Challenges and risks of frozen foods

Exkal's solution

exkal

FOR FUTURE GENERATIONS

Why?
Purposes of using freezer cabinets

Reducing food waste and energy consumption are two key objectives of modern societies and their institutions (UN, EU and governments).

As freezer cabinets include doors in their initial configuration (cabinet model with Ecolabel), their energy ratings can be confusing. Compared to the cabinets most commonly found in supermarkets, wall-mounted refrigerator units, typically with C and B ratings, the EEI ratings of most freezer cabinets are above 50 - F, E and a few with a D rating - which could create the impression that little progress has been made with models of this kind. The reason for this confusion is the fact that two cabinets are different: wall-mounted refrigerator units are open, while freezer cabinets are closed.

Furthermore, according to the ISO 23953 standard, the certification testing process has a far greater impact on freezer cabinets than on wall-mounted refrigerator units, due to the defrost cycles and the number of times the door has to be opened to simulate restocking and customers' behaviour as they shop. This is due to the difference in temperature between the freezer cabinet and the room, which is double that of refrigerator units. And in most remote cabinets, the doors are larger and therefore the impact of opening them is greater.

This means that in units of this kind, the difference in temperature between the coldest package at the coldest time and the warmest package at the warmest time is very large, sometimes even above 20ºC. And the difference in temperature of the warmest package when it is at its coldest and warmest is also very large. In short, a severe lack of uniformity, with the preservation of frozen food equally lacking and not very efficient.

The aims of this project are to improve temperature uniformity significantly to better preserve frozen foods, to improve energy efficiency to bring their EEI (Energy Efficiency Index) up to 35, allowing them to obtain a C rating, and also to optimise their ergonomics and product visibility, reduce energy consumption, pollutant emissions and food waste, while also simplifying maintenance operations.

Reducing food waste and energy consumption: the keys to a more sustainable future.

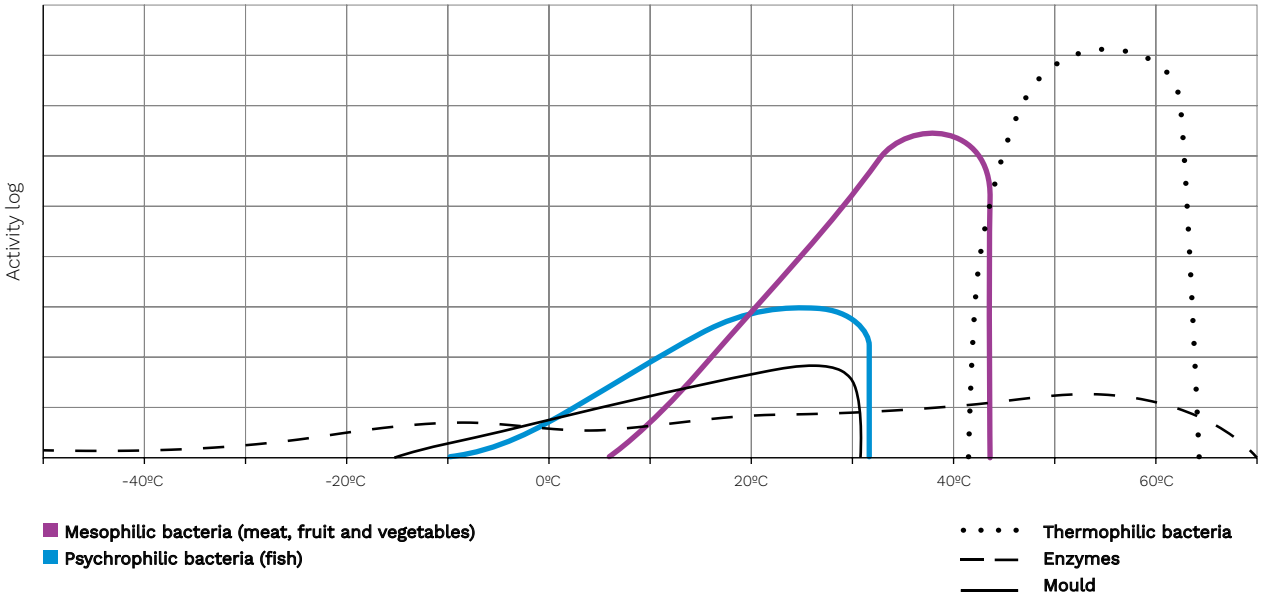
Temperature uniformity, crucial for the quality and preservation of frozen foods.

