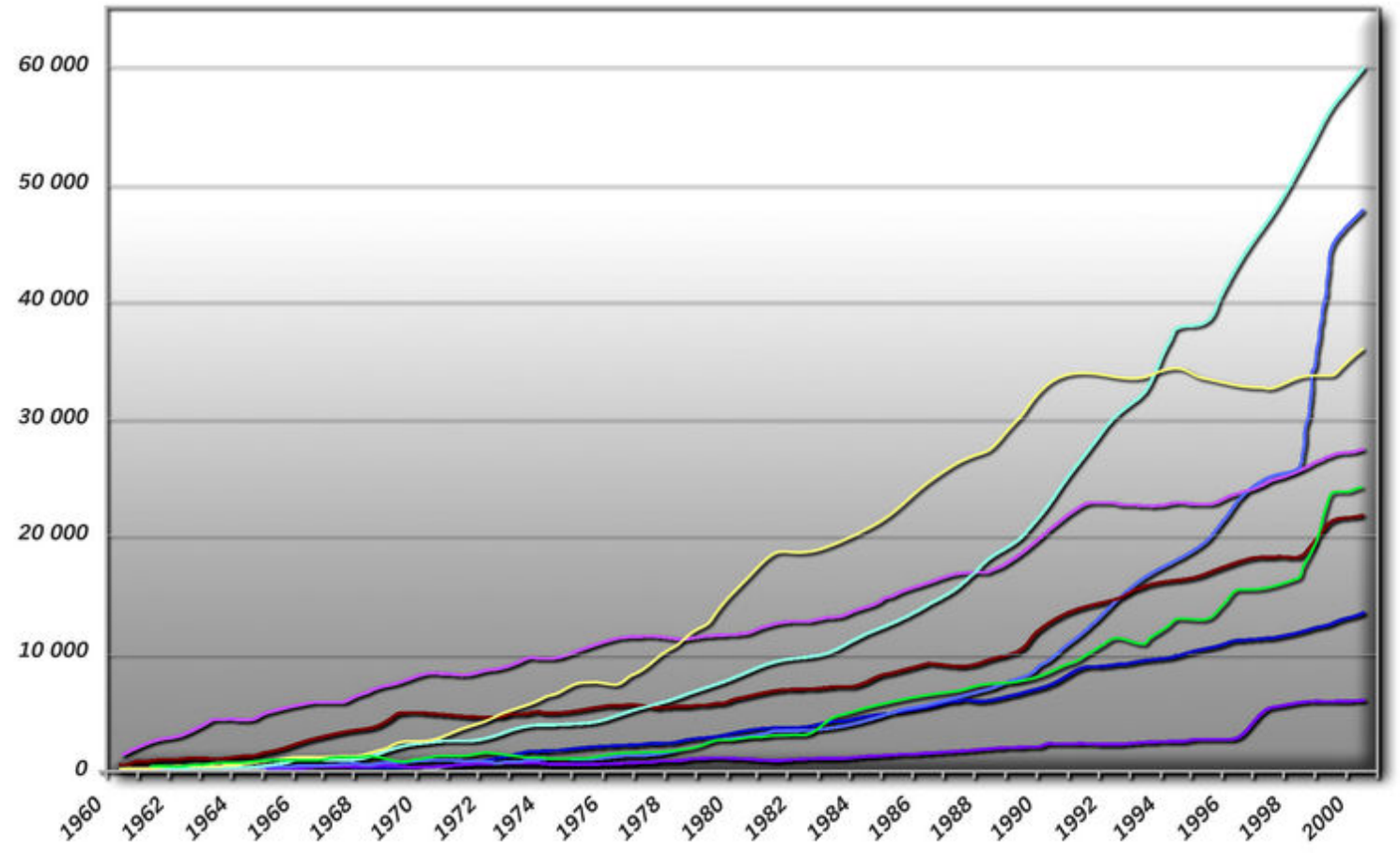
The art of freezing



Deep-frozen food sales 1960 to 2000 (t)
dark blue: partial meals - red: vegetables - yellow: potatoe based products - light blue: ready cooked meals - light purple: fruit, fruit juices
brown: fish based products (including partial meals) - green: meat and game (raw) - dark purple: others (including dairy products, bakery products, specialities)

Whether the fast freezing of cooked meals or blast freezing of pastries is economical does not only depend on investments and operating costs, but also on production processes and the quality of the frozen products.

The process of freezing always starts at the cooled surface and then continues towards the core of the product, more or less rapidly, depending on the heat transfer coefficient and the thermal conductivity of the product to be frozen. As food mainly consists of water, freezing starts at about 0 °C. The freezing point depends on the concentration of the salts dissolved in the water, the carbohydrates and the other components of the respective product. The freezing process progresses with the formation of ice crystals depending on the freezing velocity.

