Food Safety of Natural and Organic Processed Meats

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Uncured, Natural, Organic and Conventional Labeling Claims

- **Organic**
  - 100% organic
  - Organic
  - Made with organic
  - Less than 70% organic

- **Natural**

- **Uncured**

- **Conventional**

More Restrictive

Less Restrictive
Natural / Organic Market

- Since 1990 organic food sales have increased nearly 20% each year  
  (Winter and Davis, 2006)

- Meat, poultry and seafood sector has been the fastest growing category
  - 2.5% of market share in 2005
    - Expected to increase to 10%  
  - 55.4% growth in 2005  
    (Organic Trade Association)
Natural Labeling

- USDA, Food Standards and Labeling Policy Book

- 21 CFR 101.22

- ‘(1) the product does not contain any artificial flavor or flavoring, coloring ingredient, or chemical preservative (as defined in 21 CFR 101.22), or any other artificial or synthetic ingredient; and (2) the product and its ingredients are not more than minimally processed....’
Organic Meat and Poultry Products

- National Organic Program (NOP)
  - Agricultural Marketing Service (AMS)

- The National List of Allowed and Prohibited Substances
  - 7 CFR
    - § 205.605 Nonagricultural (nonorganic) substances allowed as ingredients in or on processed products labeled as “organic” or “made with organic (specified ingredients or food group(s)).”
    - § 205.606 Nonorganically produced agricultural products allowed as ingredients in or on processed products labeled as “organic” or “made with organic (specified ingredients or food group(s)).”
Types of Natural / Organic Meat Products

- Fresh Products
- Cooked products
Types of Natural / Organic Meat Products

- Traditionally cured, cooked products
  - No intention of replacing nitrate/nitrite
    - Uncured appearance and flavor
USDA Definition of **Uncured** Meat Products

Definition found in 9 CFR 317.17 and 9 CFR 319.2
- Normal cured products that can be made without nitrites or nitrates added
- Other normal ingredients are allowed

Statements/words that must be added
- “Uncured” before common name
  - i.e. *Uncured Frankfurters*
- “No Nitrate or Nitrite Added …..” statement must be added
- “Not Preserved – Keep Refrigerated Below 40°F At All Times” statement must be added
“Naturally Cured” Meat and Poultry Products
Types of Natural / Organic Meat Products

- Traditionally cured, cooked products
  - Intention to replace nitrate/nitrite
    - Cured appearance and flavor
Purpose of Sodium Nitrate / Nitrite

- Cured meat color
- Cured meat aroma and flavor
- Powerful antioxidant
  - Effective in controlling fat oxidation
- Preservative/antimicrobial properties
  - *Clostridium botulinum, Clostridium perfringens, Listeria monocytogenes*
“Cultured” “Natural Curing” Systems

- Vegetable juice powders and juices
  - Standardized up to 30,000 ppm nitrate
  - Nitrite ion vs. sodium nitrite

- Lactic Acid Starter Cultures
  - Staphylococcus carnosus
  - Staphylococcus carnosus / vitulinus
  - Staphylococcus carnosus / utilis
  - Staphylococcus carnosus / Micrococcus varians

- Cure Accelerators
  - Cherry Powder (Ascorbic acid)
  - Lemon powder (pH reducer)
“Pre-Converted” “Natural Curing” Systems

- Pre-converted vegetable powders and juices
  - Standardized up to 10,000 ppm nitrite
  - Nitrite ion vs. sodium nitrite

- Cure Accelerators
  - Cherry Powder (Ascorbic acid)
  - Lemon powder (pH reducer)

***Generally less ingoing nitrite from pre-converted system than “cultured” system***
Nitrate and Nitrite Found in “Naturally Cured” Sausages

