Brining and Marination

“Enhanced Poultry Products”

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Auburn University
U.S. Poultry Industry: Market Segments

% of Production


Whole
Parts
Further Processed

0 20 40 60 80 100
Consumer Trends

- Value-added for convenience
- Minimal preparation time
- Portion sizing
- High protein
- Enhanced flavor,
  - diverse palate
  - ethnic
- Organic
Consumer Trends

- The $115- to $150-billion ready-to-eat (RTE) segment is exploding

- 73% of consumers make evening meal decision around 4:30 P.M. the same day

- Majority want meal preparation to be 45 minutes or less

- Most meals chosen have 5 ingredients or less High protein
Enhanced Meat Products

• “Enhanced meat can be defined as fresh, whole muscle meat that has been injected with a solution of water and other ingredients that may include salt, phosphates, antioxidants, and flavorings”
Enhanced Poultry Meat Labels

- "Contains up to 7% of a solution to enhance juiciness and tenderness of water, salt, modified food starch, sodium phosphates and natural flavors."

- "Injected with up to 15% of a solution to enhance juiciness. Solution ingredients: turkey broth, salt, sugar, sodium phosphates, flavoring"
Marination vs. Brining

**MARINATION**
- Evolved as a method of meat preservation
- Includes a mixture of oil and acidic liquids
  - Vinegar, lemon juice or wine and other spices
- pH of system lower than typical brines
- Typically includes salt and may include phosphates
- Soak &/or injected (~10% uptake), tumbled
Marination vs. Brining

- **BRINE**
  - Soaking meat in or injecting meat with a salt water solution
  - Usually alkaline phosphates
  - Other seasonings maybe added as well
  - Maybe used as a soak solution, injected into the meat and then soaked or they maybe injected and tumbled
  - Can be used as a functional step in production of value added products
Areas of Further Processing

- Cut-up
- Debone

- Formed: whole
- Formed: comminuted
- Formed: emulsion
Overview.....

- Meat Chemistry
- Functional Ingredients
- Injection Marination
- Tumbling
- Other
Water: Muscle is around 70% water

- Phases
  - Bound water
    - Water molecules closely associated with muscle proteins
  - Immobilized water
    - Water attracted to bound molecules, net charge attraction
  - Free water
    - Easily separates, loosely bound
Protein

Bound ~4%

Immobilized ~10-15%

Free ~80%
ATP

Slaughter

Rigor onset

5.9

pH

ATP

1 µM/g

Muscle responsive to stimuli

Muscle unresponsive

> 90% actomyosin bond formation = shortening

not shortened

shortened
Phases of Rigor Mortis

- Completion (Hrs)

- Chicken: 4-6 hours
- Turkey: 6-8 hours
- Beef: (approx. 24 hours)
Water Holding Capacity

- Decreases in muscle pH during rigor development causes:
  - Reduced net protein charge
  - Reduced interstitial space

<table>
<thead>
<tr>
<th>NET CHARGE = +</th>
<th>NO NET CHARGE</th>
<th>NET CHARGE = -</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ + + + +</td>
<td>- - - - -</td>
<td>- - - - -</td>
</tr>
<tr>
<td>+ + + +</td>
<td>- + - -</td>
<td>- - - -</td>
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<td>+ +</td>
<td>- +</td>
<td>- -</td>
</tr>
<tr>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Steric Effect

- 2/3 of all reduced WHC due to steric effect
- Spatial issue
- Steric effect related to rigor mortis development
Muscle Proteins

- **Myofibrillar (55%)**
  - Structural
  - High ionic (salt soluble)
  - Most functional in processed meats

- **Sarcoplasmic (35%)**
  - Cellular content
  - Low ionic
  - Little effect on processed meats

