Food Safety, University of Arkansas, Fayetteville, Arkansas, 72704, USA; 2Sea Star International LLC, 2138 East Revere Place, Fayetteville, Arkansas, 72701, USA; and 3Department of Agricultural Economics, Bioscience Engineering Faculty, Ghent University, Coupure links 653, B-9000 Ghent, Belgium

MS 11-543: Received 12 December 2011/Accepted 24 January 2012
Prepared solvent-extracted antimicrobials in the laboratory (Acetic acid and Methanol) and compared with commercial liquid smokes (of different woods) against food pathogens.
<table>
<thead>
<tr>
<th>Strain</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>E. coli</em> O157:H7</td>
<td>ATCC 43888</td>
</tr>
<tr>
<td><em>Salmonella Enteritidis</em></td>
<td>PT 13A, Poultry Science, University of Arkansas, Fayetteville</td>
</tr>
<tr>
<td><em>S. aureus</em></td>
<td>ATCC 25923</td>
</tr>
<tr>
<td><em>S. aureus</em></td>
<td>ATCC 6538</td>
</tr>
<tr>
<td><em>S. aureus</em> Mu50, MRSA (meticillin resistant)</td>
<td>Obtained from Dr. Brian Wilkinson’s laboratory, Illinois State University, Normal</td>
</tr>
<tr>
<td><em>S. aureus</em> Col, MRSA (meticillin resistant, homogeneous)</td>
<td>Obtained from Dr. Brian Wilkinson’s laboratory, Illinois State University, Normal</td>
</tr>
<tr>
<td><em>Listeria monocytogenes</em> 174, serotype 1/2a</td>
<td>Strain 10403S, wild type, obtained from Dr. Weidemann, Cornell University, Ithaca, NY</td>
</tr>
<tr>
<td><em>Listeria monocytogenes</em> 163 Scott A, serotype 4b</td>
<td>Strain NADC (National Animal Disease Center) 2045, obtained from Dr. Aubrey Mendonca, Department of Food Science and Human Nutrition, Iowa State University, Ames</td>
</tr>
<tr>
<td><em>Salmonella Typhimurium</em> 29</td>
<td>Obtained from Dr. Michael Slavik, University of Arkansas, Fayetteville; source, CDC</td>
</tr>
<tr>
<td><em>Salmonella Typhimurium</em> LT2</td>
<td>ATCC 19585</td>
</tr>
</tbody>
</table>
Minimum inhibitory concentrations (% MIC)
%MICs of commercial liquid smoke samples (A) and solvent-extracted antimicrobials prepared in the laboratory (B) against major food pathogens. Mean MIC comparisons were done separately for each bacterial strain. Bars labeled with different letters indicate a significant difference (P < 0.05) between treatments for a particular bacterium.
%MICs of commercial liquid smoke samples (A) and solvent-extracted antimicrobials prepared in the laboratory (B) against major food pathogens. Mean MIC comparisons were done separately for each bacterial strain. Bars labeled with different letters indicate a significant difference \((P < 0.05)\) between treatments for a particular bacterium.
Solvent extracted antimicrobials prepared using pecan shells indicated significant differences between their inhibitory concentrations depending on the type of solvents used for extraction.

Liquid smoke samples tested in this study could serve as effective natural antimicrobials and their inhibitory effects depended more on the use of solvents for extraction rather than the wood sources.
Efficacy of Antimicrobials Extracted from Organic Pecan Shell for Inhibiting the Growth of *Listeria* spp.

Dinesh Babu, Philip G. Crandall, Casey L. Johnson, Corliss A. O’Bryan, and Steven C. Ricke
• We tested the efficacy of natural antimicrobials extracted from organic pecan shells.

• We estimated the minimum inhibitory concentrations of the antimicrobials against pure cultures and tested on inhibition of *Listeria* strains and inoculated on a chicken skin model and native bacteria on chicken skin.
Inhibition of *L. monocytogenes* on chicken skin
Table 1—*Listeria* serotypes subjected to the antimicrobial treatments.

