ยุคใหม่ของนวัตกรรมการผลิตอาหารแช่เย็นและแช่แข็ง

รศ. ดร.วรรณสวัสดิ์ รัฐพิทักษ์สันติ

wannasawat.r@ku.th

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Outline:

FACULTY OF AGRO-INDUSTRY KASETSART UNIVERSITY

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- Novel Technologies

03 HPP for Longer-Lasting Chilled & Frozen Meals

- Condition Selection
- Commercially Available Products in The Global Market

“Chilled food” vs “Frozen food”

- Chilled food
  - Any food in which temperature of food is reduced to, and maintained at, a temperature below that of ambient temperature; but above temperature where any of its water content will change from a liquid to a solid
  - Many foods, initial freezing point is around -1°C
  - Shelf life of chilled food ranges from a few days to many weeks
  - Maximum shelf life is achieved at a temperature close to initial freezing point

- Frozen food
  - Below freezing point of a food, chemical reactions are retarded & microbial growth is inhibited
  - Shelf life of frozen food could be a few years, as long as the temperature remains below -12°C during storage
  - Once thawed, microorganisms present in the food become active, and under the right conditions will multiply to levels that can lead to foodborne illness

Trends of chilled & frozen food

Global chilled food industry profile (Sept, 2014)

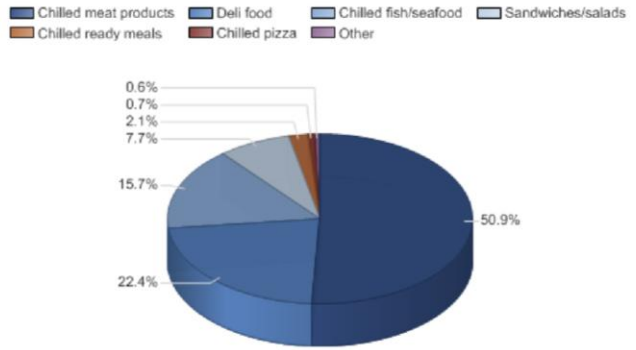
Market value

The global chilled & deli food market grew by 2.4% in 2013 to reach a value of $748,378.6 million.

The compound annual growth rate of the market in the period 2009–13 was 2.6%.

Table 1: Global chilled & deli food market value: $ million, 2009–13

Year	$ million	€ million	% Growth
2009	674,283.2	507,705.1	
2010	691,858.1	5 0,938.3	2.6%
2011	711,260.9	535,547.7	2.8%
2012	730,841.7	550,291.2	2.8%
2013	748,378.6	563,495.7	2.4%
CAGR: 2009–13			2.6%



Source: MARKETLINE (2014)

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US frozen food industry (2022-2026)

Total establishments, sales & employment trends of frozen food manufacturing in the USA

	Year					Percent Chg. Year-to-Year			
	2022	2023	2024	2025	2026	22-23	23-24	24-25	25-26
Establishments	1,550	1,579	1,572	1,588	1,603	1.9%	-0.5%	1.1%	0.9%
Sales ($Millions)	38,707	38,513	38,238	38,588	38,960	-0.5%	-0.7%	0.9%	1.0%
Employment	84,732	86,311	85,903	86,812	83,955	1.9%	-0.5%	1.1%	-3.3%

The Industry is forecasted to reach 1,588 establishments in 2025 and will change by 1.1 percent from 2024 to 2025. Industry sales are projected to hit $38.6 billion in 2025 and will change by 0.9 percent from 2024 to 2025.

Source: Barnes Reports (2025)

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Estimated sales in 2025 by sub-industries of US frozen foods

Sub-Industries	Category*	Establish-ments	Sales ($Millions)
Frozen fruits and vegetables	Major1	237	3,131.7
Frozen fruits and vegetables	Minor1	46	1,223.9
Citrus pulp, dried	Minor2	16	36.0
Fruits, quick frozen and cold pack (frozen)	Minor2	97	3,731.6
Potato products, quick frozen and cold pack	Minor2	62	530.6
Vegetables, quick frozen & cold pack, excl. potato products	Minor2	105	6,154.0
Fruit juices	Minor1	183	4,500.9
Fruit juices, frozen	Minor2	22	96.0
Frozen specialties, nec	Major1	411	8,262.0
Breakfasts, frozen and packaged	Minor2	27	2,537.7
Dinners, frozen and packaged	Minor2	45	2,949.8
Ethnic foods, nec, frozen	Minor2	114	1,450.3
Lunches, frozen and packaged	Minor2	7	129.3
Pizza, frozen	Minor2	143	3,100.9
Snacks, incl. onion rings, cheese sticks, etc.	Minor2	49	265.0
Spaghetti and meatballs, frozen	Minor2	1	3.2
Waffles, frozen	Minor2	21	484.8
Whipped topping, frozen	Minor2	1	0.8

Source: Barnes Reports (2025)

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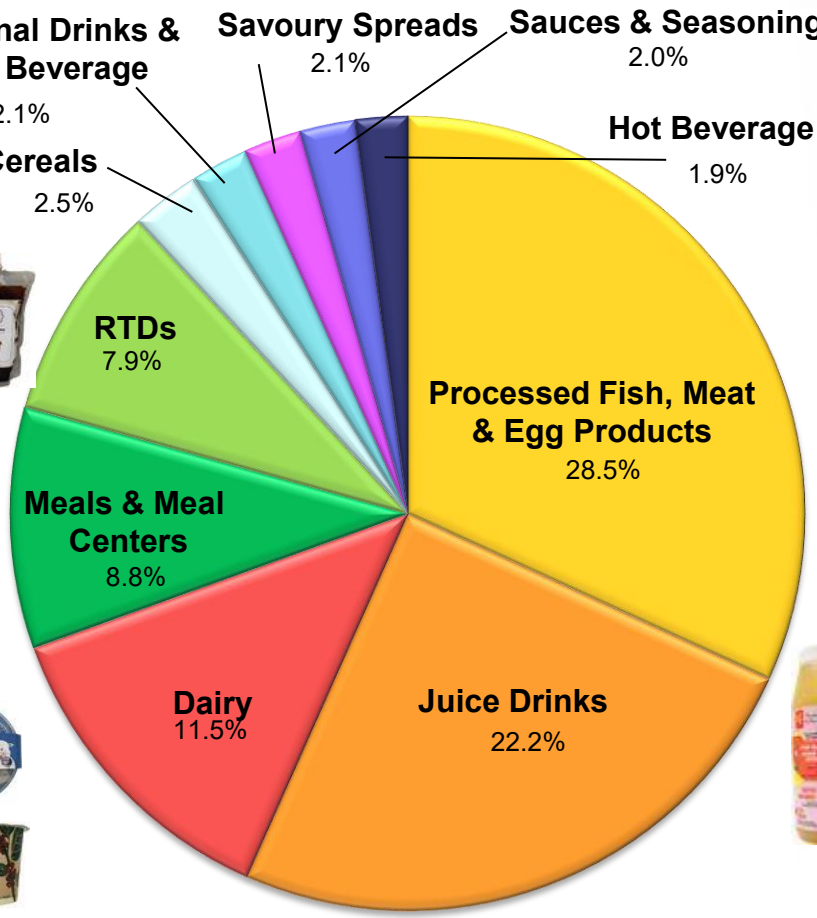
Worldwide Distribution of Chilled Food Products

