Modern Processing in Nutrient Preservation

Jackkrit Worachotdechasakul
B Eng (HONS) Chemical Engineering
Sales Manager at JBT Marel
Jackkrit.Worachotdechasakul@jbtmarel.com

JBT Marel

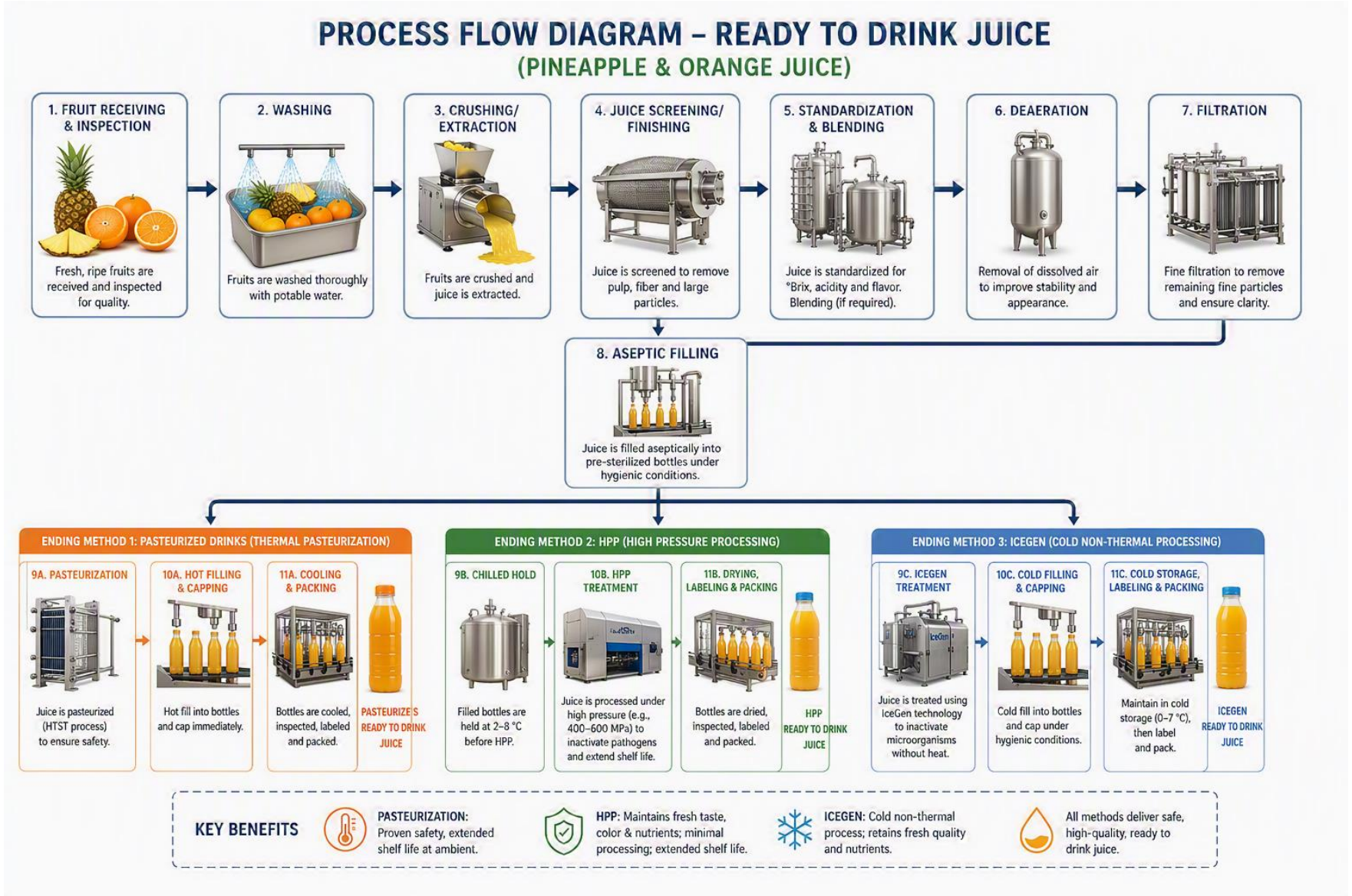
Speaker Profile

จักรกฤษ วรโชติเดชาสกุล

- Bachelor of Engineering (B.Eng.) in Chemical Engineering – First Class Honours from the University of Nottingham, UK.
- Expertise in
  - Handling technology in food and beverage.
  - Evaporation design especially in sugar, sweeteners, fruit juices, and wastewater ZLD.
  - In-Container sterilization including batch retorts and continuous hydrostatic sterilization.
  - Nutrient preservation technology; pasteurization, UHT, HPP, and IceGen.
- Expectation
  - Provide an overview of the modern preservation technology in fruit and vegetable processing.

Agenda

- Ohmic Heating – Fast heating by electricity.
- High Pressure Processing (HPP) – Non thermal preservation.
- IceGen – Extend shelf life by slurry ice technology.

