Vacuum Packaging Fresh Meat with Nitrite Containing Film

Dan Siegel

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Vacuum Packaging Fresh Meat with Nitrite Containing Film

Outline of Presentation

- Review Fresh Meat Packaging and Color
- Describe Nitrite Film Packaging
- List of New Research Opportunities
History of Fresh Meat Packaging

♦ 50 years ago (prior to 1960):
  - Most fresh meat was cut at small local slaughter houses
  - Packaging format: “Hand Wrapped Paper”
Boxed Beef and Vacuum Shrink Bags

The Wholesale Fresh Meat Package
History of Fresh Meat Packaging

- **Slaughterhouses**
  - Become large
  - Locate centrally

- **Retail Grocers**
  - Employ the butchers
  - Cut and grind into retail cuts
The Retail Grocer’s Fresh Meat Package (1960-present)

Display Life:
- Pork, Beef, Lamb = 3 days
- Chicken = 5 days

Typical Wrapped Tray
- PVC stretch film (oxygen permeable),
- soaker pad and foam tray
Fresh Meat Packaging in 1970’s

- Chicken cutting was removed from the retail grocer and the slaughterer began to cut and package it for retail display.
  - Economics of in store cutting.
  - Food safety concerns.
  - Vertical integration by poultry processors.
Case Ready Packaging

Definition

Centralized fabrication and packaging of a retail cut of fresh meat so as to make it ready for the display case without re-packaging at store level.
The Case Ready Chicken Package

Shelf Life = 10 - 14 days

Typical Wrapped Tray

Printed polyolefin shrink wrap (oxygen permeable), soaker pad and foam tray
Case Ready Packaging

“Typical Wrapped Tray”

Unacceptable for Case Ready Red Meat

- Even though meat remains wholesome, its color turns brown within 3 days.
- 10-14 days are needed to allow for distribution from a centralized facility.
Basics of Fresh Meat Color

♦ It is the relative abundance of the three types of myoglobin that determine color.
Fresh Meat Color Triangle

Fresh Cut Deoxymyoglobin (Fe^{2+})

Oxygenation

Reduction MRA + OCR

Oxidation

Bloomed Oxymyoglobin (Fe^{2+})

Discolored Metmyoglobin (Fe^{3+})
Basics of Fresh Meat Color

- It is the relative abundance of the three types of myoglobin that determine color.

- Low partial pressure of oxygen accelerates metmyoglobin formation.
The Effect of Oxygen on the Relative Percentage of Meat Pigments

- Deoxymyoglobin (Purple)
- Oxymyoglobin (Red)
- Metmyoglobin (Brown)
Metcurve

Typical “PVC Wrapped Tray”

The Effect of Time on Color Pigments
Research Focus (1980’s-present)

- Extending color life of red meats:
  - **Additives** e.g. phosphates, sequestrants, reducing agents and antioxidants.
  - **Packaging** e.g. peelable barrier, perforated venting, active gas exchange.
  - **Gases** e.g. pressurized gases, noble gases and carbon monoxide.
Case Ready Today

Percent of market by category:
1. Chicken – 95%
2. Pork - 60%
3. Ground Beef – 70%
4. Whole Muscle Beef - 30%
Case Ready Packaging Formats

Red Meat:

1. Vacuum – whole muscle
   ♦ Shrink bags
   ♦ Forming/Nonforming
   ♦ Skin Pack

2. Chubs – ground beef
   ♦ Printed film

3. Modified Atmosphere Package (MAP)
   ♦ High oxygen
   ♦ Oxygen free with carbon monoxide
Case Ready Packaging Formats

**BEEF**

1. High Oxygen MAP
   - Ground Beef
2. Oxygen free MAP with CO
   - Whole Muscle
High Oxygen MAP

Oxygen as a Myoglobin Blooming Agent

Shelf Life = 10 - 14 days
Fresh Meat Surface Color

High Oxygen MAP

O2 used as myoglobin blooming agent

Fresh Cut DEOXY (Fe²⁺)

Oxygenation

Discolored MET (Fe³⁺)

Reduction MRA + OCR

O₂

e⁻

Oxygenation

Bloomed OXY (Fe²⁺)