What are frozen products?

No crystals are formed **on refrigerated products**, so preservation quality is almost entirely dependent on bacterial behaviour.

The first thing a refrigerator cabinet has to do is prevent bacterial proliferation/multiplication. Secondly, the food should not be allowed to partially freeze. The former is assured by keeping the product below its upper temperature limit and the latter requires it to remain above the lower temperature limit (-1/+5ºC).

Temperature uniformity, a key factor in preserving the quality, texture and flavour of frozen foods.



The quality and shelf life of a refrigerated product are dependent on maintaining a temperature that meets the two requirements of commercial refrigeration and limits bacterial activity. A cabinet with greater temperature uniformity has a better chance of achieving the objective (Fresh Food cabinet range).

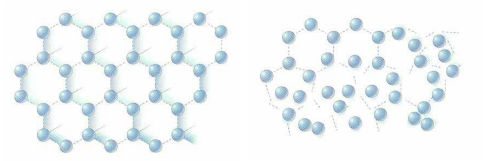
Crystals do form **on frozen foods**.

Bacterial activity is prevented regardless of the temperature of the product, so this is not the limiting factor. The limiting factors are variations in product temperature and recrystallisation. Variations in temperature during storage have a significant impact on the quality and shelf life of frozen foods.

A freezer cabinet that maintains a uniform temperature can minimise these negative effects, better preserving the texture, flavour and nutritional value of the food and prolonging its shelf life. Therefore, a unit that provides a more stable temperature is essential to maintain the quality of the products and ensure customer satisfaction. Temperature fluctuations during the storage and transportation of frozen foods have long been a major concern in the industry.

Meat products: ice recrystallisation due to variations in storage temperature leads to microstructural changes in meat products, resulting in irreversible damage to cells and tissues, degrading the quality of frozen meat during storage. Other frozen foods are similar.

Water exhibits anomalous expansion, unlike other liquids. Water in its solid state (ice) has a very open structure. This means that the particles occupy fixed positions in the lattice and there are large gaps between them. As the ice melts, this structure breaks down and the water particles occupy these empty spaces, forming clusters. This results in a lower volume and, therefore, a higher density.



In EXKAL's latest ranges of freezer cabinets, technological change means disruptive change. When a project's target values are surpassed by even more than 50%, it is no longer a simple upgrade or improvement. This has been achieved with EXKAL's 5th generation of freezer cabinets.

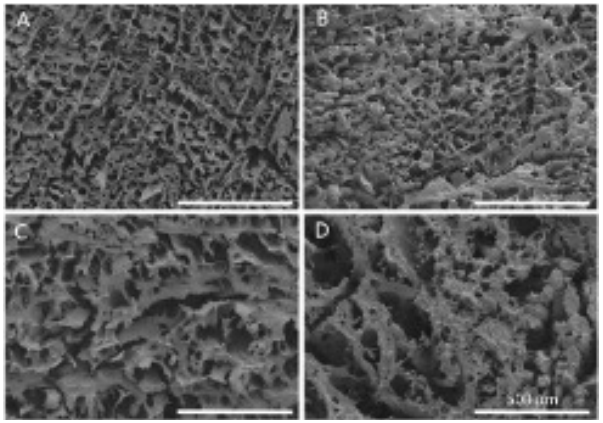
With our new remote freezer cabinet technology, the temperature uniformity range, i.e. the difference between the coldest package when it is at its coldest and the warmest package at its warmest over a 24-hour cycle, is less than 8°. However, with current technologies, this difference is above 16°C in the top cabinets available on the market.

The second key value - the temperature variation of products in the 24-hour cycle - is less than 4° with our technology. However, with existing technologies, this variation is around 10ºC in the best cabinets available on the market.