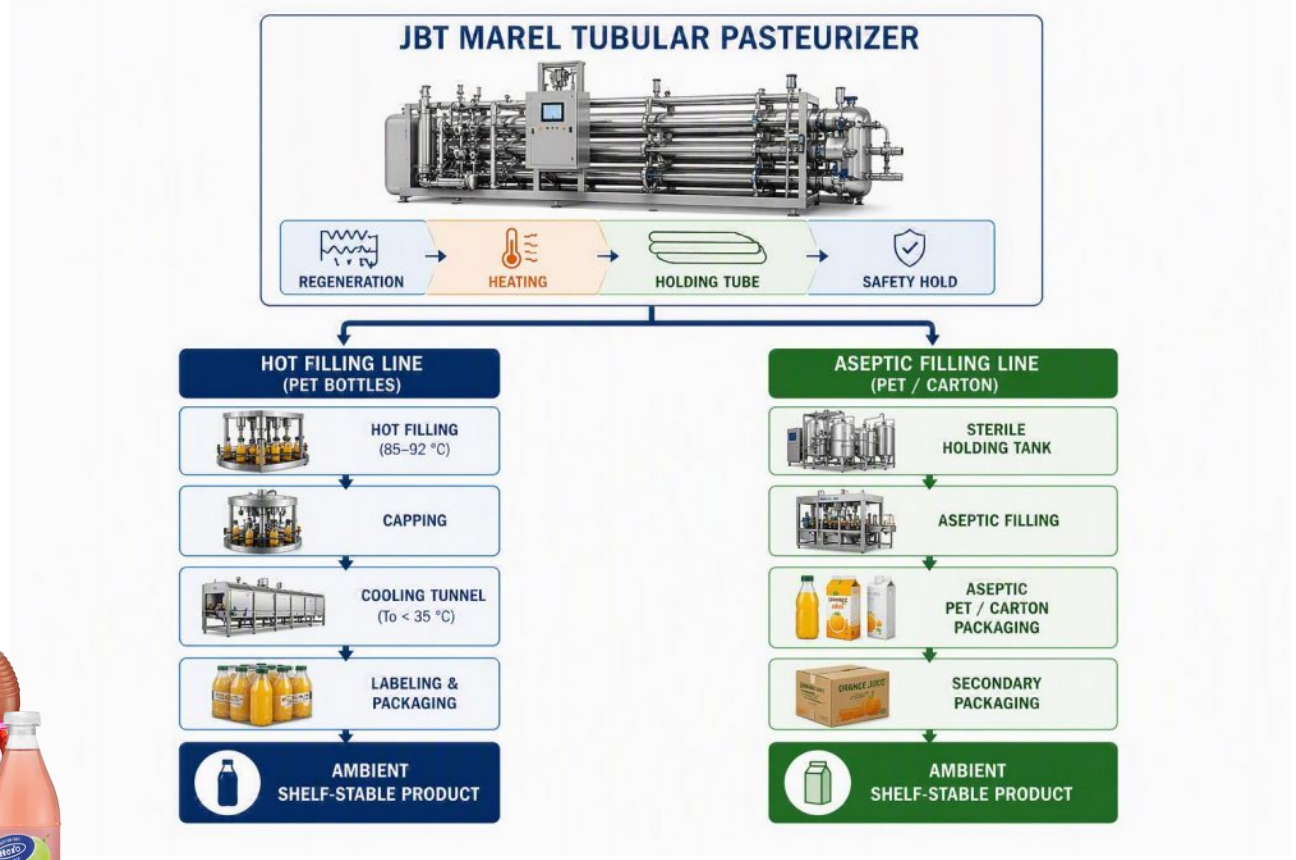

PROCESS FLOW DIAGRAM – READY TO DRINK JUICE
(PINEAPPLE & ORANGE JUICE)
1. FRUIT RECEIVING & INSPECTION
Fresh, ripe fruits are received and inspected for quality.
2. WASHING
Fruits are washed thoroughly with potable water.
3. CRUSHING/ EXTRACTION
Fruits are crushed and juice is extracted.
4. JUICE SCREENING/ FINISHING
Juice is screened to remove pulp, fiber and large particles.
5. STANDARDIZATION & BLENDING
Juice is standardized for °Brix, acidity and flavor. Blending (if required).
6. DEAERATION
Removal of dissolved air to improve stability and appearance.
7. FILTRATION
Fine filtration to remove remaining fine particles and ensure clarity.
8. ASEPTIC FILLING
Juice is filled aseptically into pre-sterilized bottles under hygienic conditions.
ENDING METHOD 1: PASTEURIZED DRINKS (THERMAL PASTEURIZATION)
9A. PASTEURIZATION
Juice is pasteurized (HTST process) to ensure safety.
10A. HOT FILLING & CAPPING
Hot fill into bottles and cap immediately.
11A. COOLING & PACKING
Bottles are cooled, inspected, labeled and packed.
PASTEURIZED READY TO DRINK JUICE
ENDING METHOD 2: HPP (HIGH PRESSURE PROCESSING)
9B. CHILLED HOLD
Filled bottles are held at 2–8 °C before HPP.
10B. HPP TREATMENT
Juice is processed under high pressure (e.g., 400–600 MPa) to inactivate pathogens and extend shelf life.
11B. DRYING, LABELING & PACKING
Bottles are dried, inspected, labeled and packed.
HPP READY TO DRINK JUICE
ENDING METHOD 3: ICEGEN (COLD NON-THERMAL PROCESSING)
9C. ICEGEN TREATMENT
Juice is treated using IceGen technology to inactivate microorganisms without heat.
10C. COLD FILLING & CAPPING
Cold fill into bottles and cap under hygienic conditions.
11C. COLD STORAGE, LABELING & PACKING
Maintain in cold storage (0–7 °C), then label and pack.
ICEGEN READY TO DRINK JUICE
KEY BENEFITS
PASTEURIZATION: Proven safety, extended shelf life at ambient.
HPP: Maintains fresh taste, color & nutrients; minimal processing; extended shelf life.
ICEGEN: Cold non-thermal process; retains fresh quality and nutrients.
All methods deliver safe, high-quality, ready to drink juice.

SteriDeal® Ohmic

- Ohmic pasteurizers offer faster, more energy-efficient heating that preserves food quality, extends shelf life, and reduces production costs compared to conventional thermal methods. They are especially valued in dairy, juice, and egg processing industries for maintaining nutritional and functional properties while ensuring microbial safety.

What is a pasteurizer?

- A pasteurizer is a device that applies controlled heat treatment to food or beverages to make them safe and extend shelf life without fully sterilizing the product.
- Extend shelf life between 6-12 months
  - Pasteurization: 90–95°C for 15–30 sec
- Inactivate microorganisms.
- Stabilize flavor and color.