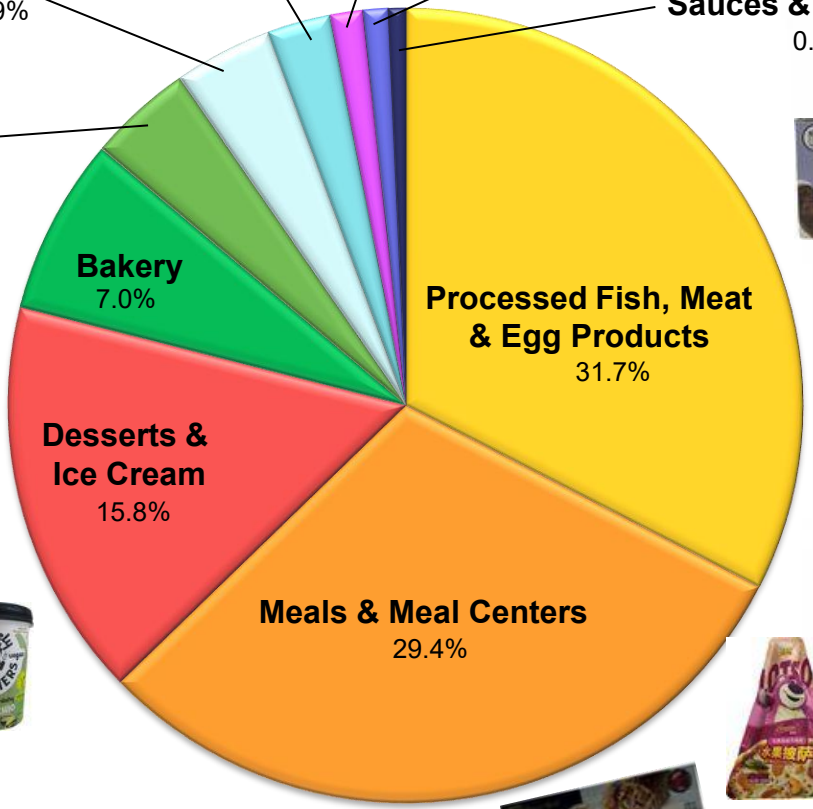
Year 2020–June 2025



Source: Global New Products Database (GNPD)

Worldwide Distribution of Frozen Food Products

Year 2020–June 2025



Source: Global New Products Database (GNPD)

Top 5 Claims

Year 2020–June 2025

Chilled Food

- 31.2% Ethical – Environment Friendly Package
- 27.3% Ethical – Recycling
- 21.4% No Additives/ Preservatives
- 20.2% Ethical – Sustainable
- 19.2% Ease of Use

Frozen Food

- 30.4% Microwaveable
- 21.7% Ease of Use
- 21.7% Social Media
- 21.7% Ethical – Environment Friendly Package
- 21.7% No Additives/ Preservatives

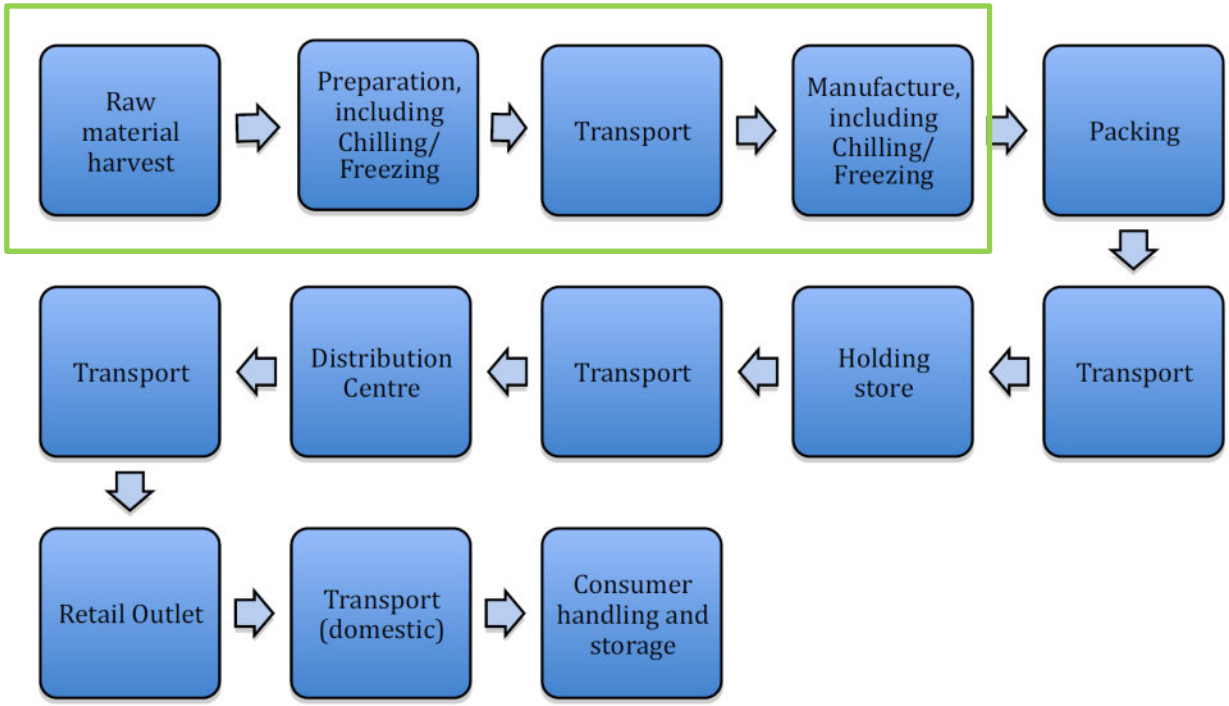
Chilling & freezing technologies

Principles

Traditional technologies

Novel technologies

Typical cold-chain



Source: James and James (2023)

Objective of primary & secondary chilling/freezing is to change the average temperature of the food

Aim of chilled or frozen storage through cold-chain is to maintain the food's temperature

GMP
GHP
HACCP

Principles of chilling & freezing

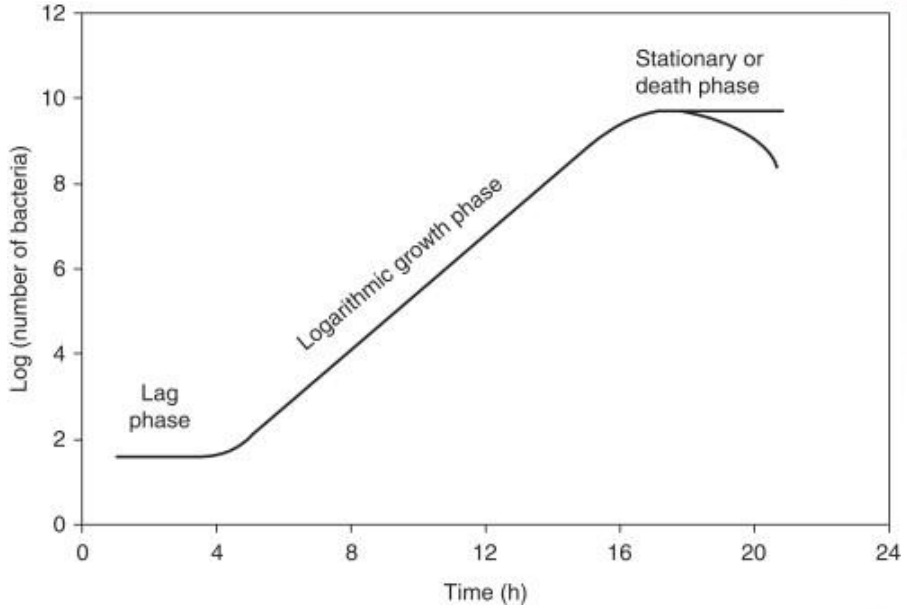
- Chilling & freezing are processes of removing heat
- Achieved by four basic mechanisms
  - Conduction
  - Convection
  - Radiation
  - Evaporation

- Conduction
  - Requires a good physical contact between food to be chilled/ frozen and cooling medium
  - Foods shall be shaped into regular shapes, such as blocks of meat or fish
- Convection
  - The most important heat transfer mechanism employed in the majority of food chilling/ freezing systems
  - Use of transfer medium
    - Refrigerated air (most cases)
    - Liquid or cryogenic gas (some cases)

- Radiation
  - Requires a large temperature difference between surface of food being cooled and that of surrounding surfaces to achieve significant heat flow
  - Only important in initial stages in a system where the food is not surrounded by other products
- Evaporation
  - Evaporation from a food surface reduces yield and is not desirable in most food refrigeration operations
  - Useful in initial cooling of cooked food products

Chilling

- Lowering temperatures of foods to retard microbial growth & slow enzyme activity
  - Microorganisms are there
- Reducing temperatures below the optimum growth range of a microorganism increases its generation time
  - They are multiplying with slow growth rate