Very low air temperatures of -40 °C and high air velocity lead to the formation of microscopic ice crystals. The water molecules do not have time to bind together during freezing, thus no large ice crystals form at the cell walls. Therefore, the cell structure will not be damaged by the formation of large ice crystals. If the freezing velocity is too low, water molecules have enough time to diffuse from the cells into the spaces between the cells. As a consequence, large ice crystals form and damage the cell walls, the concentration of dissolved salts increases and the molecular structure of the dissolved protein substances change. Therefore, during defrosting, less water can be re-absorbed and cell fluid diffuses through the damaged cell walls. High cell fluid losses reduce the quality, taste, appearance and durability of the defrosted products. This process is also called dehydration and leads to the drying out of the product to be frozen. Note: Low air temperatures and high velocity of air flow lead to rapid freezing of the product surface and therefore prevent dehydration. The following factors influence transpiration and thus the transfer of water molecules of the frozen products into the cold air:

- Cooling temperature
- Velocity and direction of air flow
- Surface properties of the goods
- Vapour pressure difference between the cold air and the water in the frozen goods

An example for blast freezing: Cooked food at 95 °C will be cooled down to a core temperature of –18 °C within 0.5 to 4 hours, depending on:

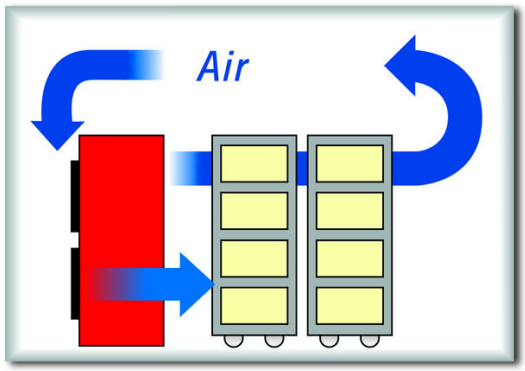
- Water content
- Fat content
- Thermal conductivity

Example:

- Menu components
- Blanched vegetables
- Fresh mushrooms
- Desserts
- Ice cream
- Cakes
- Meat
- Fish
- Liver
- Smoked salmon

To optimise the blast freezers efficiency it is important to adjust the product quantity to the blast freezer's performance and not to its capacity.

Typical air coolers for blast freezers are equipped with forced draught fans, which are installed in the freezing chamber at a sufficient distance from the wall to allow the aspiration of the surrounding air and potential maintenance work. The air is directed over the frozen goods and flows through the interspaces back to the air cooler.



Forced draught fans ensure ideal air flow across two tray racks.

To avoid an air short-circuit, a protective metal sheet must be installed between the drip tray and the ground, which also provides protection from damage by fork-lift trucks. Naturally, we can also design, construct and produce customised units for you, adapted to different conditions (refrigeration capacity, size of freezing chamber, freezing temperature, air speed,

construction sizes). The standard range of the Güntner GFN blast freezers can be found on a separate data sheet and on the Güntner Product Calculator.

Product	Start of freezing °C
Meat	-0.6 to -1.2
Fish	-0.6 to -2.0
Milk	-0.5
Egg white	-2.0
Egg yolk	-0.65
Onions, peas	-0.9
Strawberries	-0.9
Peaches	-1.4
Apples, pears	-2.0
Plums	-2.4

Table: Bundesanstalt für Ernährung, Karlsruhe

Designation	Designation
Still Air	-0.15
Cold air	0.1 to 1.5
Slow freezing	0.1 to 0.2
Rapid freezing	0.5 to 3.0
Very rapid freezing	5.0 to 10.0

Table: Bundesanstalt für Ernährung, Karlsruhe

Deep-frozen food consumption per head in Europe 2000: (in kg, not including ice cream)

Great Britain	47.6
Sweden	44.6
Norway	42.1
Germany	31.8
France*	30.0
Finnland	25.4
Spain	22.1
Belgium	21.6
The Netherlands*	19.4
Greece*	18.0
Italy	11.7

*without raw poultry

Source: Deutsches Tiefkühlinstitut e.V.Cologne, according to indications of the European partner organisations. Data partly estimated.

Comparison

These measurements have been carried out under the same conditions in an installation with strong air outlets. The existing nitrogen gas spray unit has been replaced by a Güntner blast freezer.

	Nitrogen gas spray	Blast freezing with finned heat exchanger
Product	Meat	Meat
Product thickness	About 10 cm	About 10 cm
Cooling	Continuous	Continuous
Starting temperature	+80 °C	+80 °C
Time required	3.5 h	4 h
End temperature of the core	0 °C	0 °C
Operating costs per unit	0.12 € / kg N_2	0.06 € / kWh
Operating costs per kg	0.10 €	0.01 €

Conclusion

The Güntner blast freezer requires at most only 1/10 of the operating costs compared to a nitrogen gas spray cooling unit.

The following models and options complete the standard range of the Güntner GFN blast freezers.

Variants of the GFN blast freezer	• Epoxy coated fins • Stainless steel casing and piping (on request) • 60 Hz fans (on request) • Reduced air flow (on request) • Refrigerants (other products on request) (forced pump circulation e.g. CO_2, NH_3)

Accessories of the GFN blast freezer	• Electrical peripheral fan heating • Insulated washers • Bend/connection covers • Fan separation sheet with heater • Hot gas coil and tray heater • Electrical coil and tray heater • Shut off valve (HG)