Our technological breakthrough reduces temperature fluctuations to less than 4°C, marking a disruptive change in frozen food preservation.

Changes in ice crystals during frozen storage have an adverse affect on the microstructure of frozen foods. These microstructural changes lead to a significant decline in quality, including loss of turgidity and texture, high drip loss and changes in the colour and flavour of the products.

The formation and growth of ice crystals during the freezing process damages the cells in food products and causes changes in the pH, osmotic pressure and ionic strength of the concentrated unfrozen matrix. These changes trigger adverse biochemical and physicochemical reactions, such as protein denaturation, lipid oxidation and enzymatic degradation, especially in meat and seafood.



A key aspect that has to be considered is the size and shape stability of the ice crystals that form. They are not stable and tend to change during storage through a process called recrystallisation. Variations in temperature during storage accelerate these changes, affecting the quality and shelf life of the products.

Lower temperature fluctuations ensure a longer shelf life and a better consumer experience.

Variations in storage temperatures affect the size and location of ice crystals that form in the food and these in turn play a microstructural role. When critical changes in quality are linked to physical processes, such as ice recrystallisation and moisture migration, the extent of temperature fluctuation is always a matter of concern, as is the average temperature. Larger fluctuations lead to faster changes in the food.

How to display and preserve frozen products

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Function of freezer cabinets

The function of commercial refrigeration cabinets is to display and preserve food at the required temperature for direct sale to consumers. This means that the products have to be loaded and reloaded at their storage temperature. A cabinet's cooling capacity/requirements are what it needs to offset any losses, so it will not have any extra capacity to cool the products if they are not loaded into the cabinet at the right temperature.

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Characteristics of freezer cabinets

We can distinguish between commercial refrigeration cabinets and classify them according to their level of quality based on their main characteristics.

The Ecodesign and Ecolabel directives identify the most important characteristics regarding annual energy consumption (AE) and storage temperature class. But there are other aspects we can consider when assessing them.

The evaporation temperature (ET) has always been regarded as a key characteristic and is synonymous with high quality. A commercial refrigeration cabinet with a high ET, as close as possible to the storage temperature of the refrigerated/frozen product, always ensures outstanding performance. It has a positive impact on energy consumption by significantly reducing the energy used to condense and freeze the water vapour in the recirculating air (less frost forms on the evaporator). The moisture content of the recirculated air will be higher, which is particularly important in refrigeration cabinets where the products on display are not packaged. This facilitates and reduces defrosting times, as less frost forms on the evaporator and it is softer due to its higher temperature.

The air velocity at product display level is equally important in refrigeration cabinets with unpackaged products, because of the drying effect of air on the displayed products (especially meat).
Temperature uniformity within the body of the refrigerator is a key factor. In fact, it has always set the limits and driven technological advances. Uniformity has always been decisive in achieving the highest levels of performance; firstly 3M1 class, with a uniformity of -1/+5°C, and more recently 3M0, with a uniformity of -1/+4°C. Cabinets with greater uniformity are usually also more energy-efficient. Improving this performance is the challenge we are facing today. Improving on this uniformity will pave the way for significant improvements in commercial refrigeration cabinets. Being able to avoid temperatures below -1ºC and keeping +4ºC as the upper limit represents an important improvement for ready-to-eat salads, as it avoids the risk of freezing the tips of the vegetables. Lowering the upper limit from +4ºC without dropping below -1ºC allows us to reduce the amount of bacterial activity and extend the shelf life of meat and fish. In commercial refrigeration cabinets for frozen products, this improved uniformity leads to a reduction in recrystallisation, which improves the preservation and shelf life of frozen foods.

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Types of freezer cabinets

Depending on their refrigeration system, they can be remote, integral and semi-integral.

Depending on their physical shape, they can be upright, semi-upright and chest cabinets.

Depending on how you access the food inside them, they can be open and closed.

Depending on their temperature, they can store refrigerated products and frozen products.

Depending on the service required/provided, they can be for assisted service or self-service.