SHORT TIME HEAT TREATMENT IN BEVERAGE

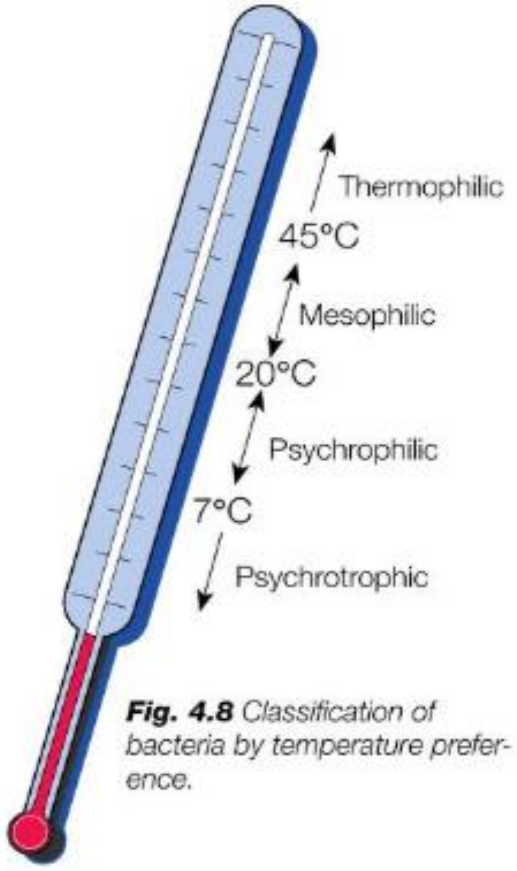


Fig. 4.8 *Classification of bacteria by temperature preference.*

Heat treatment	Purpose	Details	Shelf life
Thermization	to kill most psychrotrophic bacteria	few seconds at 65°C	about 1 day 7°C
Low pasteurization	to kill all pathogenic organisms	15 seconds at 72°C	about 7 days 7°C
High pasteurization	to kill almost all vegetative micro-organisms	15 seconds at 85°C	about 10 days 7°C
Extended shelf-life pasteurization (ESL)	to kill almost all vegetative micro-organisms and some spores	4 seconds at 125°C	about 2 to 3 weeks at 7°C
UHT treatment	to kill all micro-organisms including spores	4 seconds at 140 °C	9 - 12 months at room temperature

Straight Tube Heat Exchangers
Overview




- **Construction:**

  Tube bundles in straight tube-in-tube and multi-tube-in-shell designs are created by welding tubes to a tube sheet, using either 3-meter or 6-meter pipes.

- **Connections and Maintenance:**

  U-shaped bends connect the bundles, requiring gaskets and leak detection ports for assembly and maintenance, and serve as transition points.

- **Sterilization System Design:**

  The design must accommodate thermal expansion and withstand necessary temperatures and pressures, including phases of high-temperature sustainment or cooling.

UHT HELICAL COIL HEAT EXCHANGERS

Advantages of Utilizing “Dean Effect” in Coil UHT System

- **Enhanced Heat Transfer Efficiency**:

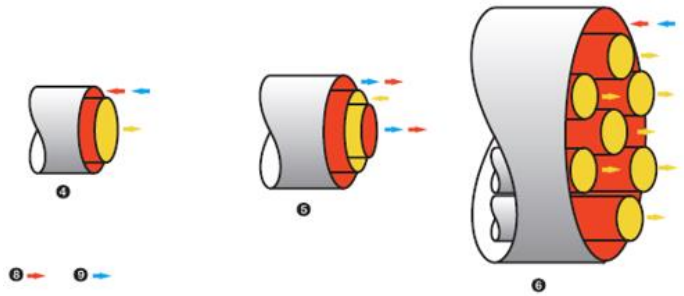
  Achieves up to 30% improvement in uniform heat transfer compared to straight tube designs.

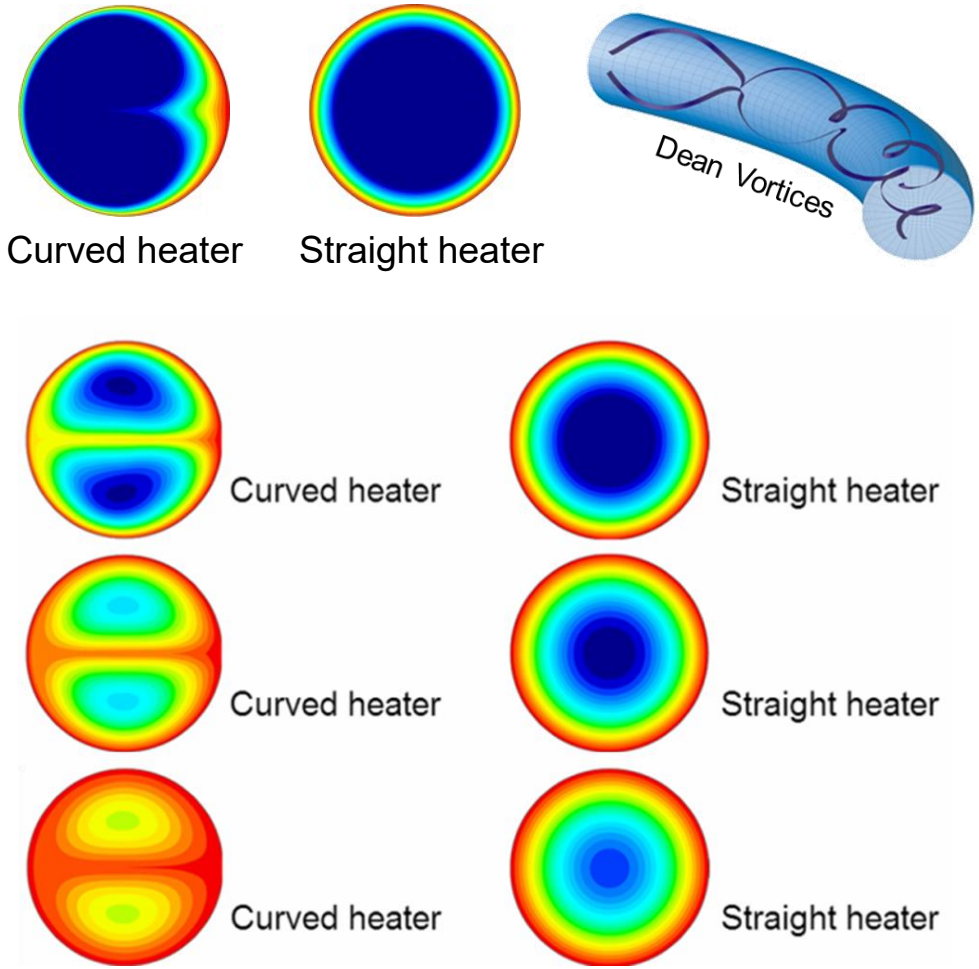
- **Superior Product Quality**:

  Achieves consistent sterility while improving product quality through up to 30% more uniform heat transfer compared to straight tube systems.

