→ White Paper

BOC
A Linde company

Preserving food freshness, flavour, and nutrition

Exploring cryogenic freezing and cooling

Consumers want fresh. So how do you improve shelf-life, maximise food safety and exceed consumer expectations?

Customers always expect something new, fresh, and affordable in today's fast-paced food industry. To stay ahead of the game, food manufacturers and vendors must constantly innovate and develop novel products that meet these expectations. This requires the use of advanced processing technologies that can maintain the freshness, taste, and nutrition of food items.

Enter cryogenics – a freezing and chilling process to preserve food safety and quality often overlooked due to concerns about its cost and compatibility with specific food requirements.

Whether you've previously overlooked cryogenics or are actively seeking ways to improve product quality, this white paper aims to shed light on cryogenic solutions' benefits for enhancing quality, boosting productivity, and optimizing production areas. It also debunks common misconceptions, highlights the advantages of cryogenics, and introduces the latest technologies and solutions available.

A closer look at the fundamental differences between cryogenic freezing and mechanical freezing makes it evident that cryogenic freezing can unlock more profits for food producers. This challenges the industry norm that mechanical freezing is more cost-effective due to its lower energy consumption, revealing a potential trap that may limit the profitability of your food production processes.

Top applications for cryogenic freezing and chilling include hamburger patties, diced cooked chicken, pizza toppings, dumplings, seafood and prepared foods.

Mechanical freezing and chilling as the traditional method of preserving food

In the food industry, controlling or eliminating bacterial activity is crucial, but it can be challenging. Chilling and freezing are among the most effective methods available. Traditional mechanical freezing relies on conventional freezer units that chill air, which is then circulated to gradually lower items' temperature to freezing levels. While this process is effective, it has some limitations.

One significant drawback of mechanical freezing is its impact on production throughput. It can create bottlenecks in the production line, limiting the speed and flexibility of throughput. Moreover, it involves high investment, making it less viable for small and medium-sized businesses. Additionally, mechanical freezing can lead to dehydration losses of the food product, affecting its overall quality and appeal.

Even though chilling and freezing are effective methods for controlling bacterial activity, their drawbacks may affect their suitability for specific applications. However, when the temperature drops below freezing point, micro-organisms' growth rate decreases rapidly. This is because lowering the product temperature, as well as reducing free liquid water activity, deprives micro-organisms of the water they require to metabolise.

Cryogenics stands as an excellent alternative to mechanical freezing

Cryogenic solutions are efficient, highly versatile and environmentally friendly.

Ideal for rapidly freezing post-cooked food products to maintain quality and reduce contamination risk.

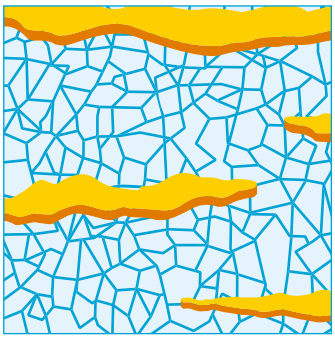
Cryogenic freezing utilises cryogenic liquids such as liquid nitrogen (LIN) or liquid carbon dioxide (LCO_2) to directly contact food products. This creates an extremely cold environment for rapid freezing and chilling at temperatures as low as -196°C. Compared to traditional mechanical freezing and chilling methods, cryogenic solutions offer several unique advantages.

Cryogenic solutions are renowned for their efficiency, delivering faster freezing and higher yields while requiring less capital and occupying a smaller footprint. LIN and CO_2 are quickly and effectively used in cryogenic processes to lower the temperature of food products, minimising the formation of large ice crystals that can adversely affect texture and flavour. This preserves the food's taste, texture, and nutritional value better than mechanical freezing.

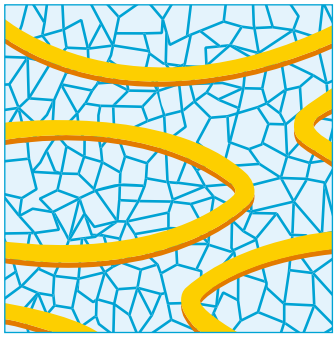
In addition to their efficiency, cryogenic solutions are highly versatile and environmentally friendly, typically resulting in a smaller carbon footprint compared to mechanical freezing. They reduce energy consumption and the need for chemical preservatives, which aligns with the food industry's sustainability goals. Cryogenic liquid gases also provide a practical, flexible, and low noise means of maintaining precise temperatures during the transport of chilled or frozen food products. This is vital for ensuring that these items remain at their intended temperature throughout the journey, safeguarding their quality and integrity.

These advantages make cryogenics particularly popular for rapidly freezing post-cooked food products, such as ready-made meals, pizzas, battered and fried items, and coated products. By doing so, cryogenic solutions help maintain quality and reduce the risk of contamination.