<table>
<thead>
<tr>
<th>TRT</th>
<th>PPM Residual Nitrite</th>
<th>PPM Residual Nitrate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-Incubate</td>
<td>Post-Incubate</td>
</tr>
<tr>
<td>1 (0.20% VJP + 30 min)</td>
<td>0&lt;sup&gt;h&lt;/sup&gt;</td>
<td>5.6&lt;sup&gt;ij&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>51.2&lt;sup&gt;i&lt;/sup&gt;</td>
</tr>
<tr>
<td>2 (0.20% VJP + 120 min)</td>
<td>0&lt;sup&gt;h&lt;/sup&gt;</td>
<td>24.5&lt;sup&gt;h&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>52.0&lt;sup&gt;i&lt;/sup&gt;</td>
</tr>
<tr>
<td>3 (0.40% VJP + 30 min)</td>
<td>0&lt;sup&gt;h&lt;/sup&gt;</td>
<td>7.7&lt;sup&gt;i&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>99.2&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td>4 (0.40% VJP + 120 min)</td>
<td>0&lt;sup&gt;h&lt;/sup&gt;</td>
<td>46.0&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>99.6&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td>C (156 ppm nitrite)</td>
<td>59.1&lt;sup&gt;g&lt;/sup&gt;</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>34.8&lt;sup&gt;h&lt;/sup&gt;</td>
</tr>
<tr>
<td>SEM</td>
<td>0.62</td>
<td>1.22</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.35</td>
</tr>
</tbody>
</table>

<sup>g-j</sup> Means within same column with different superscripts are different (P<0.05).

### Residual Nitrite in “Naturally Cured” Sausages

<table>
<thead>
<tr>
<th>TRT</th>
<th>0</th>
<th>14</th>
<th>28</th>
<th>56</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (0.20% VJP + 30 min)</td>
<td>16.1e</td>
<td>10.6f</td>
<td>8.8gh</td>
<td>4.9gh</td>
<td>4.9gh</td>
</tr>
<tr>
<td>2 (0.20% VJP + 120 min)</td>
<td>24.7e</td>
<td>21.7e</td>
<td>17.2f</td>
<td>12.0gh</td>
<td>9.1h</td>
</tr>
<tr>
<td>3 (0.40% VJP + 30 min)</td>
<td>21.3e</td>
<td>16.6f</td>
<td>12.9gh</td>
<td>9.9gh</td>
<td>8.5g</td>
</tr>
<tr>
<td>4 (0.40% VJP + 120 min)</td>
<td>58.5e</td>
<td>44.3f</td>
<td>33.1g</td>
<td>22.3h</td>
<td>16.3i</td>
</tr>
<tr>
<td>C (156 ppm nitrite)</td>
<td>46.9e</td>
<td>31.4f</td>
<td>22.0g</td>
<td>12.4hi</td>
<td>8.7i</td>
</tr>
</tbody>
</table>

SEM = 1.02

- Means within same row with different superscripts are different (P<0.05).
- Means within same column with different superscripts are different (P<0.05).

Available/Generated Nitrite Between Pre-converted & Cultured System

- Less ingoing nitrite?
  - 30,000 ppm (nitrate) x 0.30% = 90 ppm?
    - Expect 30-75% conversion?
      - Potential of 30-70 ppm after conversion?
  
- 10,000 ppm (nitrite) x 0.30% = 30 ppm?

**Nitrate/nitrite vs. Sodium nitrate/nitrite

- ~1.4:1 conversion
Natural & Organic Quality

- Water and protein binding
  - Control of raw materials
  - Modifications to processing
  - Control of pH
  - Ingredient choices
Natural & Organic Quality

- **Antioxidant protection**
  - ~ 50 ppm nitrite
  - Dependent on amount of unsaturated lipids
  - Natural alternatives?

- **Maintaining cured color**
  - 2-14 ppm nitrite induces cured color
  - 40-50 ppm nitrite generally considered adequate
  - pH considerations
## Uncured Sausage: Cured Pigment

<table>
<thead>
<tr>
<th>TRT&lt;sup&gt;b&lt;/sup&gt;</th>
<th>0</th>
<th>14</th>
<th>28</th>
<th>56</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (0.20% VJP + 30 min)</td>
<td>76.4</td>
<td>93.8</td>
<td>98.2</td>
<td>97.1</td>
<td>101.9</td>
</tr>
<tr>
<td>2 (0.20% VJP + 120 min)</td>
<td>106.0</td>
<td>108.1</td>
<td>108.9</td>
<td>105.9</td>
<td>107.9</td>
</tr>
<tr>
<td>3 (0.40% VJP + 30 min)</td>
<td>81.9</td>
<td>97.7</td>
<td>100.4</td>
<td>101.4</td>
<td>103.5</td>
</tr>
<tr>
<td>4 (0.40% VJP + 120 min)</td>
<td>105.0</td>
<td>107.6</td>
<td>108.1</td>
<td>106.6</td>
<td>108.7</td>
</tr>
<tr>
<td>C (156 ppm nitrite)</td>
<td>108.4</td>
<td>110.0</td>
<td>110.1</td>
<td>109.5</td>
<td>110.2</td>
</tr>
</tbody>
</table>

SEM = 1.68

<sup>b</sup> TRT = Treatment combinations where: 1=low VJP + short min-hold; 2=low VJP + long min-hold; 3=high VJP + short min-hold; 4=high VJP + long min-hold; C=156 ppm (mg/kg) sodium nitrite.