These are the most common types. But there are a few more. Combi-cabinets consisting of two or more cabinets with different cooling combinations - refrigerated/frozen, frozen/different temperatures, etc. Dual temperature cabinets, multi-purpose units, cabinets for trolleys,etc.

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Types of technology

Depending on the type of evaporator: ventilated evaporators, which are the most common type, in which the evaporator is composed of a set of tubes and fins through which air is forced by a fan; static evaporators, in which the air is circulated by gravity; and evaporators with coils, in which the air is cooled by contact.

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Types of system

Depending on the type of system: direct expansion and systems with secondary refrigerants.

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Importance of installation and configuration

Proper installation is crucial for a remote commercial refrigeration cabinet. As it is not equipped with a condensation-compression system, its operation largely depends on the liquid supply to the system. An inadequate supply of liquid will result in poor and highly inefficient

operation. Supplying liquid CO_2 that has not been sub-cooled will lead to gasification and, as a result, an inadequate supply of liquid to the evaporator.

The settings and control systems are also of vital importance. For the machine to operate at the specified temperature, the setpoint, differential and control system must be configured. An all-or-nothing system is recommended when the cabinet is operated at a constant evaporation temperature. In such cases, modulating control is not recommended. If the evaporation temperature is variable according to demand and uses suction control, modulating or proportional systems are suitable. Defrosting cycles must be performed efficiently, in terms of final defrosting temperature, the start-up temperature set for fans and drip times in cabinets when defrosting is performed with the fans switched off.

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Importance of filling cabinets correctly

As explained above, cabinets must be filled and refilled with food that is at the correct temperature. And always below the maximum load line. If the temperature of the products is not correct, the commercial refrigeration cabinet will not be able to bring the products to the required temperature. If they are loaded above the maximum load line, the cabinet's temperature control and power consumption settings will be lost.

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Importance of cabinet maintenance

Like most, if not all machines, commercial refrigeration cabinets require maintenance. Failure to perform basic maintenance will result in the cabinet no longer operating within the desired temperature and efficiency parameters. Its warranty will also be voided.

Warranties Act. Article 9.4.- Damage or defects due to wear and tear caused by normal use of the equipment are excluded from the warranty. Furthermore, the warranty, which shall be deemed to have expired, shall not cover damage and defects caused by improper servicing or maintenance, incorrect or negligent storage and handling, misuse, use of unsuitable liquids and gases and improper flow rates or pressure levels, faulty installation, variations in power supply quality (voltage, frequency, disturbances), modifications made to the power supply without the Company's approval, installations carried out or subsequently modified without following the product's technical instructions and, generally, any reason that is not attributable to the Company.

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Continuous changes in storage temperatures of frozen products

The laws that state that frozen food must be stored at a temperature of -18°C are over 90 years old. We now have a greater and better understanding of food, so these laws need to be reviewed and, if necessary, updated.

With energy savings and optimal preservation of frozen food in mind, some large food retail chains have decided to change the frozen food storage parameters in some of their stores from -18ºC to -15ºC. Not only will the frozen products be just as well preserved, they may even be better preserved.

Along similar lines, some ice cream manufacturers are developing ice creams that can be stored at -12°C. The energy savings can be as high as 20%.

This will require changes in food safety legislation and the standards applicable to commercial refrigeration cabinets.

Exkal's proposal

To overcome these obstacles and the emerging challenges of the present and future, Exkal's R&D&I team is continuously looking for the best solutions and developing the most sustainable innovations.

These are our latest major developments.

Exkal's solution

Niagara and Thukela freezer cabinets

5th generation

Niagara and Thukela are our 5th generation of upright freezer cabinets with doors. They are designed to improve temperature uniformity, reduce product temperature variations in 24-hour cycles, and optimise ergonomics. By fulfilling these criteria, significant improvements in energy efficiency, reductions in pollutant emissions, optimisation of product visibility and improvements in food preservation are achieved, thus reducing food waste.

5th generation Niagara and Thukela: outstanding energy efficiency, temperature uniformity and sustainability, reducing food waste and energy consumption.

