AGENDA

- **Tim Birmingham**, Almond Board of California, moderator
- **Ramesh Gunawardena**, JBT
- **Paul Favia**, Laitram Machinery
- **Jim Becker**, Revtech
JSP-C Hybrid Steam Pasteurization System

Almond Conference

Ramesh Gunawardena / December 5, 2018
Overview

• Objective
• Background Modes of Heat & Mass Transfer
• Actionable approach to determine the variables with the greatest influence
• Describe the overall pasteurization model
• Conceptual design
• Principles of operation applied to next generation solution
• Validation considerations
• Processing capacity and cost of ownership
• Design features - an emphasis on functionality, simplicity, performance
• Q & A
Objective

How we started:

Apply knowledge of cooking principles to surface pasteurization of low moisture foods

Where we are today: A technology update
### 3³ Factorial Arrangement

<table>
<thead>
<tr>
<th>Oven Temperature</th>
<th>Percent MV</th>
<th>Fan Speed</th>
<th>Air Velocity (ft./min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>375°F</td>
<td>40</td>
<td>50(2250)</td>
<td>75(3375)</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>80</td>
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<tr>
<td>425°F</td>
<td>40</td>
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<td>60</td>
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<td></td>
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<tr>
<td></td>
<td>80</td>
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<tr>
<td>475°F</td>
<td>40</td>
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<td>60</td>
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<tr>
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<td>80</td>
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<td></td>
</tr>
</tbody>
</table>
Heat Transfer for Surface Pasteurization

- Background

• Process by which heat energy is delivered to a bulk product for the purpose of .....?

• Path Specific

• Factors involved in heat transfer
  - Temperature
  - Heat Mode
  - Thermal Conductivity
Variables to Consider

Heat to the product surfaces

Equipment
- Operating temperature
- Humidity
- Velocity
- Heat transfer rate
- Dwell time

Product
- Surface temperature
- Core temperature
- Thermal conductivity
- Product bed depth
- Specific heat
- Thermal diffusivity
Heat Transfer Modes - Background

Heat transfer occurs through three basic modes:

- Conduction
- Convection
- Radiation

Heat is also exchanged as a result of mass (water) condensation or evaporation.
**Modes of Mass Transfer - Background**

**Diffusion**

**Convection**

**Condensation** when

\[ T_{\text{air, dewpoint}} > T_{\text{product, surface}} \]

**Evaporation** when

\[ T_{\text{air, dewpoint}} < T_{\text{product, surface}} \]
# Development Objectives Vs. Design Considerations

<table>
<thead>
<tr>
<th>Development Objectives</th>
<th>Design Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide consistent &gt;5 Log reduction of SE PT-30</td>
<td>Rapid and lethal energy transfer</td>
</tr>
<tr>
<td>Maintain natural quality and product characteristics</td>
<td>Compress time</td>
</tr>
<tr>
<td>Design must ensure that all nuts on the conveyor receive identical treatment</td>
<td>Heat transfer mechanisms arranged in the proper sequence</td>
</tr>
<tr>
<td></td>
<td>Uniform energy transfer through</td>
</tr>
<tr>
<td></td>
<td>- Correct fluid conditioning</td>
</tr>
<tr>
<td></td>
<td>- Fluid distribution balance</td>
</tr>
</tbody>
</table>
Effective Heat Transfer Coefficients (Btu/hr-Ft²-°F)

- Condensation
- Contact
- Frying
- Impingement
- Forced Convection
- Free Convection

Magnitude
Pasteurizing with High Humidity

- Rapid Heat Transfer From Condensation
- Evaporative Cooling & Drying

Desired Lethality

Processing Time

- Processing Temperature:
  - 180°F
  - 190°F
  - 200°F
  - 205°F
  - 210°F
  - 230°F
Pasteurizing with High Humidity

- **Rapid Heat Transfer From Condensation**
- **Dew Point**
- **Evaporative Cooling & Drying**