Uncured Sausage: Multi-Strain Starter Cultures- CIE a* color

<table>
<thead>
<tr>
<th>TRT</th>
<th>DAY</th>
<th>0</th>
<th>14</th>
<th>28</th>
<th>56</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (0.01% SC + 0 min)</td>
<td></td>
<td>9.11(^m)</td>
<td>9.28(^m)</td>
<td>9.24(^m)</td>
<td>9.73(^m)</td>
<td>10.36(^m)</td>
</tr>
<tr>
<td>2 (0.01% SC + 90 min)</td>
<td></td>
<td>15.36(^n)</td>
<td>15.04(^n)</td>
<td>14.86(^n)</td>
<td>14.68(^n)</td>
<td>14.90(^n)</td>
</tr>
<tr>
<td>3 (0.02% SC + 0 min)</td>
<td></td>
<td>11.65(^g)</td>
<td>12.04(^g)</td>
<td>13.26(^h)</td>
<td>13.35(^i)</td>
<td>14.15(^i)</td>
</tr>
<tr>
<td>4 (0.02% SC + 90 min)</td>
<td></td>
<td>15.63(^n)</td>
<td>15.20(^n)</td>
<td>15.01(^n)</td>
<td>14.60(^n)</td>
<td>15.13(^n)</td>
</tr>
<tr>
<td>C (156 ppm nitrite)</td>
<td></td>
<td>16.07(^n)</td>
<td>15.76(^n)</td>
<td>15.70(^n)</td>
<td>15.52(^n)</td>
<td>15.49(^n)</td>
</tr>
</tbody>
</table>

SEM = 0.57

\(^g\)\(^i\) Means within same row with different superscripts are different (P<0.05)

\(^m\)\(^n\) Means within same column with different superscripts are different (P<0.05)

Natural & Organic Safety = ?

- *Clostridium botulinum* inhibition
  - 50-60 ppm ingoing nitrite?
  - Difficult to assess without challenge studies
    - Difficult to quantify true amount of nitrite generated

- *Clostridium perfringens*

- *Listeria monocytogenes*
Natural & Organic Ingredients

- USDA ingredient classification
  - Natural antimicrobial and chemical preservative are not considered different by the agency

- Results in few options for processors
  - Ingredients / flavorings with “antimicrobial” properties
  - Antimicrobials added at “flavoring” levels
    - i.e. Sodium lactate
  - Post processing applications
    - High pressure pasteurization
    - Steam / water pasteurization
### Clostridium botulinum Growth in “Naturally Cured” Frankfurters

Time until botulism toxin was detected during vacuum-packed storage of inoculated frankfurters and ham at various storage temperatures

<table>
<thead>
<tr>
<th>Products stored at:</th>
<th>72°F</th>
<th>50°F</th>
<th>40°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>uncured control (no nitrite)</td>
<td>5 days</td>
<td>14 days</td>
<td>63 days</td>
</tr>
<tr>
<td>conventional cure (156 ppm)</td>
<td>14 days</td>
<td>none/84 days</td>
<td>none/84 days</td>
</tr>
<tr>
<td>natural cure</td>
<td>5 days</td>
<td>14 days</td>
<td>63 days</td>
</tr>
<tr>
<td>natural cure + VS507</td>
<td>5 days</td>
<td>none/84 days</td>
<td>none/84 days</td>
</tr>
<tr>
<td>natural cure + VD55</td>
<td>none/84 days</td>
<td>none/84 days</td>
<td>none/84 days</td>
</tr>
</tbody>
</table>

Sebranek et al. (2010; unpublished data)
Clostridium perfringens Growth in “Naturally Cured” Meat Products