- **Stromal (connective tissue)**
  - Most abundant protein in body
  - Insoluble in salt or water
  - Somewhat useful in processed meats
Myofibrillar proteins (55%)
- Myosin
- Actin
- Actomyosin (post rigor)
- Salt soluble > 4 Molar
- Isoelectric point ~5.3
Muscle Proteins

- Functional Properties of Muscle Proteins
  - Water holding capacity
  - Meat particle binding
  - Gelation
  - Fat encapsulation
  - Browning (Maillard) Reaction
  - Protein Skin
Components of Marination

- Water
- Salt
- Sodium Phosphate
- Modified Food Starch
- Soy Protein Concentrate/Isolate
- Seasoning
- Other: Gums, Carrageenan
Salt

- Enhance product flavor
- Increase moisture retention
- Act as a synergist with STPP to extract salt soluble proteins
- Inhibit the outgrowth of *Clostridium botulinum* via salt’s synergistic role with sodium nitrite
- At high concentrations, salt applied to the surface of meat dehydrates the meat and serves as a preservative
Salt

- Level not regulated
- 2% average
  - 1.5%-3%
- Types:
  - Fine
  - Granular/Coarse
  - Ionized
  - De-ionized
  - Sea Salt- may contain high level of impurities
Phosphates

- Water Binding (Increased Yield)
- Synergist with salt to extract myofibrillar proteins
- Improve texture
- Flavor Stabilization
- Color Preservation
- Prevent lipid oxidation
Kind of Phosphates

Monophosphates

Diphosphates

Triphosphates

Polyphosphates
Increased yield at higher pH and higher dosage

- 0.5 % Dosage
- 0.3 % Dosage

Yield [%]

- pH 7.3
- pH 8.8
- pH 9.5
# Classes, Formulas, pH, Solubility, and Functions of Several Phosphates

## Class: Orthophosphates

<table>
<thead>
<tr>
<th>Phosphate name</th>
<th>Generally accepted formula</th>
<th>pH 1% solut.</th>
<th>Solubility at 25C (g/100g water)</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monosodium phosphate</td>
<td>NaH$_2$PO$_4$</td>
<td>4.6</td>
<td>87</td>
<td>emulsifier, buffer</td>
</tr>
<tr>
<td>Disodium phosphates</td>
<td>Na$_2$HPO$_4$</td>
<td>9.2</td>
<td>12</td>
<td>emulsifier, buffer</td>
</tr>
<tr>
<td>Disodium phosphate dihydrate</td>
<td>Na$_2$HPO$_4$+2H$_2$O</td>
<td>9.1</td>
<td>15</td>
<td>emulsifier, buffer</td>
</tr>
<tr>
<td>Trisodium phosphate</td>
<td>Na$_3$PO$_4$</td>
<td>11.8</td>
<td>14</td>
<td>emulsifier, buffer</td>
</tr>
<tr>
<td>Monopotassium phosphate</td>
<td>KH$_2$PO$_4$</td>
<td>4.6</td>
<td>25</td>
<td>water binding in meat</td>
</tr>
<tr>
<td>Dipotassium phosphate</td>
<td>K$_2$HPO$_4$</td>
<td>9.3</td>
<td>168</td>
<td>emulsifier, buffer</td>
</tr>
<tr>
<td>Tripotassium phosphate</td>
<td>K$_3$PO$_4$</td>
<td>11.9</td>
<td>107</td>
<td>emulsifier, buffer</td>
</tr>
</tbody>
</table>

Food Technology 1990
# Classes, Formulas, pH, Solubility, and Functions of Several Phosphates