O₂ used as myoglobin blooming agent
The Effect of Time on Color Pigments

Metcurve
High Oxygen MAP

The Effect of Time on Color Pigments
High Oxygen Ground Beef

10 Days
High Oxygen Ground Beef

12 Days - Expired Display Life (still wholesome)
Premature Browning

Oxidation in High Oxygen MAP

Chub

High Ox MAP

Cooked to 140°F Internal
Black Bone

Oxidation in High Oxygen MAP
Disadvantages of High Oxygen MAP

- Oxidation of color/flavor
- Premature Browning
- Black bone
- Shelf life (< 2 weeks)
- Display life (< 3 days)
- Bulky (higher costs for shipping, warehousing, and display)
- Poorly suited to freezing
- Off-line leaker detection
- Sustainability and cost
Oxygen free MAP with CO

CO as Myoglobin Blooming Agent
Shelf Life > 28 days
Fresh Meat Surface Color

Oxygen Free MAP with CO

CO is used as myoglobin blooming agent

Myoglobin Carboxylation:
1. MRA + OCR
2. Carbon Monoxide
3. Eliminate oxygen

Carboxylation by CO
The Effect of Time on Surface Pigments

Metcurve
Oxygen Free MAP with CO

The Effect of Time on Surface Pigments
Disadvantages of CO MAP

- Persistent pinking
- Consumer concern
- Bulky (higher costs for shipping, warehousing and display)
- Poorly suited to freezing
- Off line leaker detection
- Sustainability and cost
- Banned in Europe
PVC Wrapped Tray in Mother Bag
PVC Wrapped Tray in Mother Bag

Additional disadvantages:
- Short display life (< 3 days)
- Leaking packages
- Sustainability and cost
Nitrite Film Packaging

We can cause and maintain the consumer preferred red color in a vacuum package by adding sodium nitrite to the film.

Objective: To nitrosylate the myoglobin pigments that comprise the viewing surface.
Resin Pellets
Basic Cast Extrusion

Nitrite Containing Resin

Barrel

Screw

Extrusion Die

Film
Cross Section of Nitrite Film

Package Exterior

Outer Layer

Sealant Layer

Barrier Layer

Meat Product Surface

Invisible Sodium Nitrite Crystals
The required amount of nitrite is directly related to the concentration of myoglobin in the meat.

- Beef: 3-10 mg/g
- Pork: 1-3 mg/g
- Poultry: <1 mg/g
Nitrite Film Packaging

Amount of Nitrite:

- Less than 10% migrates from the film.
- Typical ingoing nitrite for beef < 2 ppm.
- Residual nitrite is not detectable.
Curing vs Nitrite Film Packaging

Curing (150-200 ppm NaNO₂):

Fresh Cut Deoxy (Fe²⁺) → NO + O₂ → Discolored NitrosoMet (Fe³⁺) → pH<5.0 → NO from NaNO₂ → Dinitroso hemachromagen (Fe²⁺)

Discolored NitrosoMet (Fe³⁺) → Mono Nitroso (Fe²⁺) → Heat → Dinitroso hemachromagen (Fe²⁺)

Nitrite Film Packaging (1-10 ppm NaNO₂):

Fresh Cut Deoxy (Fe²⁺) → NO → Discolored NitrosoMet (Fe³⁺) → Nitroso (Fe²⁺)
Fresh Meat Surface Color

Nitrite Film Packaging

NO is used as a myoglobin blooming agent

Myoglobin Nitrosylation:
1. Nitrite containing film
2. Fresh Meat
3. Vacuum Packaging
4. Bloom time

Nitrosylation

Discolored NITROSOMET (Fe³⁺) → Reduction MRA + OCR → Bloomed NITROSO (Fe²⁺)

Fresh Cut DEOXY (Fe²⁺) → NO₂⁻ + O₂ → Oxygenation → Bloomed OXY (Fe²⁺)

Discolored MET (Fe³⁺) → Reduction MRA + OCR → Oxidation → Fresh Cut DEOXY (Fe²⁺)
Metcurve
Nitrite Film Packaging

The Effect of Time on Surface Pigments
Nitrite Film Packaging

Requirements:

1. The Film
   - Barrier to oxygen
   - Source of Nitrite

2. The Meat
   - Fresh Meat with good reducing activity (MRA/ARA/OCR)
   - Minimal exposure time to oxygen before packaging

3. Vacuum Packaging
   - Eliminates atmospheric oxygen
   - Causes the film to make intimate contact with meat surface
   - Must be hermetically sealed to prevent ingress of oxygen