- Generation time of pseudomonad (a common spoilage microorganism)
  - 1 h at 20°C, 2.5 h at 10°C, 5 h at 5°C, 8 h at 2°C or 11 h at 0°C

TABLE 20.1 Minimum and Optimum Growth Temperatures for Pathogens Associated with Foods

	Minimum Temperature (°C)	Optimum Temperature (°C)
Infective		
Campylobacter spp.	30	42–43
Pathogenic *Escherichia coli* strains	7	35–40
Escherichia coli O157:H7	6–7	42
Salmonella spp.	5	35–43
Aeromonas hydrophila	−0.1–1.2	15–20
Listeria monocytogenes	−1–0	30–37
Yersinia enterocolitica	−2	28–29
Toxigenic		
Clostridium perfringens	12	43–47
Clostridium botulinum proteolytic	10	35
Staphylococcus aureus	7	35–40
Bacillus cereus	4	28–35
Clostridium botulinum non-proteolytic	3	30

Source: James and James (2014)

Effect of chilling rate on food safety

TABLE 23.2 International Chilling Time Guidelines/Recommendations for the Cooling of Cooked Foods

Country	Chilling Range (°C)	Time (h)	Chilling Rate (°C/min)	Storage Temperature (°C)	References
Australia	60–21	≤2	0.33	5	De Jong et al. (2004)
	21–5	≤4	0.07		
Canada	60–20	≤2	0.33	4	CFISIG and Canadian Food Inspection System Implementation Group (2004)
	20–4	≤4	0.07		
Codex Alimentarius	60–10	≤2	0.42	–	Codex Alimentarius (1999)
Denmark	65–10	≤3	0.31	<5	Evans et al. (1996)
France	70–10	≤2	0.50	0–3	Evans et al. (1996)
Germany	80–15	≤2	0.54	2	Evans et al. (1996)
	(15–2)	≤24			
Ireland	70–3	≤2.5	0.45	3	Food Safety Authority of Ireland (FSAI) (2004)
The Netherlands	60–7	≤5	0.18	–	De Jong et al. (2004)
	7–4	≤24			
Sweden	80–8	≤4	0.30	3	Evans et al. (1996)
UK	70–3	≤1.5	0.74	3	UK Department of Health (1989)
USA	60–5	4–6	0.23–0.15	–	De Jong et al. (2004)

Source: James and James (2023)

- Temperature of the product should be rapidly reduced between 60 and 7°C to prevent multiplication of any surviving organisms in cooked/ pasteurized chilled food products
- Further reduction to lower temperatures is required to reduce growth of spoilage bacteria and prevent the growth/ germination of any surviving pathogenic organisms/ spores

Freezing

- Lowering the food's temperature to a point that halts life processes
  - Ice crystal formation
  - Microorganisms do not die but remain dormant until the food is thawed
  - Dramatically slows enzymatic reactions

Effect of freezing on food safety

- Spoilage microorganisms do not grow below ca. –10 to –12°C and pathogens below –1.5°C, thus growth of pathogenic microorganisms is only normally relevant to handling before freezing or during thawing
- Pathogens surviving freezing and frozen storage
  - *Salmonella* spp.
  - *Staphylococcus* spp.
- Spoilage bacteria tend to inhibit their subsequent growth on defrosting

Effect of freezing rate on food quality

- Size, shape & location (intracellular or extracellular) of ice crystals formed in freezing process affect natural properties of cell structure, thus influencing the quality of frozen food

- Slow freezing rate induced physical changes of frozen foods
  - Formation of large ice crystals with sharp edges, expansion, disruption of the osmotic equilibrium between the cells and their surroundings may induce irreversible damage to texture of vegetables, fruits & muscle food

Classification of chilling/ freezing equipment

- Direct methods
  - Energy is extracted directly from food into heat transfer medium (air, liquid nitrogen)
  - Ex: air blast chiller/ air blast freezer
- Indirect methods
  - Cooling is generated externally and then applied to food through heat exchanger
  - Ex: plate freezer

Equipment used for chilling/ freezing

- Air Chiller/ Freezer
- Immersion/ Spray Chiller/ Freezer
- Cryogenic Freezer
- Vacuum Chiller
- Plate Chiller / Freezer
- Belt Freezer
- Scraped Surface Freezer
- Stirred Jacketed Vessel

Simple batch air cooling system for cooling trays of product

Continuous air chilling system for whole poultry

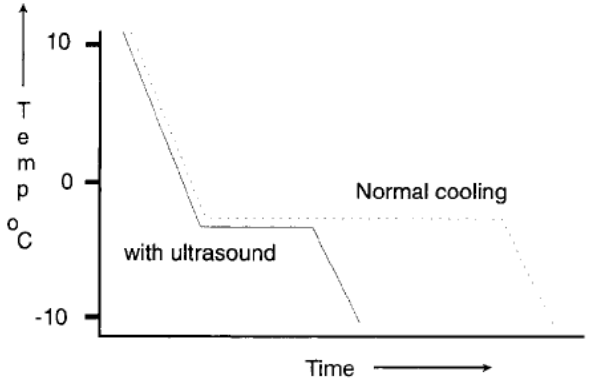
Source: James and James (2023)

Novel freezing technologies

- Ultra-low temperature freezing (UTF)
- Liquid nitrogen rapid freezing (LNRF)
- Immersion freezing (IF)
- Ultrasonic assisted immersion freezing (UIF)
- High pressure assisted freezing (HPF)
- Electrostatic field assisted freezing (EFF)
- Magnetic field assisted freezing (MFF)
- Radiofrequency assisted freezing (RF)

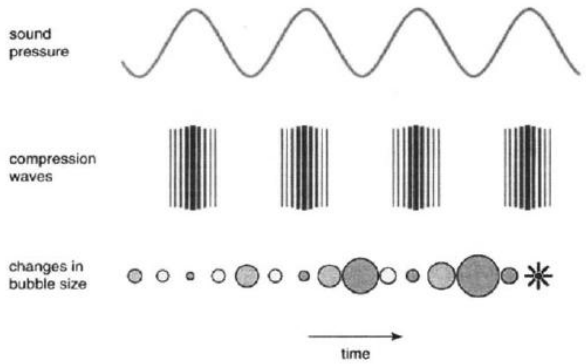
Ultrasonic assisted immersion freezing (UIF)

- Ultrasonic frequencies used in food freezing, drying & extraction typically range from 20 to 100 kHz
- Ability to produce tiny ice crystals & preserve original quality characteristics of frozen food by
  - Initiating nucleation
  - Accelerating heat & mass transfer



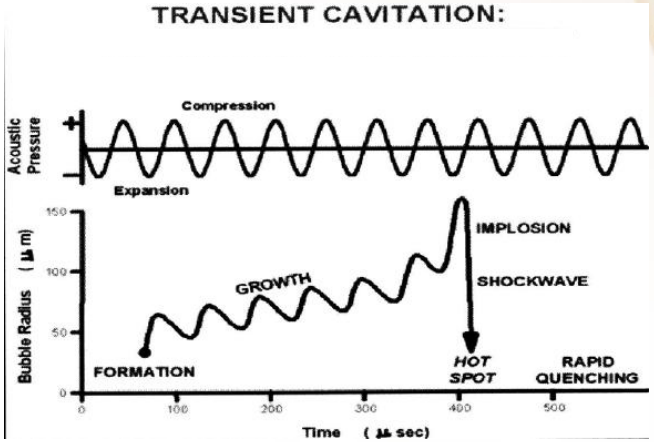
Mechanism

1. Formation of bubbles by cavitation



Bubbles produced by the cavitation effect of ultrasound can serve as crystal nuclei, promoting the formation of fine ice crystals

2. Implosion of bubbles



When cavitation bubbles collapse, fierce forces are generated that break existing ice crystals into small fragments. Then, these fragments serve as new crystal nuclei, facilitating the nucleation of secondary ice crystals

3. Finally, movement of cavitation bubbles inevitably generates microflows that enhance convective heat transfer rate & further accelerate the freezing process

Source: Suslick (1994); Qiu et al. (2022)