- **Versatility**:

  Ideal for processing high-viscosity products and those prone to rapid fouling.





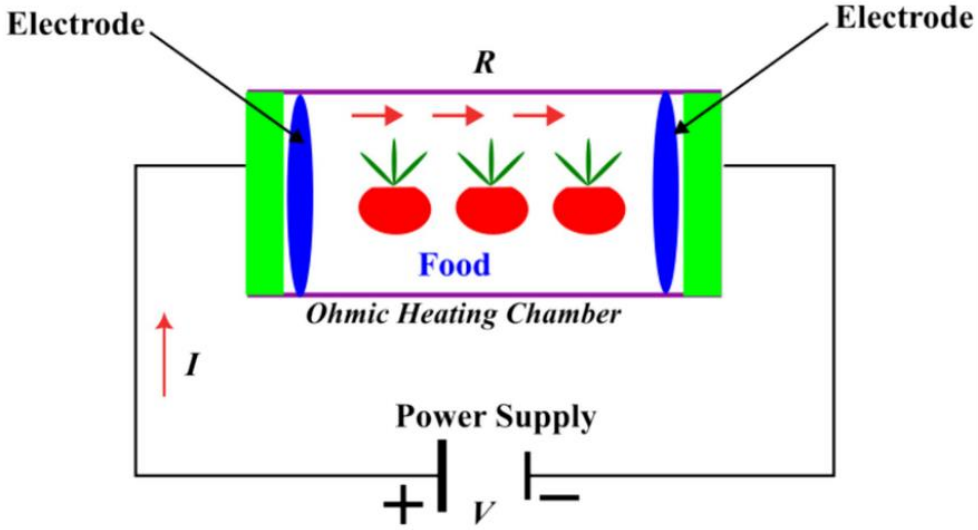
THEORY
Introduction to Ohmic Heating

- DEFINITION:

  Electrical resistance heating process

- PRINCIPLE:

  Heat generation through electric current passing through a material.



Working principles of ohmic heating (dos Santos et al. 2024).

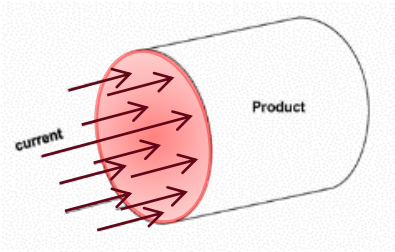
Ohmic Heating

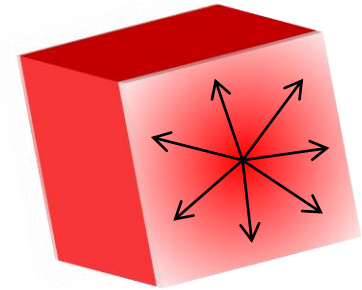
Benefits of Ohmic Heating for Food

- UNIFORM HEATING
  - Provides consistent temperature distribution.
  - Ensures consistent temperature distribution within food products.
  - Reduces the risk of overheating or underheating specific areas

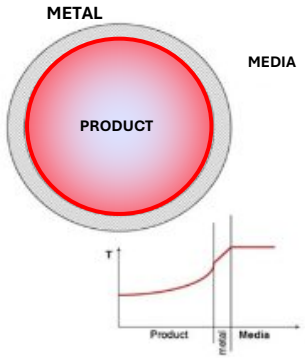
- ADVANTAGES
  - Faster heating rates compared to conventional methods.
  - Energy-efficient process with reduced consumption.
  - Minimal thermal gradients, preserving food quality by minimizing thermal damage.

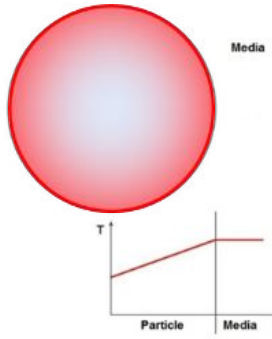
Ohmic





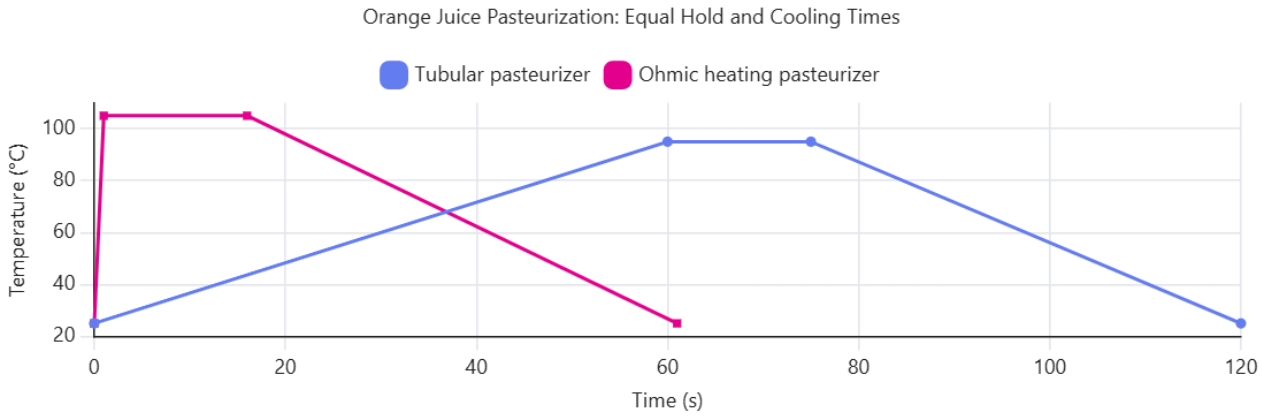
Conventional





Product liquid

Heating method comparison; Ohmic vs Tubular



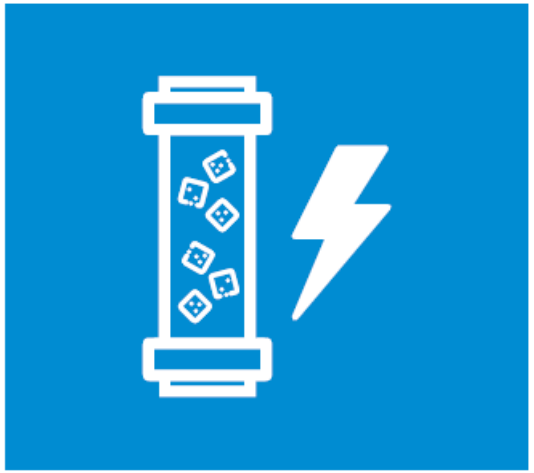
- Retain fresh flavour
- Less colour change due to exposing to heat
- Less vitamin C degradation
- Better fresh juice characteristics