## Class: Condensed Phosphates Pyrophosphates

<table>
<thead>
<tr>
<th>Phosphate name</th>
<th>Generally accepted formula</th>
<th>pH 1% solut.</th>
<th>Solubility at 25°C (g/100g water)</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium acid pyrophosphate</td>
<td>Na$_2$H$_2$P$_2$O$_7$</td>
<td>4.3</td>
<td>15</td>
<td>emulsifier, buffer, sequestrant, water-binding agent in meal</td>
</tr>
<tr>
<td>Tetrasodium pyrophosphate</td>
<td>Na$_4$P$_2$O$_7$</td>
<td>10.3</td>
<td>8</td>
<td>dispersant, coagulant, crystallization inhibitor in canned tuna</td>
</tr>
<tr>
<td>Tetrapotassium pyrophosphate</td>
<td>K$_4$P$_2$O$_7$</td>
<td>10.5</td>
<td>187</td>
<td>emulsifier, water binding agent in meats, suspending agent</td>
</tr>
</tbody>
</table>

Food Technology 1990
Classes, Formulas, pH, Solubility, and Functions of Several Phosphates

Class: Tripolyphosphates

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<thead>
<tr>
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<th>pH 1% solut.</th>
<th>Solubility at 25°C (g/100g water)</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium Tripolyphosphate</td>
<td>Na$_5$P$<em>3$O$</em>{10}$</td>
<td>9.9</td>
<td>15</td>
<td>Emulsifier, water binding agent in meats</td>
</tr>
<tr>
<td>Potassium tripolyphosphate</td>
<td>K$_8$P$<em>3$O$</em>{10}$</td>
<td>9.6</td>
<td>193</td>
<td>Emulsifier, water binding agent in meats</td>
</tr>
</tbody>
</table>

Food Technology 1990
## Classes, Formulas, pH, Solubility, and Functions of Several Phosphates

### Class: Long-chain polyphosphates

<table>
<thead>
<tr>
<th>Phosphate name</th>
<th>Generally accepted formula</th>
<th>pH 1% solut.</th>
<th>Solubility at 25°C (g/100g water)</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>(NaPO₃)₆+Na₂O</td>
<td>7.7</td>
<td>40a</td>
<td>Sequestrant, emulsifier, water binding agent in meats, suspending agent</td>
</tr>
<tr>
<td>Polyphosphates, glassy, or Graham’s Salt; three chain lengths; Sodium hexametaphosphate has an average chain length of 13</td>
<td>(NaPO₃)₁₃+NA₂O</td>
<td>6.9</td>
<td>40a</td>
<td>Sequestrant, emulsifier, water binding agent in meats, suspending agent</td>
</tr>
<tr>
<td></td>
<td>(NaPO)₂₁+Na₂O</td>
<td>6.3</td>
<td></td>
<td>Sequestrant, emulsifier, water binding agent in meats, suspending agent</td>
</tr>
</tbody>
</table>

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## Classes, Formulas, pH, Solubility, and Functions of Several Phosphates

**Class:** Metaphosphates, Tri-, Tetra-

<table>
<thead>
<tr>
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<th>Generally accepted formula</th>
<th>pH 1% solut.</th>
<th>Solubility at 25°C (g/100g water)</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium trimetaphosphate</td>
<td>(NaPO₃)₃</td>
<td>6.7</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Sodium tetrametaphosphate</td>
<td>(NaPO₃)₄+4H₂O</td>
<td>6.2</td>
<td>18</td>
<td></td>
</tr>
</tbody>
</table>
Maximum solubility in salt-brines at 20 °C
Phosphates

- Diphosphate or pyro content (smaller chains) provide buffering capacity
- Need to dissolve phosphate prior to adding salt
- No greater than 0.5% in finished product
- STPP account for 80% of phosphates used
What to look for when buying a sodium Phosphates

- Product must be free of impurities
- Are plants using hard or softened water
- pH- needs to be controlled
- Solubility, product must dissolve
- Stays in solution
- Is product effective at lower usage levels
- Increase in yields
- Retain water during freeze thaw period
What to look for when buying a sodium Phosphates

• Compounds are chemically bound molecule to molecule (standard phosphates are granular to granular such as a 90-10 blend)
• Are you getting enough di-phosphate to retain moisture.
• Should be salt tolerant
Sodium and Potassium Lactate