Application of UIF for improving quality of thawed meat

Meat source	Packaging	Freezing	Storage	Thawing	Main results	References
Pork (longissimus muscles), 24 h PM	Poly nylon pouches	AF, −20 ± 0.5 °C; IF, −20 ± 0.5 °C, with 5 % fluoride plus 95 % ethanol as a coolant; UIF-180 W, −20 ± 0.5 °C; until the core temperature reached −18 °C	−18 ± 1 °C; 0, 30, 60, 90, 120, 150, and 180 d	4 °C air; overnight	UIF samples had smaller and more evenly distributed ice crystals, lower thawing loss, cooking loss, and lipid oxidation, and higher redness and cutting force.	(Zhang et al., 2019)
Ground pork (boneless pork leg)	—	IF, −30 ± 0.5 °C, with 95 % ethanol plus 5 % fluoride as a coolant; AF, −30 ± 0.5 °C; UIF, −30 ± 0.5 °C, 80 W/L, 20 kHz; until the core temperature reached −18 °C	−20 ± 0.5 °C freezer; 15, 30, 45, 60, 75, and 90 d	4 °C refrigerator; until the core temperature reached 4 °C	UIF samples showed a faster freezing rate, lower juice loss and cooking loss, higher WHC and a* value, less protein denaturation and protein/lipid oxidation, and better microstructure.	(Wu et al., 2021)

AF, air freezing; IF, immersion freezing; PM, post-mortem; UIF, ultrasonic assisted immersion freezing; WHC, water holding capacity

Benefits & limitations of UIF

- Benefits
  - Reducing quality deterioration
  - Preserving nutrients
- Limitations
  - High equipment requirements & associated costs

High pressure assisted freezing (HPF)

- HPF technology achieves the water–ice phase transition by applying high pressure during the freezing process
  - Under external pressure, the freezing point of water drops below 0°C (e.g., at 210 MPa, the freezing point of water drops to -21°C)
  - Once pressure is released, a supercooling state is created
    - ✓ Increasing rate of ice core formation
    - ✓ Promoting production of tiny ice crystals
    - ✓ Improving quality of frozen products

Not always good

- Several studies of HPF have shown undesirable changes in foods
  - In porcine & bovine muscle, typical sarcomere tissue was severely damaged and constituent myofibrillar protein was extensively unfolded, indicating protein denaturation
  - Significant color change
  - Increase of total drip loss

Potential solutions

- To minimize color deterioration
  - First, freezing the meat products using air blast freezing
  - Then, treating with high pressure

- To reduce total drip loss
  - First, employing high pressure treatment
  - Then, applying air blast freezing

Application of HPF affecting quality of thawed meat

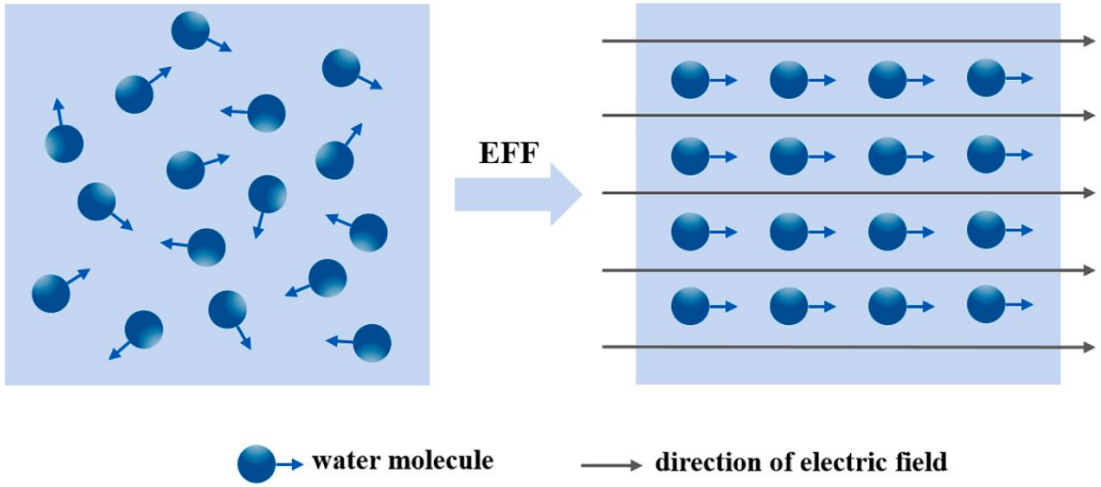
Meat source	Packaging	Freezing	Storage	Thawing	Main results	References
Pork (M. longissimus dorsi); beef (M. semitendinosus)	Vacuum-sealed in polyethylene bags	ABF, −40 °C; pressure shift freezing (PSF), −20 °C, 200 MPa; until the core temperature reached −20 °C	—	20 °C; overnight	PSF significantly increased the degree of protein denaturation.	(Fernández-Martín et al., 2000)
Pork (boneless rib portions)	Moisture-impermeable plastic pouch	Pressure shift freezing (PSF), 100, 150, and 200 MPa; ABF, −20 °C; IF, −20 °C; until the surface temperature was close to the initial freezing point of water	−20 °C conventional freezer; until further treatments	20 °C	PSF samples showed considerable denaturation of MP at 150 and 200 MPa, and significant color changes above 150 MPa, compared to ABF and IF samples; PSF did not cause obvious changes in drip loss.	(Zhu et al., 2004)
Beef (Longissimus dorsi muscles), 5 d PM	Vacuum packaged in laminated bags	ABF, −30 °C; froze the beef by ABF (−30 °C) and then treated them with high pressure-low temperature (−35 °C, 650 MPa, 10 min)	−18 °C walk-in cooler; 45 d	5 °C walk-in cooler; 12 h	After thawing, the color of beef with ABF plus high pressure-low temperature treatment is similar to that of fresh samples; high pressure did not affect shear force.	(Fernández et al., 2007)
Pork (Longissimus dorsi), 24 h PM	Vacuum	After being treated at 200, 300, and 400 MPa respectively for 5 min at 4 °C, samples were kept at 4 °C up to 2 h	−20 °C; 0, 14, 28, 56, and 84 d	—	High pressure treatment reduced the drip loss by 35 % after 84 d of storage.	(Jia et al., 2021)

ABF, air blast freezing; IF, immersion freezing; HPF, high pressure assisted freezing; MP, myofibrillar protein; PM, post-mortem; PSF, pressure shift freezing

Electrostatic field assisted freezing (EFF)

- EFF helps increase the supercooling degree, promote uniform nucleation & form tiny ice crystals
- Electrostatic field may modify and reduce free energy barrier of nucleation, and the increased nucleation rate may enhance number of small ice crystals
- Quality improvement of frozen meat with EF treatment might be related to nucleation rate and crystal growth pattern

Effect of electric field on water molecules



- Electrostatic field could induce polarization of water molecules by redirecting their direction
- Free energy is reduced due to rearrangement of water molecules, thus forming more ordered clusters & promoting nucleation

Classification of EFF

- Low-voltage electrostatic field assisted freezing (LEFF)
  - 0-2,500 V
- High-voltage electrostatic field assisted freezing (HEFF)
  - Above 2,500 V