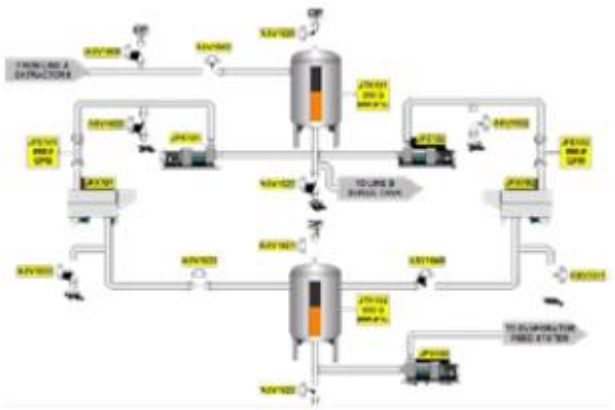
Parameter	Fresh	Tubular	Ohmic
L* (brightness)	Highest	Lower	Closer to fresh
Browning Index	Lowest	Higher	Lower
ΔE	0	Larger	Smaller

THEORY
Considerations for Effective Ohmic Heating in Food Processing

- ELECTRICAL PROPERTIES OF FOOD
  - Conductivity varies among different food types; crucial for effectiveness.

- SYSTEM DESIGN
  - Proper electrode design and configuration are essential for uniform heating.



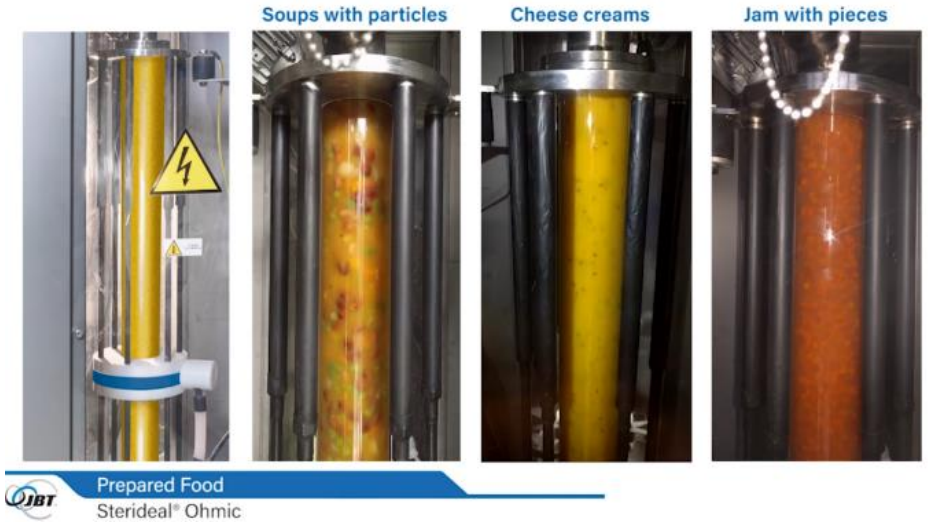


THEORY
Conclusion

- Ohmic heating offers significant advantages for food processing.
- It is increasingly adopted for its efficiency and quality preservation in food safety applications.

SteriDeal® Ohmic

- Viscosity: Max 5000 cPo (100s-1 at 20°C)
- Max particle size 10 °Bx: 12x12x12 mm
- Capacity: 350 LPH approximately for visocity 5,000 cP
- Product conductivity range: 0.5 – 90 mS/cm
- Product range:
  - Fruit & vegetable juices and purees
  - Fruit & vegetable dices (fruit preparation)
  - Milk, yoghurt, alternative dairy &beverage (with and without particles)
  - Tes & coffee
  - Liquid food
  - Protein mix
- Pilot unit include:
  - Product feed pump
  - 1 unit of Ohmic heating section
  - 1 unit of Coiled holding section (holding section can be added depends on product)
  - 1 unit of Coiled cooling section
  - 1 unit of Aseptic tank
  - 1 unit of Recirculation tank
  - 1 set of Control system and cabinet



High Pressure Processing

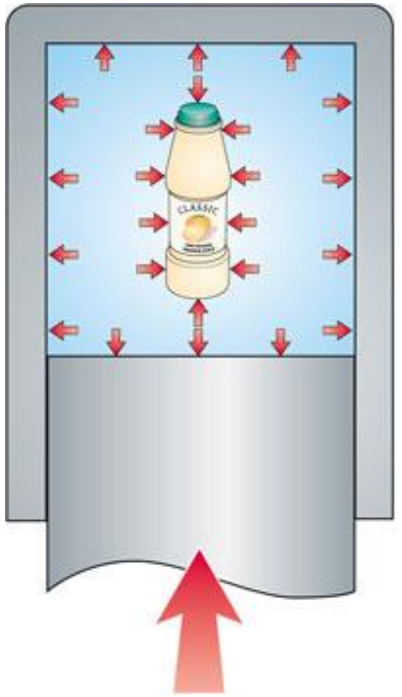
Launched HPP Products and Brands

THEORY
Introduction to High Pressure Process Technology (HPP)

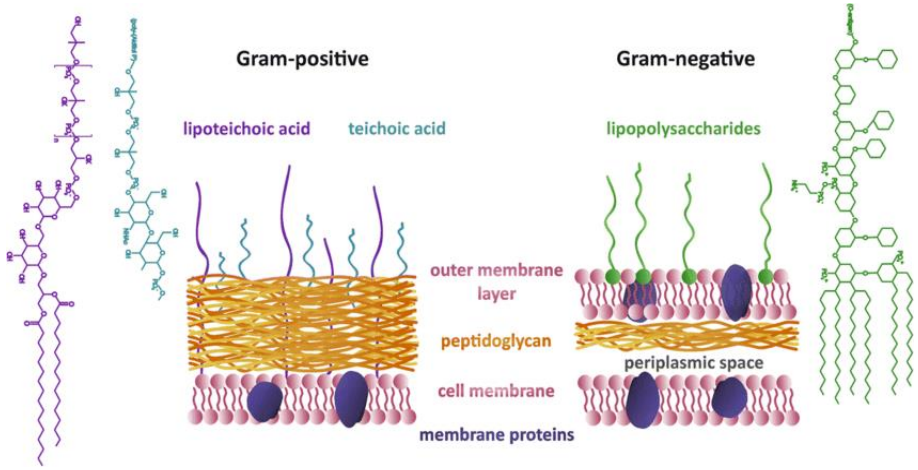
- DEFINITION

  A non-thermal food preservation method that uses high pressure to inactivate pathogens and extend shelf life.