<table>
<thead>
<tr>
<th><em>Listeria</em> strain</th>
<th>Serotype</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>L. innocua</em> (Li 169)</td>
<td>M1</td>
</tr>
<tr>
<td><em>L. monocytogenes</em> (Lm 187)</td>
<td>4b</td>
</tr>
<tr>
<td><em>L. monocytogenes</em> (Lm 188)</td>
<td>4b</td>
</tr>
<tr>
<td><em>L. monocytogenes</em> (Lm 189)</td>
<td>1/2a</td>
</tr>
<tr>
<td><em>L. monocytogenes</em> (Lm 190)</td>
<td>1/2a</td>
</tr>
<tr>
<td><em>L. monocytogenes</em> (Lm 191)</td>
<td>1/2a</td>
</tr>
<tr>
<td><em>L. ivanovii</em> (Li 192)</td>
<td>—</td>
</tr>
</tbody>
</table>
Table 2—Minimal inhibitory concentrations of pecan shell extracts on *Listeria* species individually and as a cocktail. Different capital letters in a row indicate significant difference ($P < 0.05$) between species; different lower case letters within a column indicate significant difference ($P < 0.05$) for treatment within species.

<table>
<thead>
<tr>
<th></th>
<th>Li 169</th>
<th>Lm 186</th>
<th>Lm 187</th>
<th>Lm 188</th>
<th>Lm 190</th>
<th>Lm 191</th>
<th>L. ivanovii</th>
<th>Cocktail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pecan shell extract (unroasted)</td>
<td>1.5Ba</td>
<td>1.5Ba</td>
<td>1.5Ba</td>
<td>1.5Ba</td>
<td>1.5Bb</td>
<td>3Aa</td>
<td>1.5Ba</td>
<td>1.5Ba</td>
</tr>
<tr>
<td>Roasted pecan shell powder extract</td>
<td>0.75Bb</td>
<td>0.75Bb</td>
<td>0.375Cb</td>
<td>0.375Cb</td>
<td>6Aa</td>
<td>0.188Db</td>
<td>0.375Cb</td>
<td>0.375Cb</td>
</tr>
</tbody>
</table>
Figure 1—Effect of unroasted pecan shell extract on indigenous microflora of uninoculated chicken skin. Error bars represent standard error of the mean. Three replication mean comparisons were done using SAS 9.2 statistical software and different letters on each bar indicate significant difference (P < 0.05) between treated and untreated.
Figure 2—Effect of 0.75% unroasted pecan shell extract on the growth of *Listeria* cocktail mix inoculated on chicken skin. Skin models were treated for 15 or 30 min. Error bars represent standard deviation from the mean. Three replication mean comparisons were done using SAS 9.2 statistical software and different letters on each bar indicate significant difference ($P < 0.05$) with other treatments.
Figure 3–Effect of unroasted pecan shell (PS) and roasted pecan shell powder (PSP) extracts at 1.5% for 30 min showing inhibition of Listeria cocktail mix inoculated on chicken skin. For Lm_PS and Lm_PSP, Listeria were added first; for PS_Lm and PSP_Lm the skin samples were treated first before addition of Listeria. Three replication mean comparisons were done using SAS 9.2 statistical software and different letters on each bar indicate significant statistical difference ($P < 0.05$) with other treatments.
Minimum inhibitory concentrations (% MIC)

L. monocytogenes strains
- Lm 169
- Lm 186
- Lm 187
- Lm 188
- Lm 190
- Lm 191
- Lm 192
- Lm cocktail mix

Pecan shell extract (unroasted)

Pecan shell powder (roasted) extract
Efficacy of natural antimicrobials

Pecan shell (PS) and Pecan shell powder (PSP) extract treatments before and after Lm inoculation

Inoculum Control (BPW) Lm_PS PS_Lm Lm_PSP PSP_Lm

L. monocytogenes (Lm) recovery from chicken skin (Log CFU/cm²)

1st fraction
2nd fraction
• Extraction method that affects the concentration of inherent inhibitory compounds may affect the efficacy of the antimicrobial preparations.

• Organic poultry products will benefit from use of these antimicrobials prepared from organic pecan shells.
Antimicrobial Combinations that Help Protect Against Salmonella spp. & L. monocytogenes in Organic & Natural Poultry Products

Period of Performance: 01/01/2012 - 12/31/2012

Recipient Firm
SEA STAR INTERNATIONAL, LLC
2138 REVERE PL
Fayetteville, AR 72701

Principal Investigator
Dinesh Babu

Firm POC
Philip G. Crandall

Abstract
This is a critical crossroads for the poultry industry with a majority of consumers demanding minimal or chemical free foods and the ever present threat of foodborne illness from Salmonella and Listeria associated with raw and ready-to-eat (RTE) poultry products. As a potential solution, we have demonstrated the effectiveness of novel, all natural antimicrobials. This proposed Phase II research will optimize combinations of antimicrobials that will provide additional hurdles of protection from Listeria and Salmonella to minimize the risk of foodborne illness for poultry. This research will minimize the growth of spoilage organisms to provide a much needed increase in shelf-life for these high-value products, while maintaining the quality of the organic foods. Specific details are contained in the Commercialization Plan. This proposal will add-value to agricultural wastes currently being burned as cheap fuel sources by upgrading the waste product to food grade antimicrobials. We will do this in a sustainable manner that minimizes or eliminates most of the liquid wastes typically associated with biological extraction methods.