Application of EFF for improving quality of thawed meat

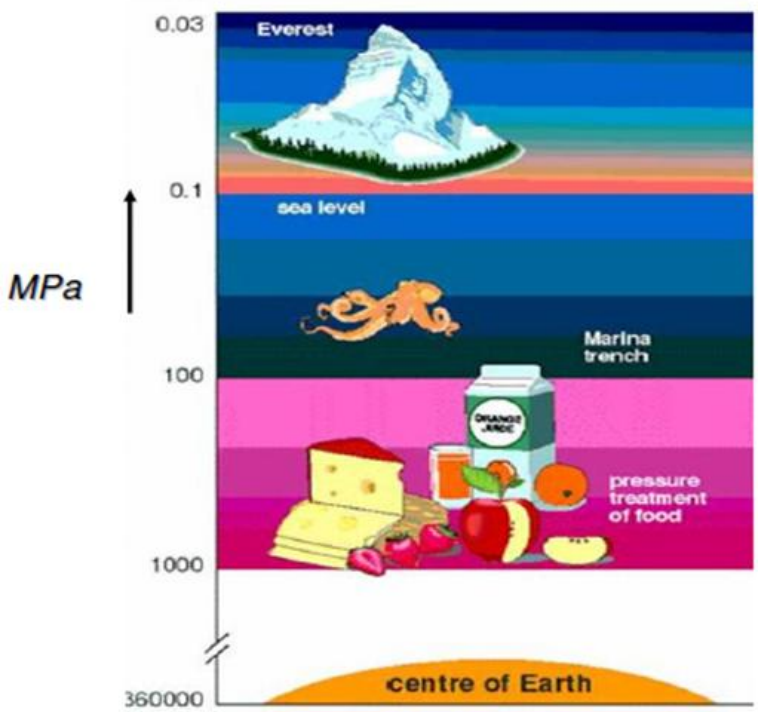
Meat source	Packaging	Freezing	Storage	Thawing	Main results	References
Beef (thigh meat), 7 d PM	Polyethylene bags	ABF, −30 °C; LEFF, −30 °C, 2500 V; until the core temperature reached −18 °C	—	4 °C refrigerator; until the core temperature reached 0 °C	LEFF decreased the thawing loss and press loss, enhanced the hardness and tenderness, promoted more rapid ice nucleation and more uniform crystal nuclei, and reduced the migration of immobilized water to free water.	(Xie et al., 2021)
Beef (tenderloin), 48 h PM	—	AF, −30 °C; LEFF, −30 °C, 2500 V; until the core temperature reached −18 °C	—	4 °C refrigerator; until the core temperature reached 4 °C	LEFF better maintained the regular lattice array and increased the WHC of the myofibril by 36 %.	(Xie, Zhou, Chen, et al., 2023)
Pork (longissimus thoracis et lumborum muscles)	Polyethylene bags	L-18: LEFF, −18 °C, 2500 V; L-38: LEFF, −38 °C, 2500 V; C-18: ABF, −18 °C; C-38: ABF, −38 °C	L-18 and C-18: stored at −18 °C; L-38 and C-38: stored at −38 °C; 0, 1, 2, 3, 4, and 5 months	4 °C; until the core temperature reached 4 °C	LEFF helped improve meat color, maintain the muscle fiber microstructure, and reduce muscle protein denaturation.	(Wu et al., 2024)
Lamb (hind legs)	Polyethylene bags	LEFF, −18 °C, 2500 V; common freezing, −18 °C; 24 h	—	4 °C refrigerator; 24 h	LEFF samples exhibited lower carbonyl content, dityrosine content, and surface hydrophobicity, and higher sulfhydryl content, solubility, and Ca^{2+}-ATPase activity.	(Yang et al., 2023)
Lamb sirloin meat (gluteus medius)	Bare meat freezing; polyethylene film-covered thawing	HEFF, −20 °C; 0, 4, 8, and 12 kV	—	5 °C cold incubator; 3 h	HEFF (4, 8, and 12 kV) reduced the average ice crystal size and drip loss in comparison to the conventional freezing (0 kV); the color and hardness were not significantly influenced.	(Dalvi-Isfahan et al., 2016)
Pork tenderloin	Plastic bags	In a miniature refrigerator with or without high-voltage electrostatic fields (0, 4, 6, 8, and 10 kV)	—	20 ± 1 °C; 1 h	HEFF samples showed a smaller total area of ice crystals for the cross sections than those without electrostatic fields; the color, pH, and WHC were closer to those of fresh samples.	(Jia, He, et al., 2017)

Benefits & limitations of EFF

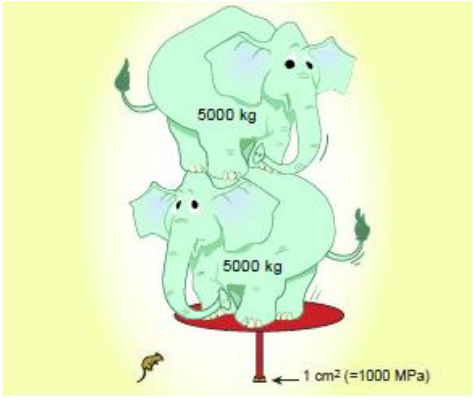
- Benefits
  - Reduction in freezing injuries of meat products when treating with a specific voltage level, specifically at HEFF
- Limitations
  - High energy consumption
  - Potential safety hazards due to high output voltage

HPP for longer-lasting chilled & frozen meals

High pressure processing (HPP)



Source: Considine *et al.* (2008)

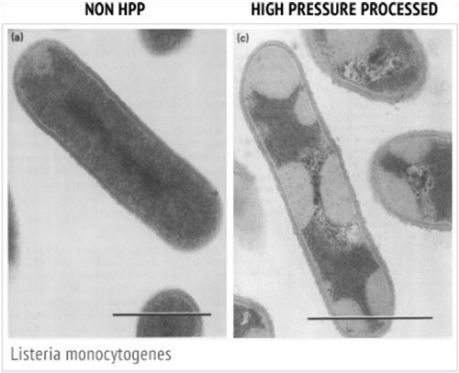


Source: http://www.hormelfoodservice.com/hpp/about/index.php

- 300-600 MPa at process temperature < 45°C
  - For RTE food products , 500 to 600 MPa is typically used
- Food safety
  - HPP technology as a post-pasteurization process or after cooking of RTE food products before chilling or freezing
  - Prevent cross-contamination
- Shelf life extension
  - Extend shelf-life by 3–10 fold over conventional process

Microbial inactivation

- HPP treatments are effective in inactivating most of the vegetative microorganisms
- Larger, more complex organisms are more susceptible to pressure
- Gram+ organisms are more resistant than Gram-
- There can be variations in pressure resistances between strains



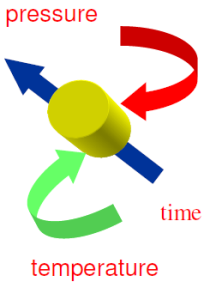
Puncturing (permeabilization) of cell membrane (300 MPa at room temperature)

Chemical changes

- The structure of high-molecular-weight molecules such as proteins & carbohydrates can be altered by HPP, smaller molecules such as volatile compounds, pigments, vitamins & other compounds connected with sensorial, nutritional & health promoting aspects are less affected

- Chemical changes in HP processed foods are minimal, because the break of covalent bonds does not occur but rather alters the hydrogen & ionic bonds

Critical process parameters



- Process related parameters

Pressure	Temperature	Time
Target pressure	Process temperature	Pressure holding time
	Product initial temperature	Pressure come-up time
		Decompression time

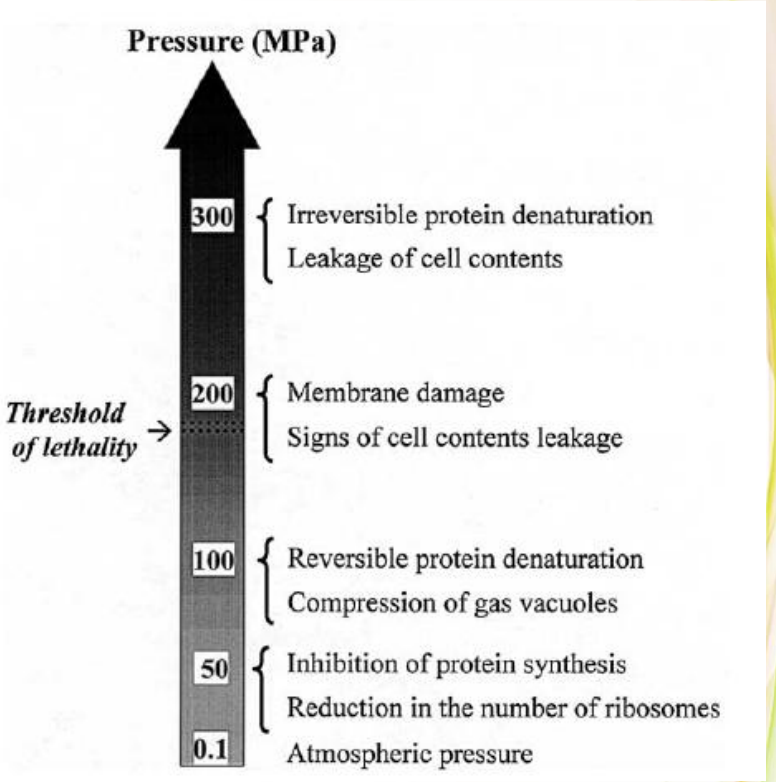
Product related parameters

- pH
- Product composition (fat ~ baroprotective effect)
- Water activity (a_w)
- Presence of microorganisms
  - Vegetative cells, spore-formers, spores
  - Type, shape
  - Initial microbial loads