4. Refrigerated Storage (12-60 hours)
   - Migration of Nitrite and reactions that cause nitrosylation
Nitrite Film Packaging

Suitable Packaging Formats:
1. Vacuum skin pack
2. Forming/nonforming
3. Shrink bags
4. Chub casings
Vacuum Skin Pack

Strip Steaks after 30 days

Nitrite Containing Film  Control Film
Vacuum Skin Pack

Pork Chops after 30 days
Forming/Nonforming

Forming: Clear w/ Nitrite

Nonforming: Black w/o Nitrite

Note: soaker pad is optional for enhanced cuts
Regulatory Status

GRAS No. 228
Labeling

Beef Loin Top Loin Steak
Color maintained with sodium nitrite from film packaging

NEW YORK STRIP STEAK

<table>
<thead>
<tr>
<th>0.90</th>
<th>$8.00</th>
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<tbody>
<tr>
<td>NET WT./LB.</td>
<td>PRICE/LB.</td>
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6713
PLU
07748

Total Price
$7.20

U.S. INSPECTED AND PASSED BY DEPARTMENT OF AGRICULTURE

KEEP REFRIGERATED

THE PACKAGE MAKES IT POSSIBLE!
Comparison to Existing MAP formats

1. High Ox MAP Tray:

   - Oxidation of color/flavor
   - Premature Browning
   - Black bone
   - Shelf life (< 2 weeks)
   - Display life (< 3 days)
   - Bulky (higher costs for shipping, warehousing, and display)
   - Poorly suited to freezing
   - Off-line leaker detection
   - Sustainability and cost

2. CO Mother Bag:

   - List of Disadvantages:
Sustainability and Cost

1. Processor Costs
   • Packaging and freight

2. Retailer Costs
   • Shrink and mark downs
# Processor Costs

<table>
<thead>
<tr>
<th>Item Description</th>
<th>CO Mother Bag</th>
<th>Nitrite Film</th>
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<tbody>
<tr>
<td>Primary package</td>
<td>$0.105</td>
<td>$0.089</td>
</tr>
<tr>
<td>Master pouch</td>
<td>$0.084</td>
<td>$0.000</td>
</tr>
<tr>
<td>Oxygen scavenger</td>
<td>$0.194</td>
<td>$0.000</td>
</tr>
<tr>
<td>Gas</td>
<td>$0.028</td>
<td>$0.000</td>
</tr>
<tr>
<td>Corrugated</td>
<td>$0.111</td>
<td>$0.038</td>
</tr>
<tr>
<td>Freight</td>
<td>$0.087</td>
<td>$0.039</td>
</tr>
<tr>
<td><strong>Total $/lb</strong></td>
<td><strong>$0.609</strong></td>
<td><strong>$0.166</strong></td>
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</table>

Approximate Savings/lb = $0.45
## Retailer Losses

<table>
<thead>
<tr>
<th>Item Description</th>
<th>CO Mother Bag</th>
<th>Nitrite Film</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price to retailer</td>
<td>$5.00</td>
<td>$4.55</td>
</tr>
<tr>
<td>Mark downs/shrink</td>
<td>8%</td>
<td>2%</td>
</tr>
<tr>
<td>Retailer’s Cost/lb</td>
<td>$5.43</td>
<td>$4.64</td>
</tr>
<tr>
<td><strong>Sales price at 25%:</strong></td>
<td>$7.24</td>
<td>$6.19</td>
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<tr>
<td><strong>Sales price at 45%:</strong></td>
<td>$9.87</td>
<td>$8.43</td>
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</tbody>
</table>

**Total Reduction of Retail Pricing** > **$1.00/lb**
Nitrite Film Packaging

DISADVANTAGES?

♦ Bloom time
♦ Regulatory Approval
  ▪ Shelf life restrictions
  ▪ Labeling
♦ Persistent Pinking
♦ Color change after removing from package
♦ Consumer activism against nitrite
Conclusion

New Research Opportunities:

♦ Science of nitrosylation and fate of nitrite
♦ Application to other species
♦ Factors that affect Postmortem Metabolism
  - Animal variations (diet, age, sex and breed)
  - Muscle variations
  - Zilpaterol HCL and ractopamine
  - Slaughter conditions
New Research Opportunities:

- Shelf life – microbiological and sensory
- Additives/methods that improve performance
  - Enhancements
  - Intervention strategies
- Consumer acceptance
- Cooking performance