http://sbirsource.com/sbir/awards/
ORIGINAL ARTICLE

Cleaning and decontamination efficacy of wiping cloths and silver dihydrogen citrate on food contact surfaces

S.M. Masuku¹, D. Babu¹, E.M. Martin¹,², O.K. Koo¹, C.A. O’Bryan¹, P.G. Crandall¹ and S.C. Ricke¹

1 Center for Food Safety and Department of Food Science, University of Arkansas, Fayetteville, AR, USA
2 Department of Biological and Agricultural Engineering, University of Arkansas, Fayetteville, AR, USA

doi:10.1111/j.1365-2672.2012.05318.x

2012/0403: received 2 March 2012, revised
30 March 2012 and accepted 13 April 2012
Cross contamination

~80% of the reported foodborne outbreaks→ Food service facilities

How efficient is the cleaning practice??

Collins et al., 1997
Aim: To test the efficacy of four wipe cloth types (cotton bar towel, nonwoven, microfibre and blended cellulose/cotton) with either quaternary ammonia cleaning solution or silver dihydrogen citrate (SDC) in cleaning food contact surfaces.
Rapid hygiene monitoring system

RLU >30 = dirty, RLU between 11 and 29 = caution and RLU < 10 = clean
Table 1 Least significant differences values showing differences in mean log RLU 100 cm\(^{-2}\) for each cloth type in the first study*

<table>
<thead>
<tr>
<th>Cloth types</th>
<th>N†</th>
<th>ATP-B test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonwoven</td>
<td>59‡</td>
<td>2.89 ± 0.30(^A)</td>
</tr>
<tr>
<td>Microfibre</td>
<td>90</td>
<td>2.30 ± 0.30(^B)</td>
</tr>
<tr>
<td>Cotton terry</td>
<td>88‡</td>
<td>2.26 ± 0.25(^{CB})</td>
</tr>
<tr>
<td>Cellulose/cotton</td>
<td>90</td>
<td>2.20 ± 0.28(^C)</td>
</tr>
</tbody>
</table>

*Means with the same letter notation are not significantly different.
†Number of samples collected per treatment.
‡N differs for some cloth types because negative values were removed (Negative values because of variability in contamination of sampling area were not included).
Cleaning effect of wiping cloths on food contact surfaces can be enhanced by dipping them in SDC disinfectant.

ATP-B measurements can be used for real-time hygiene monitoring in public sector, and testing microbial contamination provides more reliable measure of cleanliness.

This study could help to estimate and establish contamination thresholds for surfaces at public sector facilities and to base the effectiveness of cleaning methods.
Review

Whole-chain traceability, is it possible to trace your hamburger to a particular steer, a U. S. perspective

Philip G. Crandall a,*, Corliss A. O'Bryan a, Dinesh Babu a,1, Nathan Jarvis a, Mike L. Davis a, Michael Buser b, Brian Adam c, John Marcy a,d, Steven C. Ricke a

a Center for Food Safety and Department of Food Science, University of Arkansas, Fayetteville, AR 72704, United States
b Biosystems and Agricultural Engineering, Oklahoma State University, Stillwater, OK 74078, United States
c Agricultural Economics, Oklahoma State University, Stillwater, OK 74078, United States
d Department of Poultry Science, University of Arkansas, Fayetteville, AR 72701, United States
Fig. 1. Beef consumption by cut. adapted from National Cattleman's Beef Association (2012)
Fig. 2. Simplified diagram of a beef slaughter operation.
Dried Plum Products as a Substitute for Phosphate in Chicken Marinade

Nathan Jarvis, Ashley R. Clement, Corliss A. O’Bryan, Dinesh Babu, Philip G. Crandall, Casey M. Owens, Jean-Francois Meullenet, and Steven C. Ricke
ULM research plans

- Influence of dietary choline and colonization with human gut microflora and probiotic cultures on Flavin-Containing Monooxygenase (FMO) genes in gnotobiotic mice.

- Can Food Polyphenols Prevent or Limit Expansion of Toxic Liver Injury?
Thank you all