Target microorganisms

Condition selection

- Selection of HPP condition is based on
  - The degree of microbiological inactivation
  - The preservation of product quality
  - The control of detrimental pressure-induced changes



Source: Lado and Yousef (2002)

Industrial scale HPP equipment

Batch system: Industrial scale
Vertical vessel

Batch system: Industrial scale
Horizontal vessel
(55L to 525L vessel)

Source: https://www.jbtc.com/foodtech/product-finder/?_sft_product_brand=avure-technologies
https://www.hiperbaric.com/en/hpp-technology/equipment/

Packaging materials

Flexible packaging is widely used

- At least one interface of the package should be flexible for pressure transfer
- Flexible package for at least 15% compression

The most common packaging materials being used

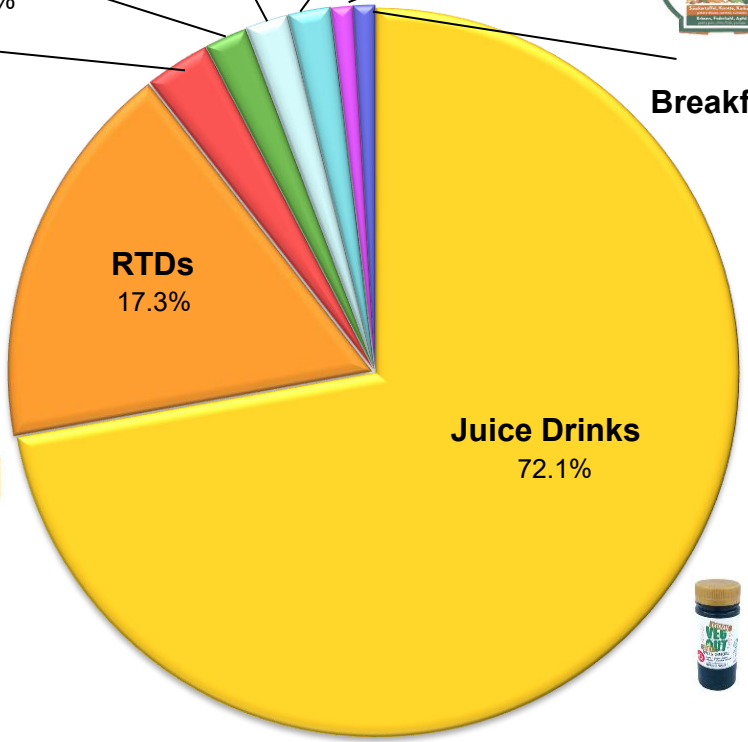
- PP, PE, PET

Source: Juliano et al. (2010)

Source: https://blog.hiperbaric.com/en/synergy-between-hpp-spicy-foods

Worldwide Distribution of Chilled Food Products by HPP

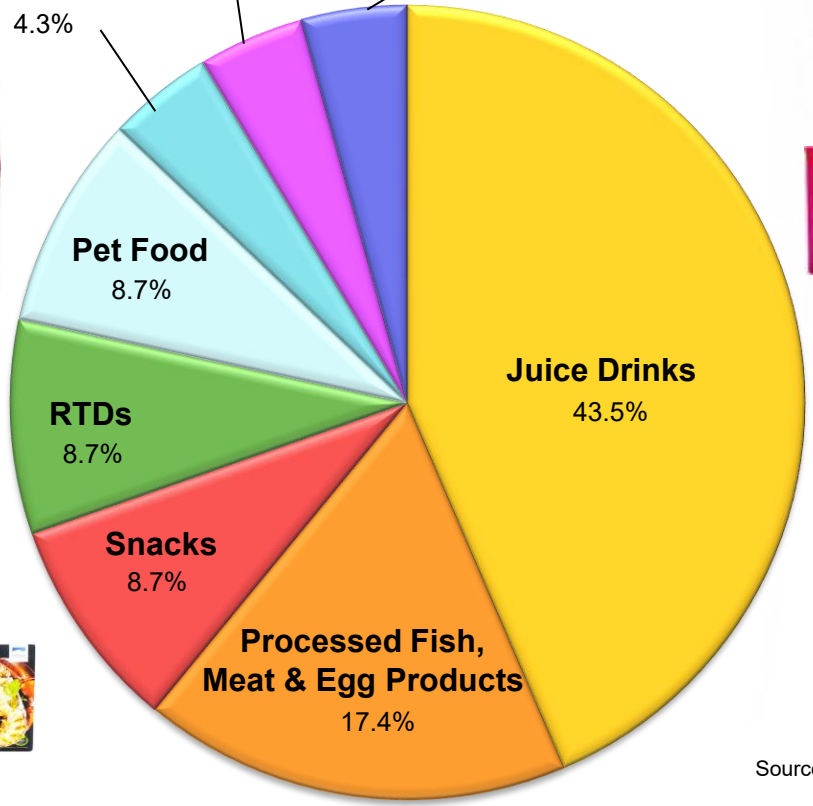
Year 2020–June 2025



Source: Global New Products Database (GNPD)

Worldwide Distribution of Frozen Food Products by HPP

Year 2020–June 2025



Source: Global New Products Database (GNPD)

Year 2020–June 2025

Top 5 Claims

Chilled Food by HPP

- 41.3% No Additives/ Preservatives
- 39.4% Free from Added/ Artificial Preservatives
- 31.7% Ethical – Environment Friendly Package
- 30.8% Ethical – Recycling
- 24.0% Vegan/No Animal Ingredients

Frozen Food by HPP

- 30.4% No Additives/ Preservatives
- 21.7% High/Added Protein
- 21.7% Free from Added/ Artificial Colourings
- 21.7% Free from Added/ Artificial Preservatives
- 21.7% Ease of Use

HPP products

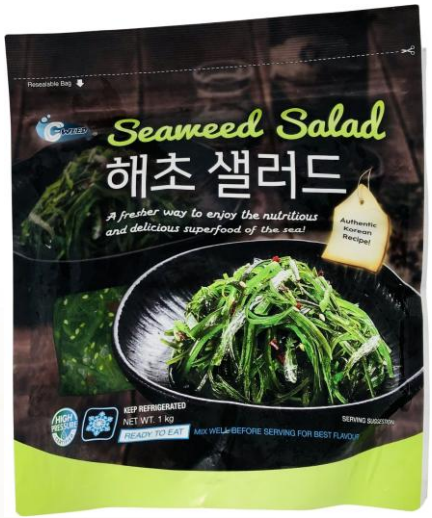
Plant-based drink

Source: Global New Products Database (GNPD)

Name	Frozen Coconut Milk
Brand	El Jade
Company	Jade F&B, South Korea
Location of Manufacturing	-
Market	South Korea
Size	1,080 ml (6 units x 180 ml)
Price	KRW 21500.00 / $17.79 / €15.76
Storage	Frozen
Shelf-Life	-
Package	Plastic PET
Ingredients	Coconut milk (82%), Purified Water (18%))
Positioning Claims	Premium

HPP products

RTEs



Source: Global New Products Database (GNPD)

Name	Seaweed Salad
Brand	C-Weed
Company	Yewon, South Korea
Location of Manufacturing	South Korea
Market	USA
Size	1,000 g
Price	$8.99 / €7.60
Storage	Chilled
Shelf-Life	-
Package	Flexible stand-up pouch (multi laminate)
Ingredients	Seaweed stem, Seasoning sauce (sugar, salt, disodium 5'-ribonucleotide, citric acid, stevia), Sesame seeds, Agar, Vinegar, Sesame oil, Lemon juice, Starch syrup, Salt, Red Pepper, FD&C yellow #5, FD&C blue #1, Ginger powder
Positioning Claims	Convenient Packaging, Ease of Use, Low/No/Reduced Calorie, Low/No/Reduced Cholesterol, Low/No/Reduced Fat