**STEAM ZONE**

**CONVECTION ZONE**

Processing Time

Desired Lethality
Pasteurizing with High Humidity

Rapid Heat Transfer From Condensation

Dew Point

Evaporative Cooling & Drying

STEAM ZONE

CONVECTION ZONE

Desired Lethality

Processing Time
Pasteurizing with High Humidity

Rapid Heat Transfer From Condensation

Dew Point

Evaporative Cooling & Drying

230°F

STEAM ZONE

CONVECTION ZONE

180°F

190°F

200°F

205°F

210°F

210°F

220°F

230°F

Processing Time

Desired Lethality
Modeling the process

High Condensation
Condensation & Evap. Cooling
Drying
Exit the Pasteurizer
Jet Steam Pasteurizer Concept

Hybrid System

Zone 1:
>90% MV

Zone 2:
80-82% MV

Zone 3:
Discharge
Moisture by Volume

A better humidity scale for T>212°F (100°C)

- Humidity
  - relative humidity
  - moisture by volume
  - dew point temperature

- All of the temperature and humidity values are linked by thermodynamics

- \( RH = \left( \frac{p_{\text{water}}}{p_{\text{saturation}}} \right) \times 100 \)
Criteria for Lethality Vs. Product Quality

**Critical Control Parameters for achieving lethality & Purpose**
- Steam zone temperatures
- Main chamber moisture by volume
- Main chamber temperature
- Velocity
- Dwell time
- Bed depth

**Essentials for Controlling Product Quality**
- Compress time
- Concentration gradient
- Correct fluid conditioning
- Fluid distribution balance
- Fat composition & types of fat
- Surface Condition/Thermal Conductivity

Proper sequence
Striking the right balance
### Possible causes of surface defects vs. Corrective actions

**Loose skins in almonds (example)**

<table>
<thead>
<tr>
<th>Causes of Surface Defects</th>
<th>Corrective Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Localized Vapor stagnation</td>
<td>Lower bed depth</td>
</tr>
<tr>
<td>Prolonged exposure in wet steam</td>
<td>Increase zone velocity</td>
</tr>
<tr>
<td>Limited pathway for vapor release</td>
<td>Adjust the bed depth</td>
</tr>
<tr>
<td></td>
<td>Fluid distribution balance</td>
</tr>
<tr>
<td></td>
<td>Raise the operating temperature</td>
</tr>
<tr>
<td></td>
<td>Understand where</td>
</tr>
</tbody>
</table>
Additional Processing Considerations for quality

- Product quality needs to be measured over time
- Degradation over time measured by FFA’s & PV
- Oxidative degradation less at lower temperatures
- Review thermal properties
- Employ design of experiments
- Use existing scientific knowledge to reduce the number of trials
### 3³ Factorial Arrangement - Almonds

<table>
<thead>
<tr>
<th>Oven Temperature</th>
<th>Percent MV</th>
<th>Dwell Time 55s</th>
<th>Dwell Time 64s</th>
<th>Dwell Time 74s</th>
</tr>
</thead>
<tbody>
<tr>
<td>370°F</td>
<td>75</td>
<td></td>
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<tr>
<td></td>
<td>78</td>
<td></td>
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<td></td>
<td>81</td>
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<tr>
<td>380°F</td>
<td>75</td>
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<td>78</td>
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<tr>
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<td>81</td>
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</tr>
</tbody>
</table>

Velocity held constant – for providing fluidization

Response variables: PV, FFA, Bacterial Count
Production Feed to the Pasteurizer

Metering Gate

Vibratory Feed Conveyor

Infeed JSP-C
JSP-C Pasteurizer Designed With Vision Of The Future
JSP-C Pasteurizer – Hood in Elevated Position

Easy Access After CIP
JSP-C Pasteurizer – Hood In Operational Position

Full Perimeter Seal
JSP-C Pasteurizer – Key Functional Elements

- Circulation Fan
- Heat Exchanger
- Plenum Damper
- CIP Tank
- Upper Finger Assembly
- Nozzle plate
- Impingement plate

End View
JSP-C Pasteurizer – Supply & Return Airflow Paths
JSP-C Pasteurizer – Supply & Return Airflow Paths
JSP-C Pasteurizer – Key Functional Elements