A unique range of cabinets

Benefits

This new system offers advanced 3S- and 3L1 temperature ranges, optimising energy efficiency, which has improved by 20%, with Niagara obtaining an energy rating (EEI) of C. Its TDA has improved by more than 5% and the cooling requirements (HER) have been significantly reduced by over 13%, with energy consumption (DEC) falling by 13%. The design of the 5th generation airflow circuit provides greater temperature uniformity, limiting variations in temperature between products to just 4ºC in each daily cycle.

Additionally, the upper rear evaporator, designed to maximise heat exchange, is in the optimal physical position and improves thermal efficiency (TE). The ergonomics are also improved in this design, with technological components located in harder-to-reach areas so that the areas used on a daily basis are easily accessible for users. This helps to reduce direct and indirect emissions and, in the long term, to lower life-cycle costs by reducing food waste, reducing maintenance and cutting energy consumption.

Finally, it should be noted that this improved energy efficiency leads to an ROI of < 2.5 years, so over its service life the purchase price will be recouped 4 times over.

Thanks to these benefits, the models in our Niagara and Thukela ranges feature the most environmentally friendly cabinets, with an outstanding capacity to reduce food waste and energy consumption.

Supercooling – tomorrow's world

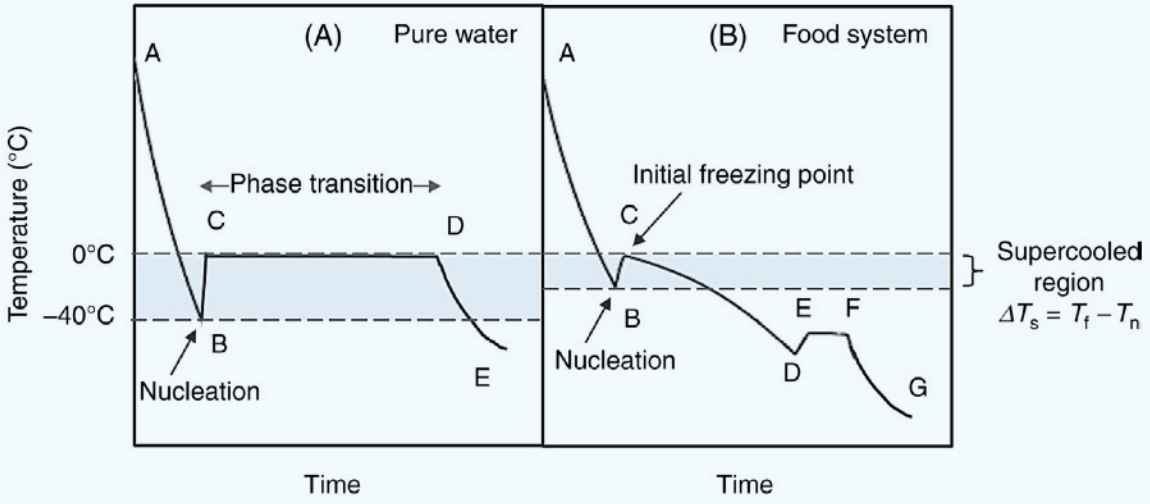
Through our R&D&I unit, Exkal is researching and working on the development of new food preservation methods. These projects include our supercooling technology, with considerable benefits and applications in the retail sector and in the cold chain in general.

What is "supercooling"?

Supercooling is a temperature lowering process in which there is no bacterial growth, no crystal formation and bacterial activity is inhibited or minimised. Once again, temperature uniformity is essential. A more uniform cabinet is far more likely to achieve optimal preservation.

For the display and preservation of food, supercooling technology is the controlled use of undercooling to keep food at a temperature several degrees below its freezing point, without the formation of ice crystals.

This technique allows fresh food to be preserved for longer, over the medium to long term, avoiding the damage that normally occurs with traditional freezing, such as the formation of crystals that affect the texture and quality of products.



Supercooling technology: prolonged preservation without ice crystals, ensuring freshness and quality in the cold chain.

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Challenges and risks of frozen foods. Exkal's solution. **ED0**