HPP products

RTEs

Source: Global New Products Database (GNPD)

Name	Pork Sausages
Brand	Yummy Kids
Company	Xiao Xiao Food Trade, China
Location of Manufacturing	China
Market	China
Size	400 g (10 units x 40 g)
Price	CNY 59.00 / $8.21 / €7.38
Storage	Chilled
Shelf-Life	-
Package	Multi laminate
Ingredients	Pork, Chicken, White granulated sugar, Drinking water, Compound seasoning, Salt, Collagen casing
Positioning Claims	Children (5-12), Ease of Use, High/Added Protein, Microwaveable

HPP products

RTEs

Source: Global New Products Database (GNPD)

Name	Paprika Flavoured Tuna Slices
Brand	Qfresh Lite
Company	Thai Union Group Public, Thailand
Location of Manufacturing	Thailand
Market	Thailand
Size	400 g (10 units x 40 g)
Price	CNY 59.00 / $8.21 / €7.38
Storage	Chilled
Shelf-Life	1 month
Package	Plastic unspecified
Ingredients	Tuna, Surimi, Paprika Seasoning, Iodised Salt, Acidity Regulator (INS 326, INS 262(i), INS 325), Antioxidant (INS 301), Humectant (INS 422, INS 451(i)), Sweetener (Aspartame), Natural Identical Flavour
Positioning Claims	Cobranded, Diet/Light, Ease of Use, Free from Added/Artificial Colourings, Free from Added/Artificial Preservatives, Halal, High/Added Protein, Low/No/Reduced Fat, Microwaveable, No Additives/Preservatives

HPP products

RTEs

Source: Global New Products Database (GNPD)

Name	Oven Roasted Turkey
Brand	Hormel Natural Choice
Company	Hormel Foods Sales, USA
Location of Manufacturing	USA
Market	Mexico
Size	227 g
Price	MXN 133.00 / $6.45 / €6.25
Storage	Chilled
Shelf-Life	-
Package	Plastic unspecified
Ingredients	Turkey Breast Meat, Water, Salt, Starch, Added Sugars (brown sugar), Carrageenan, Sodium Bicarbonate, Celery Powder, Cherry Powder, Sea Salt
Positioning Claims	All Natural Product, Convenient Packaging, Ease of Use, Free from Added/Artificial Preservatives, Gluten Free, Hormone Free, Low/No/Reduced Allergen, No Additives/Preservatives

HPP products

Ready meal

Source: Global New Products Database (GNPD)

Name	Bacon Mac & Cheese Meal
Brand	Fresh
Company	GoodFoods Group, USA
Location of Manufacturing	-
Market	USA
Size	1134 g
Price	$9.99 / €7.14
Storage	Chilled
Shelf-Life	-
Package	Plastic PET
Ingredients	Cooked Cavatappi Pasta, Half and Half (milk, cream), Uncured Bacon Bits, Provolone Cheese, White Cheddar Cheese, Flour, Dijon Mustard, Sea Salt, Paprika, White Pepper, Black Pepper
Positioning Claims	All Natural Product, Ease of Use, Microwaveable, No Additives/Preservatives, Time/Speed

HPP products

Fruits & Vegetables

Source: Global New Products Database (GNPD)

Name	Delicious Sweet Corn
Brand	Zhen Zi Mi
Company	Xian Dongfang Dairy, China
Location of Manufacturing	-
Market	Taiwan, China
Size	220 g
Price	TWD 49.00 / $1.57 / €1.44
Storage	Chilled
Shelf-Life	-
Package	Plastic other
Ingredients	Corn, Salt
Positioning Claims	Free from Added/Artificial Additives, Free from Added/Artificial Preservatives, Microwaveable, No Additives/Preservatives, Premium

HPP products

Fruits & Vegetables

Source: Global New Products Database (GNPD)

Name	Tomato Caviar
Brand	Happy Yours Bio
Company	Aperinnov', France
Location of Manufacturing	France
Market	France
Size	165 g
Price	€6.00 / $7.06
Storage	Chilled
Shelf-Life	-
Package	Plastic unspecified
Ingredients	Tomato (57%), Tomato Concentrate (16%), Sunflower Oil, Breadcrumbs (wheat flour, coconut oil, baker's yeast, salt, rye leaven, wheat gluten), Onion, Garlic, Rosemary, Basil, Salt, Thyme (1%) From Organic Farming
Positioning Claims	Ethical - Environmentally Friendly Package, Ethical - Recycling, Free from Added/Artificial Preservatives, No Additives/Preservatives, Organic, Social Media

HPP products

Fruits & Vegetables

Source: Global New Products Database (GNPD)

Name	Blueberry Puree
Brand	Natural Benefits
Company	Kee Fresh & Safe Foodtech, Taiwan
Location of Manufacturing	-
Market	Taiwan, China
Size	120 g (40 units x 30 g)
Price	TWD 355.00 / $11.29 / €10.33
Storage	Chilled
Shelf-Life	1 year
Package	Plastic unspecified
Ingredients	Blueberry, Sugar Cane Liquid, Water, Lemon, Konjac Powder
Positioning Claims	Free from Added/Artificial Additives, Free from Added/Artificial Colourings, No Additives/Preservatives, Vegan/No Animal Ingredients

HPP products

Cereals

Source: Global New Products Database (GNPD)

Name	Super Berry Overnight Oats with Blueberries & Raspberries
Brand	Press
Company	Press Healthfoods, UK
Location of Manufacturing	-
Market	UK
Size	125 g
Price	£2.99 / $3.95 / €3.54
Storage	Chilled
Shelf-Life	-
Package	Plastic PP
Ingredients	Gluten-Free Oat Drink (19.4%), Gluten-Free Oat Flakes (17%), Coconut Milk (16%), Banana Pulp (12.5%), Blueberry (12%), Apple Purée (9%), Agave Syrup (8%), Raspberry (5%), Lemon (1%), Salt (0.1%), Antioxidant (ascorbic acid)
Positioning Claims	All Natural Product, Ethical - Environmentally Friendly Package, Ethical - Environmentally Friendly Product, Ethical - Recycling, Ethical - Sustainable (Habitat/Resources), Gluten Free, Low/No/Reduced Allergen, Plant Based, Social Media, Vegan/No Animal Ingredients

HPP products

Snack

Source: Global New Products Database (GNPD)

Name	Lychee and Aloe Vera Chunks with Apple Juice
Brand	Vita+ by Eva
Company	Citricos Ex, Mexico
Location of Manufacturing	Mexico
Market	Mexico
Size	340 g (2 units x 170 g)
Price	MXN 44.50 / $2.28 / €2.08
Storage	Chilled
Shelf-Life	-
Package	Plastic PP
Ingredients	Lychee (60%), Reconstituted Apple Juice (35.67%), Aloe Vera Juice (3.2%), Water, Citric Acid, Ascorbic Acid (vitamin C)
Positioning Claims	All Natural Product, Antioxidant, GMO Free, Kosher, Low/No/Reduced Calorie, Social Media

HPP products

RTCs

Source: Global New Products Database (GNPD)

Name	Soaked Stockfish Fillet
Brand	Ghezzi
Company	Ghezzi Alimentari, Italy
Location of Manufacturing	-
Market	Italy
Size	292 g
Price	€6.69 / $7.92
Storage	Frozen
Shelf-Life	-
Package	Plastic unspecified
Ingredients	Stockfish (*Gadus morhua*), Water
Positioning Claims	Ease of Use, Free from Added/Artificial Preservatives, No Additives/Preservatives

HPP products

RTCs

Source: Global New Products Database (GNPD)