- Weak acid
- Disrupts membrane pH gradients
- Inhibit energy metabolism.
- Lactate alone only bacteriostatic at high concentrations
- 2.9% pure sodium lactate or 4.8% in a 80% solution allowed
Sodium Diacetate

- Dissociates into acetic acid and sodium acetate
- Lower pH due to presence of acetic acid
- Sodium diacetate alone only bacteriostatic at high levels
- 0.25% allowed in finished product
Validation Cotto Salami

Milkowski, 2002
Starches

- Binds water – hydrogen bonding
- Improves texture
- Increases yield
- Increases viscosity
- Used as fat replacers
- Native and modified starches
  - Modified typically used because ease of hydration
- Average use around 2.0%, 3.0% max
Starches

Amylose

Amylopectin
## Amylose Content of Various Starches

<table>
<thead>
<tr>
<th>Starch Source</th>
<th>% Amylose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waxy Rice</td>
<td>0</td>
</tr>
<tr>
<td>High Amylose Corn</td>
<td>70</td>
</tr>
<tr>
<td>Corn</td>
<td>28</td>
</tr>
<tr>
<td>Cassava</td>
<td>17</td>
</tr>
<tr>
<td>Waxy Sorghum</td>
<td>0</td>
</tr>
<tr>
<td>Wheat</td>
<td>26</td>
</tr>
<tr>
<td>Potato</td>
<td>20</td>
</tr>
</tbody>
</table>
Soy Proteins

- Binds water – hydrogen bonding
- Protein-protein binding
- Increases bite
- Cohesion
- Emulsification
- Extenders- flours
- Adds viscosity
- Increases yield
Soy Proteins

- **Defatted Soy Flour** - 50% protein
  - Used as extender for sausages and ground beef
  - Can lead to beany flavors at high levels

- **Soy Concentrate** - 70% protein

- **Soy Protein Isolate** - 90% protein
  - Excellent binder
  - Emulsification

Binds 1 to 6 grams water per gram protein, 3.5 % max
Main carageenan types and their properties.

<table>
<thead>
<tr>
<th>Carageenan Types</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa</td>
<td>Forms strong and brittle gels that are reversible when heated</td>
</tr>
<tr>
<td>Iota</td>
<td>Forms weak elastic gels that reverse when heated</td>
</tr>
<tr>
<td>Lambda</td>
<td>Thickening agent-does not form gels</td>
</tr>
</tbody>
</table>
Carageenans—Polysaccharides, Gums

- Increasing yield
- Water binding
  - Gel network
- Consistency
- Sliceability
- Spreadability
- Cohesiveness
- Decreases purge, fat content and slicing loss

0.5-1.5% in meat applications
cured hams the level is maximum of 1.5%.
Injector - needles
Formed Products

- Tumbling - Actions
Tumbling

- Increases penetration of brine
  - agitation
  - physical impact
  - vacuum - opens meat structure,
  - meat swells and draws solution in
  - helps extract salt soluble proteins to surface
  - tumble, 4° C, 1/2 hour to overnight

- Whole muscle products, large muscle parts
- Not used with comminuted poultry products
Tumbler
Tumbling

Benefits

• even out distribution of brine
• increase protein extraction
• accelerate curing reaction (cured products)
• maximize and obtain uniform yield
• reduce processing time
• reduce cooking loss
• improve sliceability
• salvage protein that would be lost in brining
Marination and Cook

- Chiller temperature -7 C
- Front halves were boned out with fillet wt of 4-4.5 oz.
- Tumble for 18 minutes, rest for 5 minutes then proceed to packaging.
- Pouched and held for 4 hrs, purge was measured, recorded and then cooked at 350 F till an internal temp of 160 F.
Results

WB Kg/g Shear Force

- Group A Non Aged
- Group B 6hrs Aged
- Group C Non Aged 15%
- Group D 6hrs Aged 15%