- PRINCIPLE
  - Applies pressure uniformly around food products.
  - Typical pressure levels reach up to 600 MPa.
  - Duration of the process is short, ensuring minimal impact on food quality.



THEORY
Key Concepts



Differences between Gram-positive and Gram-negative bacterial cell walls
(Lovering et al. 2010; Clifton et al. 2013)

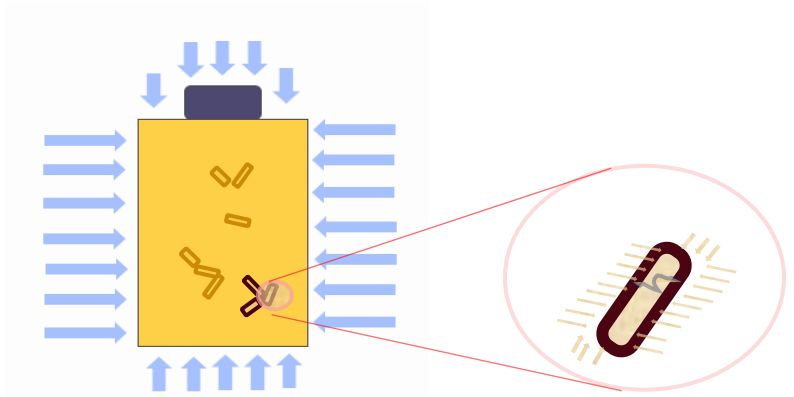
- **Uniform Pressure Application**
  - Food products are subjected to pressures up to 600 MPa.
  - Pressure is applied uniformly, ensuring consistent microbial inactivation.

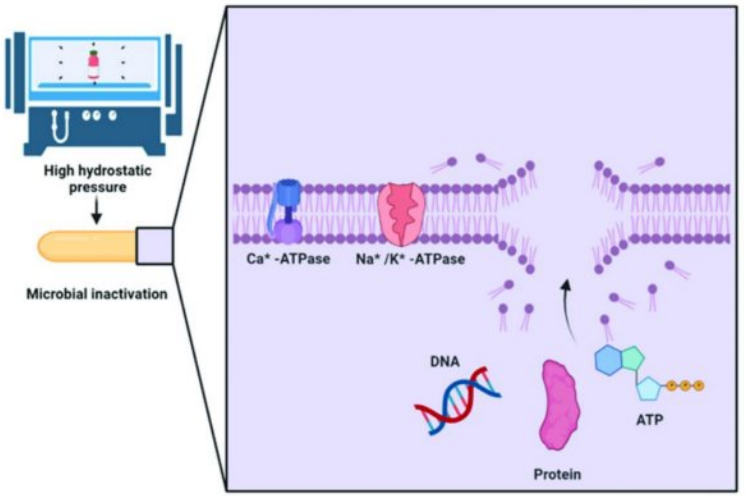
- **Disruption of Cell Walls**
  - High pressure compromises bacterial cell walls.
  - Inactivation of key pathogens: Listeria monocytogenes, Salmonella spp., Escherichia coli.

- **Effectiveness**
  - Typical pressure levels: 400 to 600 MPa.
  - Duration: 1 to 5 minutes.
  - Non-thermal method preserves taste, texture, and nutritional value.

THEORY
Key Concepts

- **3 steps Mechanism of HPP impact on Microorganism**
  - Pressure inactivates bacterial cells: Disrupts biochemical functions, prevents recovery
    - 1st Cell wall damage
      - Affects membrane-bound proteins
      - Transport system
      - Protein denaturation
      - Electroporation
      - Decrease in membrane potential
    - 2nd Affects all intracellular reactions
      - Results in cytoplasmic oxidative stress
      - Damage to ribosomes
      - Some effects on gene expression
      - Decrease in cellular ATP concentration
    - 3rd Cells are injured
      - Die off
      - Need to wait 12 to 24 hours to assess effects of HPP treatment
        - Cells will die off or recover