- **Commercial products study**
  - Frankfurters (8 naturally cured, 2 control)
  - Hams (7 naturally cured, 4 control)
  - Bacons (9 naturally cured, 1 control)

- **Surface inoculated with 5 log spore / gram**

- **Heat shocked for 20 min to internal of 75°C**

- **Cooled from 54.4°C to 26.6°C (1.5 hr) & 4.4°C (5 hr)**

- **Stored at 20°C and sampled on days 0, 1, 2, 6, 8, & 10**
Clostridium perfringens Growth in “Naturally Cured” Meat Products

FIGURE 2. Growth of inoculated C. perfringens in naturally cured and conventionally cured commercially available hams during storage at 20°C.

Adapted from Jackson et al. (2011), J. Food Prot. 74(3): 410-416.
Impact of “Natural” Ingredients on Uncured Hams

- “Naturally Cured” System

<table>
<thead>
<tr>
<th>TRT</th>
<th>Vegetable Juice Powder (nitrate or nitrite source)</th>
<th>Antimicrobial (cherry/lemon/vinegar or cultured sugar/vinegar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.2% pre-converted</td>
<td>NA</td>
</tr>
<tr>
<td>2</td>
<td>0.2% pre-converted</td>
<td>1.4% cherry/lemon/vinegar (A)</td>
</tr>
<tr>
<td>3</td>
<td>0.2% pre-converted</td>
<td>3.0% cultured sugar/vinegar (B)</td>
</tr>
<tr>
<td>4</td>
<td>0.45% nitrate source</td>
<td>NA</td>
</tr>
<tr>
<td>5</td>
<td>0.45% nitrate source</td>
<td>1.4% cherry/lemon/vinegar (A)</td>
</tr>
<tr>
<td>6</td>
<td>0.45% nitrate source</td>
<td>3.0% cultured sugar/vinegar (B)</td>
</tr>
<tr>
<td>Control</td>
<td>156 ppm Na nitrite</td>
<td>2.5% Potassium lactate/sodium diacetate</td>
</tr>
</tbody>
</table>

Adapted from Jackson et al. (2011), J. Food Prot. 74(3): 417-424.
Clostridium perfringens Growth in “Naturally Cured” Hams at 20°C

Antimicrobial “A” = 1.4% cherry/lemon/vinegar
Antimicrobial “B” = 3.0% cultured sugar/vinegar

Adapted from Jackson et al. (2011), J. Food Prot. 74(3): 417-424.
Growth of *L. monocytogenes* Over Time in Commercial Hot Dogs

<table>
<thead>
<tr>
<th>Brand</th>
<th>Process Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>C, D, E, F, G, H, I</td>
<td>Naturally cured (natural source of nitrate used)</td>
</tr>
<tr>
<td>A, B</td>
<td>Traditionally cured (nitrite added directly)</td>
</tr>
<tr>
<td>J</td>
<td>Uncured (no replacement of nitrite/nitrate)</td>
</tr>
</tbody>
</table>

Controlling *Listeria monocytogenes* in Natural, Ready-to-Eat Meat and Poultry Products

**Objective:**

To identify ingredients that suppress growth of *Listeria monocytogenes* in ready-to-eat (RTE), deli-style, meat and poultry products that meet natural or organic requirements defined by USDA.
Materials and Methods

- **Phase I**
  - **Screening in meat model system**
    - Ground turkey slurries produced
    - Exhaustive search for ingredients performed
    - Antilisterial activity measured

- **Phase II**
  - **Commercial product systems**
    - Boneless ham
    - Whole muscle roast beef
    - Deli-style turkey breast
    - Controls (ham, turkey breast, roast beef)
Figure 1. Growth of *L. monocytogenes* in Turkey Slurries at 4°C (Baseline study).