- Product Path
- Circulation Fans
- Heat Exchanger
- Upper Finger Assemblies
- Impingement Plates
- Side View
JSP-C Pasteurizer – Supply & Return Airflow Paths

Side View
JSP-C Pasteurizer – Supply & Return Airflow Paths

Side View
JSP-C Pasteurizer – Discharge Diverter Gate

Production Mode

Bypass Mode
JSP-C Almond Pasteurization System – Benefits

- Continuous process
- Cleaner product with greater product appeal
- Very short dwell times
- Shorter foot print
- Drying is part of the process
- Low operating cost ~ 0.35 Cents/Lb.
Processing Capacity and Cost of Operation*

- Pasteurization Capacity up to 4300 lbs./hr.
- Effect on yield: Negligible
- Operational Cost: $32.76/hour for Gas, Electricity and Water
- $0.0312/lb. based on 4300 lbs./hr.

*Based on JSP-C 2416
JBT pioneered their unique hybrid steam pasteurization process for almonds and received Almond Board of California's TERP approval in 2006. Since then JBT has also developed processes with onsite validations completed for Walnuts, Hazel Nuts (in-shell and kernels) and Cashews using the ABC protocols. Throughput rates for pasteurized nuts at a 5 log reduction of Salmonella Enteritidis PT-30 at the equipment discharge are as shown in the table below.

<table>
<thead>
<tr>
<th>Product</th>
<th>Throughput in JSP-I-4022 Lbs./Hr.</th>
<th>Throughput in JSP-C-2416 Lbs./Hr.</th>
<th>Throughput Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almonds</td>
<td>18,000</td>
<td>7,700</td>
<td>Validated process since Feb. 7, 2006</td>
</tr>
<tr>
<td>Walnut Halves</td>
<td>14,000</td>
<td>6,000</td>
<td>Validated process since July 21, 2017</td>
</tr>
<tr>
<td>Walnuts-Pieces</td>
<td>13,000</td>
<td>5,600</td>
<td>Validated process since July 21, 2017</td>
</tr>
<tr>
<td>Hazel Nuts</td>
<td>8,500</td>
<td>3,600</td>
<td>Validated process since May 16, 2017</td>
</tr>
<tr>
<td>Cashews</td>
<td>14,200</td>
<td>6,100</td>
<td>Validated process since June 15, 2017</td>
</tr>
<tr>
<td>Pecans</td>
<td>16,000</td>
<td>6,900</td>
<td>Range finding completed</td>
</tr>
<tr>
<td>Macadamias</td>
<td>8,000</td>
<td>3,500</td>
<td>Range finding completed</td>
</tr>
<tr>
<td>Peanuts</td>
<td>18,000</td>
<td>7,700</td>
<td>Range finding completed</td>
</tr>
</tbody>
</table>
Your turn to ask questions
JBT Technical Training Department
offering training in:
coating, frying & oven cooking applications,
line operations, maintenance, sanitation,
safety, customized training, and more
at your site or in our
Food Processing Technology Center
Almond Pasteurization
Landscape of Technologies
Almond Conference 2018

COOLSTEAM® PASTEURIZATION

Presented by Paul Favia – Crystal Process Equipment
Pasteurization…. Safety and Quality

Pasteurize (Verb)

1. To expose a food to an elevated temperature for a period of time sufficient to destroy certain organisms, as those that can cause disease or spoilage, without radically altering taste or quality.

- China 1117 AD – Heating of wine for preservation
- France 1679 – Denis Papin invents the Pressure Cooker
- Italy 1768 - Lazzaro Spallanzani discovers heat will sterilize meat broth
- France 1795 – Nicolas Appert begins modern canning in glass.
- England 1810 – Peter Durand expands Apperts work to tin cans
- France 1864 – Louis Pasteur pioneers low temperature treatment of wine
- USA, 2007 – Pasteurization of almonds is mandated

✓ Regulatory Compliance
✓ Customer Requirement
✓ Liability Mitigation
✓ Doing the Right Thing
Pasteurizing with Steam

• “Expose to... elevated temperature for a period of time” = Heat Units!