Name	Jambon
Brand	Johncook Deli Meats Less
Company	Farm Fresh Factory, South Korea
Location of Manufacturing	-
Market	South Korea
Size	100 g
Price	KRW 6500.00 / $5.76 / €4.73
Storage	Chilled
Shelf-Life	-
Package	Plastic other
Ingredients	Pork (95.47%), Yeast Ingredients, Refined Salt, Mixed Fruit Powder, Organic Sugar, Maple Syrup, Black Pepper, Bay Leaf, Whole Clove
Positioning Claims	Organic

HPP products

RTCs

Source: Global New Products Database (GNPD)

Name	Choco Rice Waffle Mix
Brand	Oneurui Ilsang Brunch
Company	Hyungkuk F&B, South Korea
Location of Manufacturing	-
Market	South Korea
Size	1,000 g
Price	KRW 11800.00 / $9.94 / €8.81
Storage	Chilled
Shelf-Life	-
Package	Plastic other
Ingredients	Rice Flour (26%), Sugar, Purified Water, Whole Egg Liquid, Milk, Cocoa Powder (6%), Corn Oil, Mixed Defatted Milk Powder (defatted milk powder, demineralized whey powder), Mixed Formulation 1 (disodium dihydrogen pyrophosphate, sodium bicarbonate, starch, dibasic calcium phosphate, calcium lactate), Emulsifier, Xanthan Gum, Refined Salt
Positioning Claims	Ease of Use, Gluten Free, Low/No/Reduced Allergen

HPP products

Plant-based

Source: Global New Products Database (GNPD)

Name	Plant Based Egg
Brand	Plant Menu
Company	Aldi, UK
Location of Manufacturing	-
Market	UK
Size	346 g
Price	£2.49 / $3.03 / €2.95
Storage	Chilled
Shelf-Life	-
Package	Plastic PET
Ingredients	Water, Pea Protein Isolate (3%), Corn Oil, Thickener (methyl cellulose), Pea Starch, Gelling Agent (gellan gum), Flavouring, Firming Agent (calcium lactate), Dried Inactive Yeast, Acid (lactic acid), Black Salt, Acidity Regulator (potassium tartrates), Colour (carotenes), Stabiliser (calcium carbonate, cellulose gum, guar gum), Vitamin B12, Vitamin D, Dextrose
Positioning Claims	Ethical - Environmentally Friendly Package, Ethical - Recycling, Functional - Other, High/Added Protein, Low/No/Reduced Saturated Fat, Microwaveable, Plant Based, Vegan/No Animal Ingredients

HPP products

Sauces & Seasonings

Source: Global New Products Database (GNPD)

Name	Spicy Raw Hummus
Brand	Parma Is Taste Fresche Idee
Company	Parma IS, Italy
Location of Manufacturing	-
Market	Italy
Size	150 g
Price	€2.29 / $2.45
Storage	Chilled
Shelf-Life	-
Package	Plastic other
Ingredients	Chickpeas (59%) (rehydrated dried chickpeas, water, salt), Water, Sunflower Oil, Onion (5%), Sesame Seed Paste (sesame), Vegetable Fibre, Salt, Natural Flavouring, Acidifier (citric acid), Parsley (0.3%), Chili Pepper (0.32%), Garlic, Cumin, Black Pepper (0.03%)
Positioning Claims	Gluten Free, Low/No/Reduced Allergen

HPP products

Sauces & Seasonings

Source: Global New Products Database (GNPD)

Name	Avocheese
Brand	Freshfy
Company	Freshfy, Spain
Location of Manufacturing	-
Market	Spain
Size	125 g
Price	€1.99 / $2.18
Storage	Chilled
Shelf-Life	-
Package	Plastic unspecified
Ingredients	Hass Avocado (85%), Lactose-Free Goat's Cheese Rolls (8%) (pasteurized goat milk, salt, lactase, rennet, calcium chloride, lactic ferments, Penicillium), Raisins (sunflower oil), Onion, Salt, Antioxidant (ascorbic acid), Preservative (potassium sorbate), Acidulant (citric acid) EU/non-EU origin
Positioning Claims	Gluten Free, Low/No/Reduced Allergen, Low/No/Reduced Lactose

HPP products

Sauces & Seasonings

Source: Global New Products Database (GNPD)

Name	Spinach Saag Simmer Sauce
Brand	Deep Indian Kitchen
Company	Deep Foods, USA
Location of Manufacturing	USA
Market	USA
Size	340.2 g
Price	$7.69 / €6.99
Storage	Chilled
Shelf-Life	-
Package	Plastic unspecified
Ingredients	Spinach, Water, Onions, Tomatoes (tomatoes, tomato juice, salt), Coconut Milk (coconut milk, water), Expeller Pressed Canola Oil, Broccoli, Spices, Tomato Puree (water, tomatoes), Chickpea Flour, Garlic, Salt, Green Chilies, Sugar, Turmeric, Fenugreek Leaves, Citric Acid, Cultured extrose
Positioning Claims	All Natural Product, Ease of Use, Ethical - Charity, GMO Free, Plant Based, Vegan/No Animal Ingredients

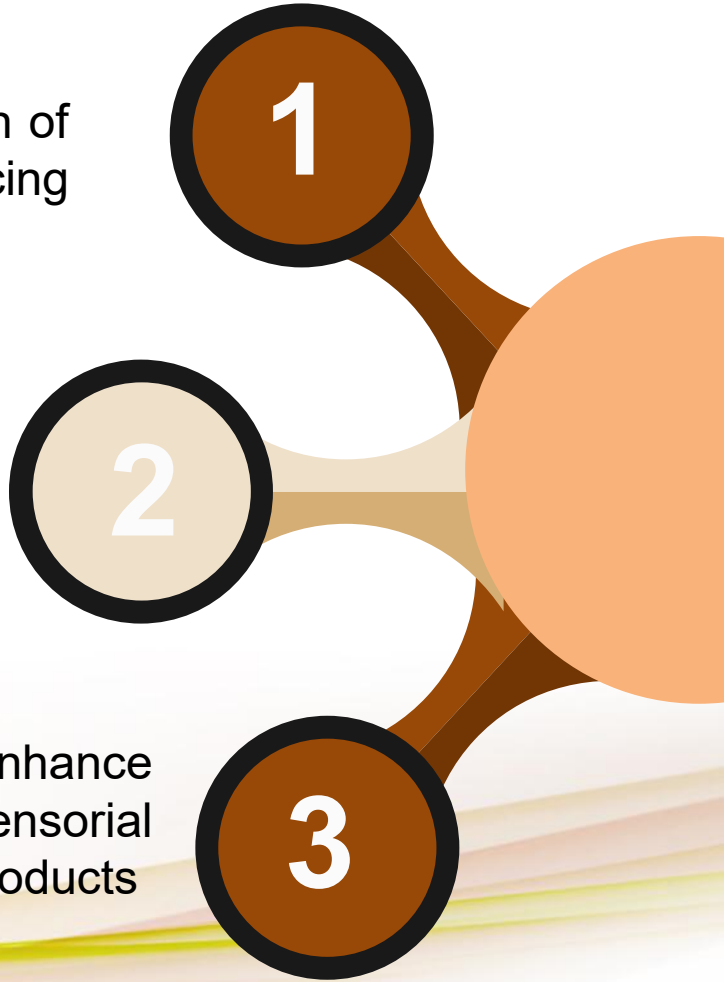
Summary

1. Novel freezing technologies can induce nucleation of ice crystals by improving freezing rate & enhancing supercooling degree

2. While various applications have been seen, most of novel freezing technologies are still in the laboratory research stage

Further research is needed before implementation

3. HPP in combined with chilling/ freezing could enhance microbiological safety, preserve nutritional & sensorial properties, as well as extend shelf life of RTE products



FACULTY OF
AGRO-INDUSTRY
DEPARTMENT OF PRODUCT DEVELOPMENT

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AGRO-INDUSTRY
KASETSART UNIVERSITY

High pressure processing for microbial inactivation and product quality enhancement

Assoc.Prof. Wannasawat Ratphitagsanti, PhD

Department of Product Development,

Faculty of Agro-Industry, Kasetsart University

Telephone: 025625004 ext. 5519

Mobile phone: 0944865398

E-mail address: wannasawat.r@ku.th