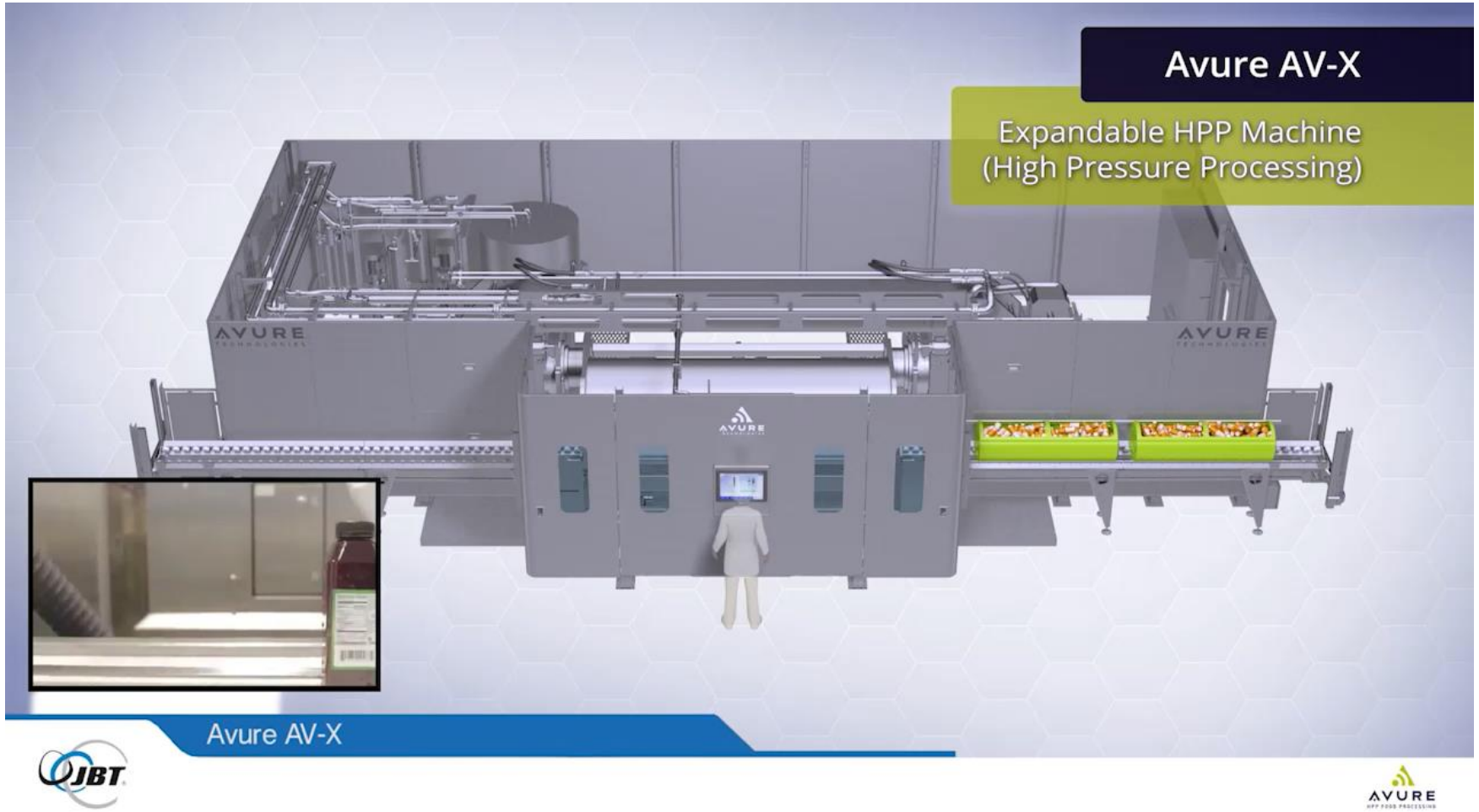
THEORY
Benefits of HPP

- **Enhanced Safety**
  - Equivalent to pasteurization (standard thermal process).
  - Achieves a log reduction of 5 to 6 in bacterial populations (reduces by 100,000 to 1,000,000).

- **Quality Preservation**
  - Non-thermal method preserves taste, texture, and nutritional value.
  - Maintains food's natural qualities without heat.

- **Extended Shelf Life**
  - Reduces microbial load, allowing products to stay fresh longer.
  - Supports clean-label products by minimizing preservatives and additives.

The Actual Process



THEORY
Applications of HPP in Food Industry

- **Common Applications**
  - Juices and Beverages: Preserves fresh taste and nutritional value.
  - Meats and Seafood: Enhances safety and extends shelf life.
  - Ready-to-Eat Meals: Preserves taste and texture without preservatives.
  - Plant-Based Foods: Supports quality and safety for the growing market.

- **Packaging Considerations**
  - Requires flexible packaging like pouch bags and screw PET bottles.
  - Glass and cans are unsuitable for HPP due to pressure requirements.

Pouch bag | **Screw Pet bottle** | **Glass bottle** | **Aluminum can**

Conclusion

- **Key Benefits**
  - Enhanced safety through effective pathogen inactivation.
  - Preservation of food quality and nutritional value.
  - Extended shelf life without the need for preservatives.

- **Applications**
  - Versatile use across various food sectors: juices, meats, ready-to-eat meals, and plant-based products.
  - Supports clean-label initiatives and meets consumer demands for fresh products.

- **Considerations**
  - Initial investment costs balanced by long-term benefits.
  - Importance of consumer education and seamless integration into existing processes.
  - Addressing enzyme activity and bacterial spore challenges.

Cold Preservation
IceGen

Technology: LiquidIce

LiquidIce is a phase changing liquid made up of millions of ice “micro-crystals” from the liquid food which remain suspended within the same liquid food solution.

Mango

Strawberry

Peach

Banana

What will ice-slurry juice bring you?

- IceGen will make **ice slurry** using water from liquid product like juices, sauces, **keeping properties of original product intact.**
- The temperature of this product is equal to **freezing** point; it could be anything from **-1.5˚C to lower**.
- A concentrate or viscous sauce of high brix level can be cooled instantly in IceGen, which otherwise may require many modules of traditional SSHEs, blast freezer, or other batch freezing technology.
- It will instantly **stop microbial and enzymatic activity** to keep quality of your product very high.
- It is a sustainable solution for frozen products as **cost of freezing** is almost **25%** in IceGen compared to a Blast Freezer.
- Product can be transported **without refrigerated trucks** from extraction location to further processing location.
- It occupies far **less space** in your factory compared to alternative freezing technologies.

Characteristics of LiquidIce

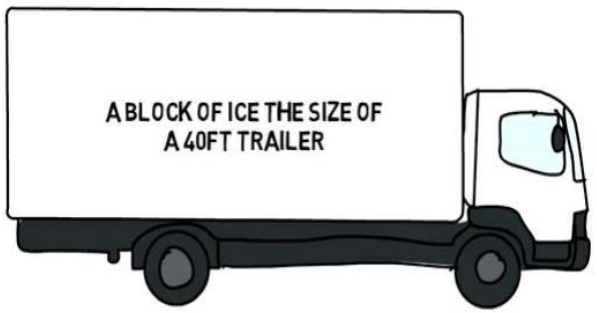
1. Consists of billions of microscopic ice crystals in a liquid form.

2. Microscopic ice crystals have a significantly higher contact surface area than one big block of ice.

If a cube is halved ‘n’ times, new surface area will grow by ‘2n’ times.