• Steam temperature and method of application directly impacts product characteristics.

• Two key relationships
  • Time and Temperature = Heat Units
  • Heat Units and Lethality = Desired Log Reduction
Challenges with Nut Pasteurization

• Nuts are a delicate product requiring gentle processing to minimize quality impact:
  • Texture
  • Flavor
  • Moisture
  • Shelf Life
  • Skin Lift
  • Color

• Laitram CoolSteam technology has evolved specifically for other delicate products.
THE COOLSTEAM® PASTEURIZATION SYSTEM
Breakthrough technology for Delicate Products

CoolSteam®
Breakthrough Technology
Revolutionized Shrimp cooking

Laitram re-enters the vegetable market with low temp steam blanching

Nut Industry: Pistachios & Almonds
Laitram is contacted by a Pistachio processor to test. CoolSteam nut pasteurization is launched

TERP approval for Almonds

16 y.o. J. M. Lapeyre Invented First Steam Cookers in 1943
To cook prior to peel in Cold Water Shrimp

Patented technology delivers significant benefits over traditional water high temp cooking systems: Yield, Energy savings, Quality and Food Safety
Laitram CoolSteam – The Sweet Spot

• “It’s a “Steam Pasteurizer” - All steam is not created equal!

• Homogeneous Steam – Air Mixture
• Rapid lethality is achieved.
• Moisture uptake is controlled
• Laitram CoolSteam process never exceeds 212 F.
Pasteurization Process – 4 Steps

- **Pre Heater** – Gentle, dry heat increases surface temperature of product to control (reduce) condensation.
- **CoolSteam Pasteurizer** – Homogenous Steam / Air mixture for gentle heat transfer.
- **Dryer** – Dry heat removes all residual moisture
- **Cooler** – Decreases product temperature to ambient or below, direct to storage or final package.

**COOLSTEAM®** means product never over 212 F
Excellent Product Quality

- **Product Looks and Tastes Raw**
  No Skin Damage, Flaking, or Color Change

- **Natural Crunch**

- **Moisture Neutral**

- **Excellent PV** *(Peroxide Value)* and **FFA** *(Free Fatty Acid)*
  Values for Walnuts

100% NATURAL
Product Applications

Proven to produce high quality:

Pistachios  Almonds  Walnuts  Cashews  Hazelnuts  Pecans  Macadamia
Food Safety

The CoolSteam® System complies with rigorous food safety standards. Our technology has been tested and approved by renowned universities, third party labs and our most demanding customers.

• Selectable 4 or 5 Log Reduction
  Recipes allow for optimal balance of lethality and quality
  Proven on Almonds, Pistachios, Cashews and Walnuts

• TERP Approved
  Validated per Almond Board of California TERP protocol

• Precise Temperature Control
  Temperature control within +/-0.5°F

• Cleanable design
  Emphasis on sanitary design principles
  Self cleaning belt
THANK YOU!

Time for Discussion & Questions
Almond Pasteurization:

Landscape of Technologies/Equipment
Pasteurization & Roasting technology
for almonds
Who is Revtech?

- Created in **1997, based in France**
- Technology: **Vibrating Electrical Heated Tube.**
- **Continuous heat treatment system for** bulk solids in food, pharmaceutical and chemical industries.
- Design, Installation and Commissioning of complete customized industrial units in the customers plant:
  
  **Tailor – made & turn – key projects.**
Principle of operation

Raw Product

Hot Product

Belt cooler

Treated Product at ambient temperature
How does it work?