Benefits of cryogenic freezing and chilling



During slow freezing ice crystals become so big that the cells are completely broken down, leading to a high degree of water loss when the product is defrosted or re-heated.



Cryogenic freezing rapidly reaches temperatures as low as -18°C within minutes. The organic cell structure remains virtually unchanged with fast freezing technology.

Minimises dehydration

In the fast-paced world of food processing, where manufacturers and producers are incessantly racing against time to preserve the quality, taste, and texture of frozen food, traditional mechanical freezing methods often fall short. These methods result in dehydration, compromising food quality. Cryogenic freezing, on the other hand, provides an innovative solution, achieving ultra-quick freezing and potential dehydration reduction from an estimated 6% to around 1%, preserving freshness, taste, texture, and nutrients.

Dehydration occurs when water transforms from a liquid to a gas (evaporation) or when it shifts from a solid to a gaseous state (sublimation). These processes can cause product shrinkage and weight loss, which may later reform as snow and subtract from the finished product's weight. The rate of dehydration is influenced by several factors, including the type of freezer, infeed temperature, the ratio of surface to volume, water content, air speed, and freezing time.

As air temperature drops, it becomes drier, resulting in quicker dehydration. Products with larger surface areas compared to their volume and weight suffer from higher dehydration rates. Food products with higher water content dehydrate more rapidly than drier items. Similarly, products with higher inlet temperatures experience more significant dehydration, especially when the inlet temperature exceeds 40°C, a visible concern with products at or above 70°C.

Compared to mechanical freezers using refrigerated air and slower freezing times, cryogenic freezing is more effective in preventing dehydration losses. Cryogenic freezing rapidly reaches temperatures as low as -18°C within minutes, effectively minimising dehydration losses and allowing producers to attain higher yields. This approach achieves reductions ranging from 1% to 6%.

Preserves freshness, taste, texture, and nutrients

Food typically contains a significant amount of water, accounting for up to 90% of the weight in most fruits and vegetables. Slower freezing methods result in larger ice crystals, which can damage the food's cell structure, leading to undesirable 'drip loss' upon defrosting. Cryogenic freezing, on the other hand, preserves the freshness, taste, texture, and nutrient content of food. With modern cryogenic freezer tunnels, unprecedented precision is attainable concerning both freezing duration and depth.

Bolsters sustainability

Cryogenic freezing can protect and strengthen your position in the food production industry if your dedication has earned you access to high-margin artisan food markets. It not only enhances food quality but also underscores your commitment to cutting-edge technology and customer satisfaction. Moreover, cryogenic freezing aligns with sustainability goals by extending the shelf life of frozen food and combating food waste.

Types of cryogenic freezing and chilling machinery and their ideal applications

CRYOLINE® CX600 Spiral Freezer

The CRYOLINE® CX600 is a high-performance spiral freezer for medium production capacities and best-in-class efficiency. The patented CRYOLINE® CX600 technology delivers higher average gas flow velocity, leading to higher heat transfer rates than standard cryogenic spiral freezers to minimise product dehydration. In addition, the CRYOLINE® CX600 has a footprint and cost advantage compared to existing spiral freezer solutions thanks to its new solid surface and self-stacking belt that allows double the amount of belt in a smaller box. Additionally, the solid surface flat belt opens the ability to process products less suited to traditional weave belts, including coated products like chicken schnitzels. Ideal for a wide range of high-quality food products: meat proteins, ready meals, other convenience foods, fish and seafood, bakery products, and cooked poultry.

CRYOLINE® MT Tunnel Freezer

This is a general-purpose, in-line tunnel freezer and cooler, combining state-of-the-art electronic controls with a high level of hygienic design. Adjustable, high-speed internal fans, controllable exhaust levels and gas injection make the use of cryogenic gases highly efficient. The tunnel has an attractive, easy-to-clean outer design that covers all the motors and pipes. A flexible, modular design means installations can range between five, eight, eleven and fourteen metres in length, with belt widths of either 600 mm, 1000 mm or 1250 mm. Ideal for meat and meat products, dairy products, fish and seafood, ready meals and other convenience foods, and bakery products.