Number of smaller cubes	Number of Surfaces	Surface Area (Total)	
1	6	6	
8	48	12	6 X 2
64	384	24	$6 X 2^2$
512	3072	48	$6 X 2^3$
4096	24576	96	$6 X 2^4$
32768	196608	192	$6 X 2^5$
262144	1572864	384	$6 X 2^6$
2097152	12582912	768	$6 X 2^7$

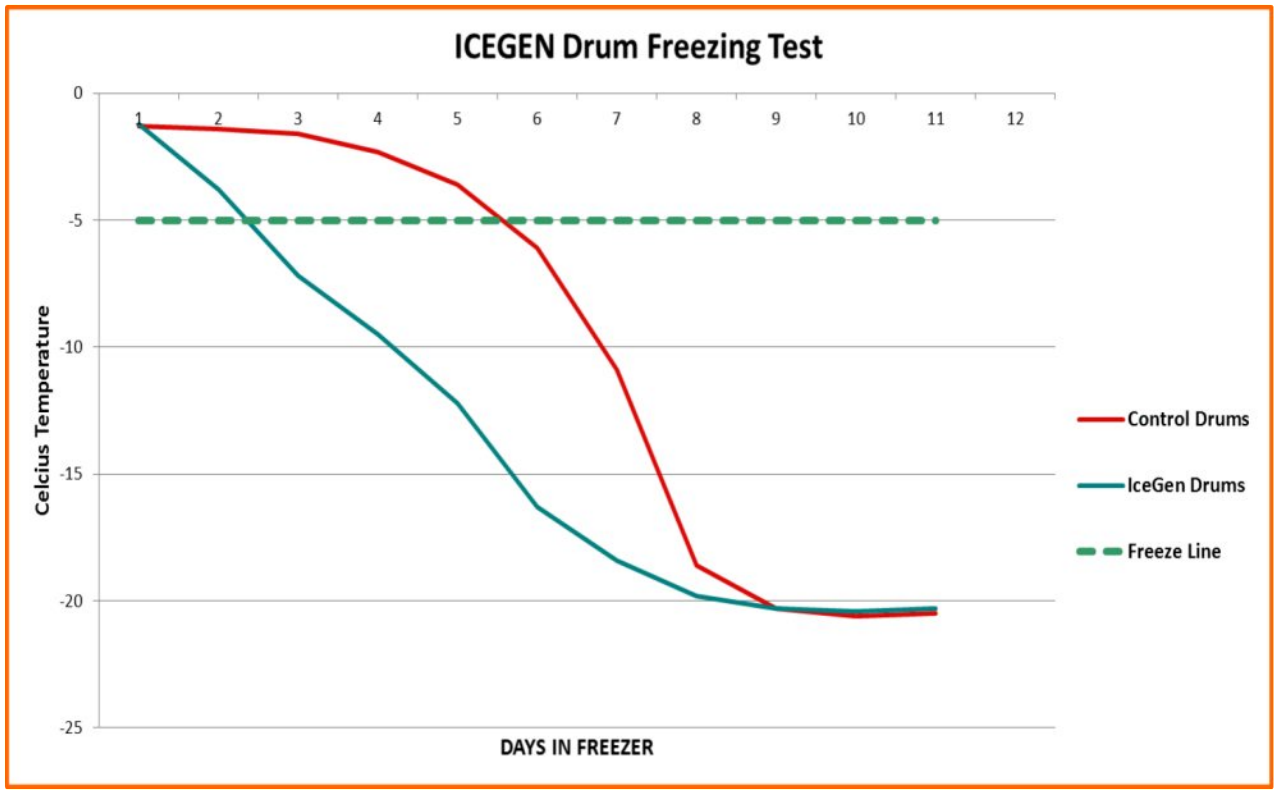
Cooling capacity of 18 X 2-liter bottles of water of liquid ice.



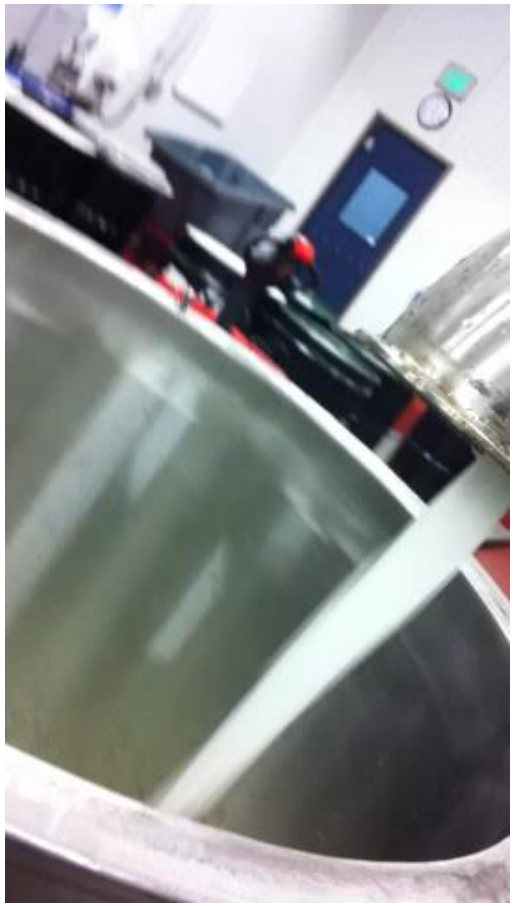
2000 times bigger!

Characteristics of LiquidIce (Continue)

3. Freezes faster; in comparison to other freezing methods.



4. Remains pumpable in high % of ice fraction.



Characteristics of LiquidIce (Continue)

5. Freezing happens homogeneously, instead of outside-in

Non-IceGened product

IceGened product

Unfreezing: Frozen outside-in

(Non-IceGen Product

Case Study: Coconut Milk is Homogeneous

Traditional Blast Freezer IceGen Freezer

- Very significant phase shift on the witness. The puree dosed after cooling via IceGen is more homogeneous with little separation of the material after thawing.

- The rapid freezing after dosing allows the puree to freeze evenly. Thawed product is also more homogeneous and allows the product to be "more beautiful".

Conclusion

Transportation
Icegen'd products in drums can be transported for extended periods without the need for refrigerated trucks.

Storage
IceGen enables faster freezing in cold rooms, reducing the time required for freezing, while maintaining a controlled temperature and saving energy.

Preservative-Free
By freezing the product within itself, Icegen eliminates the need for added preservatives, extending the product's shelf life.

NFC Lemon

Tomato Juice

Pumpability
Icegen-treated products retain their pumpable consistency.

Homogeneous Freezing
Icegen ensures uniform freezing throughout the product, preventing issues like ice crystal formation and maintaining product quality.

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