Continuous process based on a combination of 3 simple principles:

- Transportation / Mixing by **vibrations**
- Heating by direct **contact with a hot surface**
- Treatment in a **confined space to control the atmosphere**
Principle of operation

In terms of process:
(from the product point of view)

T from 120°F to 800°F

Main parameters

- Flowrate: 200 lb/h to 5 ton/h
- Temperature: 120 to 800°F
- Residence time: 1 to 40 minutes
- Atmosphere: air, steam, nitrogen…

120 to 600 ft long

Optional injection of steam

3” – 10” Diameter
Principle of operation

1. **Transport / Mixing**: in ss tube vibrated by off balanced motors

![Diagram of transport/mixing system with off balanced motors](image-url)
Principle of operation

1. **Transport / Mixing**: in ss tube vibrated by off balanced motors

- Frequency: ~ 10-12 Hz
- Amplitude: ~ 1/8 in
- Acceleration: ~ 4 g
Principle of operation

2. **Heating of the product**: by direct contact with hot ss pipe which is heated by electricity using Joule effect (High impedance tube)

Electrical current

- High current
- Low voltage < 40V
3. Operation in controlled atmosphere:
   - Product is heated in a confined atmosphere
   - Gas or steam can be injected through the process
   - Gas inertion is possible as well
Principle of operation

The main operating parameters are then:
- temperature ( +/- 1°F) with 2 or 3 independent heating zones
- residence time
- atmosphere inside the tube
- flowrate of product
Revtech for Pasteurization:

Benefits of Revtech for Pasteurization:

- Able to achieve significant reduction of pathogenic bacteria – Salmonella, E. Coli, enterobacteria, yeasts & molds…
- Minimal change on product properties
- System requires only electrical connection at 3 phase, 60hz, 460Volt
- Highly efficient transfer of energy to product
Pasteurization – How does it work?

1st phase pre-heating

2nd phase small injection of steam

Raw Product

Pasteurized hot Product

Belt cooler

Pasteurized Product at ambient temperature
Pasteurization in a Revtech

Tube at ~ 230°F

~ 2 to 5 % of steam

(20 to 50 lb/h of steam for 1,000 lb/h of product)

~ 8 min

Pre-heating

Steam atmosphere
Pasteurization in a Revtech

Product Temperature

~ 75°F

~ 176°F

Time

Pre-heating

Steam ~ 8 min

Cooling
Pasteurization – Challenge tests on almonds

On **almonds**, the primary risk is a Salmonella contamination & the goals are:

- Guarantee **a 5 log reduction on Salmonella**
- Receive approval from reference organizations: **FDA / Almond Board of California**
- Maintain the product quality: skins, color, crunchiness…

![Raw vs. Pasteurized Almonds](image)
Main Advantages

- **Continuous process:**
  - Low labor cost
  - No recontamination
  - Adapted to modern factories

- **Works for almonds as well as for other products**

- **Low energy consumption**
  - Pasteurization about 100 kW.h/ton – around $12 / ton
  - Roasting: about 150 kW.h/ton – around $20 / ton

- **Minimal maintenance & easy cleaning**
  - Spiral internals cleaned using pigging technology
  - Basic maintenance every 6 months

- **One operator** to run the unit
  (PLC controller to define recipes & record operating data)
References

More than 120 projects installed all around the world
Conclusion

The **key factors** of REVTECH Pasteurization technology:

- **Greater homogeneity** is ensured by vibration:
  
  *Every particle is treated, no particle is over treated*

- **Only gentle vibrations** (no auger, belt, mixer…): perfect preservation of the product

- Every machine can be **validated for pasteurization**
  
  *(5 or more Log reduction on Pathogens / Salmonella – FDA validated)*

Validated for almond pasteurization on three continents!
Thank you for your time.

Revtech Booth #1209
What’s Next

Wednesday, December 5 at 12:00 p.m.

• Luncheon Presentation – Hall C
  Speaker: David Deak

Luncheon is ticketed and is sponsored by Moss Adams
Silent Auction

Start your holiday shopping at our Silent Auction in Hall A+B - all proceeds go towards CA FFA scholarships!
Wednesday & Thursday until 3:00 p.m.
Buy Your Golden Ticket at the FFA Booth

100 GOLDEN TICKETS WILL BE SOLD

Throughout the conference 100 golden tickets will be sold. One lucky person will win and get their choice of one item from the live auction.

MUST BE PRESENT AT THE GALA DINNER TO WIN.

Visit the FFA silent auction booth to purchase a golden ticket and learn more!

The golden ticket winner will be drawn prior to the live auction.