The Effects of Polyphosphate Additives on *Campylobacter* Survival in Processed Chicken Exudates

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Campylobacter and the Food Supply

- Responsible for the largest annual number of foodborne bacterial gastrointestinal infections in the developed world

- Vast majority of campylobacteriosis cases are caused by *Campylobacter jejuni* and *Campylobacter coli*

- Most common methods for transmitting *Campylobacter* to humans
  - Improperly cooked poultry
  - Cross contamination of other foods by raw poultry

- Nutritionally fastidious and sensitive to normal atmospheric oxygen levels

- *Campylobacter* conundrum: How can a bacteria apparently unfit for survival within food processing environments persist in sufficient numbers to cause such a large amount of disease
Polyphosphate Marinades in Commercial Poultry Processing

- Polyphosphates are food-grade chemicals used in poultry marinades:
  - Improve water holding capacity (plumps product with water)
  - Stabilizes color and flavor, and improve tenderness
  - Reduces product loss during cooking (keeps it from drying out)

- Poultry products can be injected with or vacuum tumbled in marinades comprised of polyphosphates, dried chicken broth powder and water

- Polyphosphates demonstrate antimicrobial action against a range of bacterial species and appear most effective against dividing cells

- Producers are currently permitted to use polyphosphates in poultry at concentrations up to 0.5% (by weight)

- ~15% of all boneless chicken breast products are marinated
Campylobacter CFU/mL at 42°C 24 Hours
Exudate vs. Exudate Plus Marinade

= Exudate
= Exudate plus marinade

**C. coli** CFU/mL at 42°C for 24 Hours

Titration of Polyphosphate Concentration

C. jejuni CFU/mL at 42°C for 24 Hours
Titration of Dried Chicken Broth Powder

C. coli CFU/mL at 42°C for 24 Hours
Titration of Dried Chicken Broth Powder

C. jejuni CFU/mL at 4°C, Normal Atmosphere
Exudate vs. Exudate Plus Marinade

= Exudate
= Exudate + Marinade

**C. coli CFU/mL at 4°C, Normal Atmosphere**

Exudate vs. Exudate Plus Marinade

- **= Exudate**
- **= Exudate + Marinade**

Comparison of Exudate vs. Exudate Plus Marinade from Other Producers

<table>
<thead>
<tr>
<th>Poultry Producer</th>
<th>pH of Exudate</th>
<th>pH of Exudate Plus Marinade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producer #1</td>
<td>5.76</td>
<td>6.42</td>
</tr>
<tr>
<td>Producer #2</td>
<td>6.80</td>
<td>6.70</td>
</tr>
<tr>
<td>Producer #3</td>
<td>6.00</td>
<td>7.40</td>
</tr>
</tbody>
</table>

Chicken Exudate with the pH raised to the pH of Exudate Plus Marinade

- Exude (pH 5.76)
- Exude + Marinade (pH 6.42)

Graph showing the survival of Campylobacter in different pH conditions.

- C. jejuni RM1221
- C. coli RM1403

Log CFU/mL
Chicken Exudate Plus Marinade with the pH Lowered to the pH of Exudate Alone

= Exudate + Marinade (pH 6.42)

= Exudate (pH 5.76)

= Exudate + Marinade (pH 5.76)

<table>
<thead>
<tr>
<th></th>
<th>C. coli RM1403</th>
<th>C. coli RM1529</th>
<th>C. jejuni RM1529</th>
<th>C. jejuni RM3194</th>
</tr>
</thead>
<tbody>
<tr>
<td>C. coli</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>C. coli</td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>C. jejuni</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>C. jejuni</td>
<td>B</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
</tbody>
</table>

Gunther, N.W. 4th., Et al. Effects of polyphosphate additives on the pH of processed chicken exudates and the survival of *Campylobacter*. In press
Model: How Sodiation Effects the pH of Exudate

Chicken Exudate pH 6.70
**pH of Food Grade Polyphosphates in Exudate and Sodium:Phosphate Ratios**

<table>
<thead>
<tr>
<th>Polyphosphate</th>
<th>pH of Exudate Plus 0.5% Polyphosphate</th>
<th>Sodium:Phosphate Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>No polyphosphate control</td>
<td>5.8 (±0.07)</td>
<td>N/A</td>
</tr>
<tr>
<td>Disodium dihydrogen pyrophosphate</td>
<td>5.43 (±0.04)</td>
<td>1:1</td>
</tr>
<tr>
<td>Monosodium dihydrogen phosphate</td>
<td>5.63 (±0.07)</td>
<td>1:1</td>
</tr>
<tr>
<td>Sodium hexametaphosphate</td>
<td>5.88 (±0.06)</td>
<td>1:1 (+2)</td>
</tr>
<tr>
<td>Pentasodium triphosphate</td>
<td>6.28 (±0.04)</td>
<td>5:3</td>
</tr>
<tr>
<td>Tetrasodium pyrophosphate</td>
<td>6.51 (±0.1)</td>
<td>2:1</td>
</tr>
<tr>
<td>Trisodium phosphate</td>
<td>7.06 (±0.04)</td>
<td>3:1</td>
</tr>
</tbody>
</table>

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Gunther, N.W. 4th., Et al. Effects of polyphosphate additives on the pH of processed chicken exudates and the survival of *Campylobacter* at 42°C for 24 Hours with Different Food Grade Polyphosphates.
Gunther, N.W. 4th., Et al. Effects of polyphosphate additives on the pH of processed chicken exudates and the survival of *Campylobacter jejuni* CFU/mL at 4°C (Normal Atmosphere) with Different Polyphosphates.
Gunther, N.W. 4th., et al. Effects of polyphosphate additives on the pH of processed chicken exudates and the survival of *Campylobacter*. In press

*C. coli* CFU/mL at 4°C (Normal Atmosphere) with Different Polyphosphates

![Graph showing the survival of *Campylobacter* CFU/mL with different polyphosphates over time.](image-url)
Conclusions

- Marinades added during poultry processing significantly increase the survival of *C. jejuni* and *C. coli* under relevant food storage conditions.

- Polyphosphates are responsible for a large portion of the marinades observed effects on *Campylobacter* survival.

- Polyphosphate appear to increase *Campylobacter* survival by increasing the pH of the chicken exudate to a level preferred by the organism.

- Polyphosphates with differing levels of sodiation change the pH of chicken exudate to greater or lesser degrees.

- Some polyphosphates have limited effects on exudate pH, and therefore, are safer for use in foods where *Campylobacter* is present.
Future Directions

- Determine how polyphosphate mediated pH changes affect *Campylobacter* survival at the molecular level
  - Microarray studies
  - Comparative proteomics

- Determine if the microbial ecology (other than *Campylobacter*) of poultry exudate is affected by polyphosphates
  - 16s rRNA sequence survey

- Determine if, and how, other bacteria present in poultry exudate affect *Campylobacter* survival within poultry products
  - Co-incubation survival experiments
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