- **Slurry only**
- **0.3% Preconverted**
- **Starter**
- **Traditional 156 ppm NO2**
- **Control 1 NO2+2.8% L/D**
- **Control NO2+2.8% L/D+0.4%STPP**

"Slurry only" = 2% salt
"0.3% Preconverted" = 2% salt, 0.3% pre-converted vegetable juice powder + 0.28% cherry powder
"Starter" = 2% salt + 0.4% vegetable juice powder + starter culture + 0.28% cherry powder
"Traditional 156 ppm NO2" = 2% salt + 156 ppm nitrite + 547 ppm erythorbate
"Control 1 NO2+L/D" = 2% salt + 156 ppm nitrite + 547 erythorbate + 2.8% lactate/diacetate
"Control NO2+2.8%L/D+0.4%STPP" = 2% salt + 156 ppm nitrite + 547 erythorbate + 2.8% lactate/diacetate + 0.4%STPP
Screening Study-Inhibition of *L. monocytogenes* by Natural Ingredients in Turkey Slurries Stored at 4°C for 4 Weeks

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>% used</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No growth for cured or uncured through 4 weeks</strong></td>
<td></td>
</tr>
<tr>
<td>1  Buffered Vinegar</td>
<td>2.00%</td>
</tr>
<tr>
<td>2  Cultured sugar and vinegar blend</td>
<td>3.00%</td>
</tr>
<tr>
<td>3  Lemon/cherry/vinegar blend</td>
<td>1.50%</td>
</tr>
<tr>
<td>4  Tea Tree oil</td>
<td>0.05%</td>
</tr>
<tr>
<td>5  Vinegar/lemon juice blend</td>
<td>2.50%</td>
</tr>
<tr>
<td>6  Grapefruit/Lime/Vinegar blend</td>
<td>2.50%</td>
</tr>
<tr>
<td><strong>No growth with cured treatments for 4 weeks</strong></td>
<td></td>
</tr>
<tr>
<td>7  Cherry powder</td>
<td>0.50%</td>
</tr>
<tr>
<td>8  Grape Seed Extract powder</td>
<td>0.03%</td>
</tr>
<tr>
<td>9  Smoke flavor-2</td>
<td>1.00%</td>
</tr>
<tr>
<td><strong>Variable results (no clear correlation with nitrite)</strong></td>
<td></td>
</tr>
<tr>
<td>10 Cranberry concentrate powder w/MgOH &amp; Ca₃PO₄</td>
<td>2.00%</td>
</tr>
<tr>
<td>11 Fermentate Nisin-Rosemary blend</td>
<td>0.02%</td>
</tr>
<tr>
<td>12 Herb Blend</td>
<td>0.50%</td>
</tr>
<tr>
<td>13 Smoke flavor-1</td>
<td>1.00%</td>
</tr>
<tr>
<td><strong>No inhibition at the concentrations used</strong></td>
<td></td>
</tr>
<tr>
<td>14 Green Tea extract</td>
<td>0.10%</td>
</tr>
<tr>
<td>15 Rosemary - tocopheral blend</td>
<td>0.08%</td>
</tr>
</tbody>
</table>
# Sensory Screening

**TABLE 2:** Least squares means for sensory attributes of surface color, aroma, flavor, and overall acceptance for uncooked deli-style chicken.

<table>
<thead>
<tr>
<th>Product</th>
<th>Use Level</th>
<th>Surface Color</th>
<th>Aroma</th>
<th>Flavor</th>
<th>Overall Acceptance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffered Vinegar</td>
<td>2.0%</td>
<td>6.66&lt;sup&gt;d&lt;/sup&gt;</td>
<td>6.00</td>
<td>6.57</td>
<td>6.14&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Vinegar/lemon juice blend</td>
<td>2.5%</td>
<td>6.14&lt;sup&gt;d&lt;/sup&gt;</td>
<td>6.29</td>
<td>6.29</td>
<td>6.14&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Grape seed Extract</td>
<td>0.03%</td>
<td>5.43&lt;sup&gt;d&lt;/sup&gt;</td>
<td>5.43</td>
<td>6.14</td>
<td>5.57&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Vinegar/lime/grapefruit</td>
<td>2.5%</td>
<td>6.57&lt;sup&gt;d&lt;/sup&gt;</td>
<td>6.29</td>
<td>5.86</td>
<td>5.86&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cultured sugar/vinegar</td>
<td>3.0%</td>
<td>6.43&lt;sup&gt;d&lt;/sup&gt;</td>
<td>6.29</td>
<td>7.29&lt;sup&gt;d&lt;/sup&gt;</td>
<td>7.29&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cranberry concentrate</td>
<td>2.0%</td>
<td>1.86&lt;sup&gt;e&lt;/sup&gt;</td>
<td>5.43</td>
<td>4.86&lt;sup&gt;e&lt;/sup&gt;</td>
<td>2.86&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cherry Powder</td>
<td>0.5%</td>
<td>6.57&lt;sup&gt;d&lt;/sup&gt;</td>
<td>6.00</td>
<td>7.00</td>
<td>6.57&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Vinegar/lemon/cherry</td>
<td>1.5%</td>
<td>5.29&lt;sup&gt;d&lt;/sup&gt;</td>
<td>6.43</td>
<td>6.71</td>
<td>6.43&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Control</td>
<td>NA</td>
<td>6.14&lt;sup&gt;d&lt;/sup&gt;</td>
<td>6.57</td>
<td>7.00</td>
<td>6.29&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>SEM</td>
<td></td>
<td>0.55</td>
<td>0.42</td>
<td>0.51</td>
<td>0.48</td>
</tr>
</tbody>
</table>