CRYOLINE® CWI Impingement Freezer

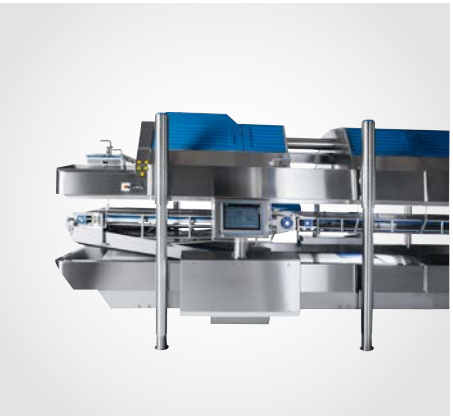
CRYOLINE® CWI is Linde's innovative high-capacity freezer solution that combines the benefits of CRYOWAVE® product agitation with impingement gas flows to give customers new-found levels of flexibility and productivity. Linde's patented impingement technology combines cryogenic gases with high-velocity convective airflow to achieve rapid chilling and freezing of food products. This has been combined with the quality gains of CRYOWAVE controllable vibration systems for individually quick frozen (IQF) products. This dual solution supports high throughput rates and provides users with the design flexibility to increase production capacity or reduce freezer length relative to traditional IQF freezing systems. This is due to the high heat transfer rate of the CRYOLINE® CWI. With a modular design, CRYOLINE® CWI installations can range between five and fourteen metres in length. Ideal for meats, seafood and IQF products such as shrimp, sliced/diced chicken, sausage, meatballs, pasta, pizza toppings, fruit and vegetables.

CRYOLINE® CW Multi-purpose Freezer

Easily switching between IQF mode and standard flat-belt tunnel freezer, the CRYOLINE® CW is a versatile multi-purpose cryogenic freezer. The CRYOWAVE® controllable vibration technology allows adjustable product amplitude for the optimisation of IQF foods while also providing the ability to perform as a standard tunnel for many other food types of differing shapes and sizes. The freezer is available in various lengths between five and fourteen metres, with typical achievable production rates of 500–2,700kg/h (1,100–6,000 lb/h). Ideal for meat and meat products, fish and seafood, fruit, ready meals, and other convenience foods.

CRYOLINE® CS Compact Spiral Freezer

The CRYOLINE® CS, with its patented, self-stacking spiral belt and its relatively small footprint of only 2.5 x 3.4 m, is capable of freezing and cooling large quantities of food products. The unique design, with the body of the freezer built around the belt, uses the coolant very efficiently. The self-stacking belt also minimises the possibility of production stops due to belt jams. Unlike most other spiral freezers, this unit can be transported to the production site in one piece for rapid installation and immediate start-up. Ideal for meat and meat products, dairy products, fish and seafood, ready meals and other convenience foods, and bakery products.



CRYOLINE® PE 800 Pellet Freezer

The patented CRYOLINE® PE fills the cavities in a belt pre-cooled by liquid nitrogen. The extremely low temperature of the belt rapidly freezes the liquid into the cavity's shape, stabilising the product before it is released at the end of the belt. The product is then transferred to an integral CRYOLINE® MT tunnel freezer to complete the process and form a 'chocolate bar' of pellets. Due to the very low thickness of the joining product, the pellets are easily separated into individual pieces. Ideal for prepared sauces, purées, fruit juices, and other liquid products.

Busting the cost myth of using cryogenics

When considering the production of roasted IQF vegetables, cryogenic freezing offers the advantage of individually quick freezing 600–800 kg per hour within 9m² of floor space. This method can potentially achieve increased yield, directly impacting the bottom line. Roasted vegetables typically enter the freezer at temperatures between 50°C and 60°C. At these elevated temperatures, the product releases moisture as water vapour. In a conventional freezer, the vegetables continue to release moisture for a significant duration before reaching a surface temperature below 10°C. Until that point, weight loss continues, reaching up to 6%. However, with cryogenic freezing, the surface temperature drops to less than 10°C in less than 30 seconds, minimising moisture loss and allowing for a potential yield increase of 5%. With a product cost of $6.00 per kilogram, the potential loss of profit due to yield loss can be as much as $0.30 per kilogram or $240 per hour. Depending on the annual production yield, improvements of $500,000 are achievable.

Quick chilling of beef trim can potentially yield an increase of 2.5%. Considering typical production rates of 2,500 kilograms per hour and a product cost of $5.00 per kilogram, the potential estimated savings per hour are over $300. This easily translates to potential annualized increases in yield values of over $600,000. Additional benefits of this process include the potential to extend shelf life by eliminating the need to hold the product overnight in cooling rooms, along with improvements in the quality and juiciness of the final product.

Get in touch to review your freezing and chilling processes

We've been a reliable presence in the food and beverage industry for a good reason—we're here to support your business. Our commitment is straightforward: we use our expertise and technology to enhance your food processes, ensuring long-term success.

If you want to improve your freezing and chilling methods, contact us at bulk.enquiries.au@boc.com. We're ready to assess your current setup and help you achieve better results.

Get in touch today for an assessment of your current food freezing and chilling processes. Reach out to bulk.enquiries.au@boc.com or visit our website.

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