<sup>a</sup>Product = various antimicrobials included in deli-style chicken breast.

<sup>b</sup>SENSORY ATTRIBUTES = Consumer panel scores using a 9 point hedonic scale where 1 = dislike extremely, 9 = like extremely.

<sup>c</sup>SEM = Standard error of the means

<sup>d,e</sup>Means within same column with different superscripts are different (P<0.05).
Figure 2. Effect of natural growth inhibitors on *Listeria monocytogenes* on uncured turkey
Averages ± SD reported for duplicate trials (n=6)

- Turkey Control No Antimicrobials
- Turkey - 1.5% lemon/cherry/vinegar blend
- Turkey - 3.0% cultured sugar/vinegar blend
- Turkey - 2.0% buffered vinegar
Figure 4. Effect of Natural Growth Inhibitors on *L. monocytogenes* on Uncured Beef

Average reported for duplicate trials (n=6)

- Beef Control No Antimicrobials
- Beef - 3.0% cultured sugar/vinegar blend
- Beef - 2.0% buffered vinegar
- Beef - 1.5% lemon/cherry/vinegar blend
Figure 3. Effect of natural growth inhibitors on *Listeria monocytogenes* on ham

Averages ± SD reported for duplicate trials (n=6)

- Natural Ham Control-No Antimicrobials
- Natural Ham - 1.5% lemon/cherry/vinegar blend
- Natural Ham - 3.0% cultured sugar/vinegar blend
- Natural Ham - 2.0% buffered vinegar
- Traditional Ham Control with 2.8% lactate/diacetate
Impact of “Natural” Ingredients on Uncured Frankfurters

“Naturally Cured” System

<table>
<thead>
<tr>
<th>TRT</th>
<th>Vegetable Juice Powder (nitrate or nitrite source)</th>
<th>Antimicrobial (cherry/lemon/vinegar or cultured sugar/vinegar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.2% pre-converted</td>
<td>NA</td>
</tr>
<tr>
<td>2</td>
<td>0.2% pre-converted</td>
<td>1.4% cherry/lemon/vinegar (c/l/v)</td>
</tr>
<tr>
<td>3</td>
<td>0.2% pre-converted</td>
<td>3.0% cultured sugar/vinegar (cs/v)</td>
</tr>
<tr>
<td>4</td>
<td>0.45% nitrate source</td>
<td>NA</td>
</tr>
<tr>
<td>5</td>
<td>0.45% nitrate source</td>
<td>1.4% cherry/lemon/vinegar (c/l/v)</td>
</tr>
<tr>
<td>6</td>
<td>0.45% nitrate source</td>
<td>3.0% cultured sugar/vinegar (cs/v)</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>2.5% Potassium lactate/sodium diacetate</td>
</tr>
</tbody>
</table>

Impact of “Natural” Ingredients on Uncured Frankfurters

Figure 9. Growth of *L. monocytogenes* on uncured, no-nitrate-or-nitrite-added (TRT 1-4) and nitrite added control (C+) uncured control (C-) EFSC sausages.

TRT 1 (nitrite-NA); TRT 2 (nitrite-c/l/v); TRT 3 (nitrite-cs/v)
TRT 4 (nitrate-NA); TRT 5 (nitrate-c/l/v); TRT 6 (nitrate-cs/v)

Natural Curing Today

- Increasing number of “natural” antimicrobials
  - Pending:
    - FDA/USDA approval
    - Effectiveness

- Greater amount of scientific knowledge slowly being generated

- Still a long way to go....
Questions?