High yield thawing: **D-Icer**

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SUMMARY

The demand for raw material in the meat industry fosters the need for stocks of frozen meat, whether due to market pressure, to guarantee an uninterrupted supply of raw materials, or due to geographical location. The growing use of frozen meat requires reliable, quality thawing in the least time possible. This article presents a comparative analysis between different types of industrial processes relative to the use of the D-Icer thawing system. Its characteristics and the keys to the process are described, along with the advantages offered by this type of technology: less time, traceability; total control over the process; improved yield; less space required and product safety; along with versatility, the possibility for modular growth and a rapid return on investment.

INTRODUCTION

Thawing raw material has always been a storage method used in the meat industry to guarantee a regular and standardised meat supply, in terms of quantity and quality, as well as economic value. The increase in the use of this resource is due to both the increase in meat product consumption as well as the difficulty, in certain markets, of obtaining fresh meat continuously.

Along with freezing, another process is becoming a challenge for many organisations: Effective industrial thawing.

The meat industry has many different thawing processes: water immersion, climatic chamber, radio frequency, microwave, and even combinations of some of these processes. The majority of these have one factor in common: the process is static, which involves a long processing time, without guarantees of a stable product, which is minimally uniform and controlled. Of all these, the most commonly used to date are the climatic chamber and water immersion.

The thawing method used is a determining factor for the raw material to maintain the characteristics of the meat. Nevertheless, the freezing and storage process that will establish this quality after thawing is no less important (Backi, C.J., 2018).

THAWING SYSTEMS

Climatic chamber

This thawing system consists of placing blocks of meet manually on shelves within a climatic chamber for air to circulate between them. Though there are variations, it is generally a long process, and depending on the product type and size of the blocks, it requires 1-2 days.

To accelerate the process a temperature gradient with high humidity (steam) tends to be used to achieve an environment that promotes thawing.

Due to the long processing times, which can take up to two days depending on the product and block measurements, microbial growth could be easily promoted. Another important factor to highlight is the need for a large thawing surface due to the space this type of process requires.

This system leads to significant variability in the final product, with differences in quality and the internal and external temperatures of the meat, which can lead to dry or crusty surfaces of the pieces. On the other hand, there could be pieces where the centre is still frozen, while others are completely thawed.

Losses in the process tend to be high, leading to considerable weight loss (4-6%), both from water and proteins, thus losing some of the properties that cannot be recovered (Pérez-Linares et al. 2005).

Water immersion

Water immersion thawing consists of placing the blocks of product in containers with water.

Water is a better conductor of heat than air, so this process is faster than the climatic chamber. The biggest inconvenience is that the water cools rapidly in contact with frozen blocks, so the water must be changed or circulated frequently, especially in the first few hours. The primary drawback is a greater loss and washing of proteins in the product, together with a high risk of microbiological contamination, since a suitable habitat for microorganismal growth is generated.

Although this technology requires a low initial investment, there are cost overruns due to the large amounts of water used, and in countries where this is a scarce resource, the economic cost increases substantially.

This process would not be suitable for the thawing of small-sized raw material like ground meat or cuts, as washing would exponentially increase the loss and risk of contamination.

Microwave (MW) or Radio frequency (RF)

The principle of this technology is based on the change of polarity of an electromagnetic field where upon vibrating the charges, heat energy is generated, permitting thawing.

In reality, it is rarely used for total product thawing and is generally used only to temper the blocks due to its high energy cost. In these systems, wide temperature variations are produced, and there is little heat penetration. The effect of both MW or RF is superficial thawing that penetrates inwards to the centre of the product. The major problem with this technology occurs when the surface is already thawed, the electromagnetic field continues acting and therefore continues to generate heat, ending up cooking the surface without yet thawing the inner part of the block.

Although the process time is very short, losses are fewer (Ku, S. K et al. 2014) and a continuous process could even be used; the major problem is that once temperatures of 0°C are reached, points of superficial overheating can already be detected in the meat (burnt areas). In addition, it must be emphasised that these are rather large lines that are difficult to clean and sanitise. This method is generally used only as a complement to other technologies to reduce the total process time.

Thawing drum

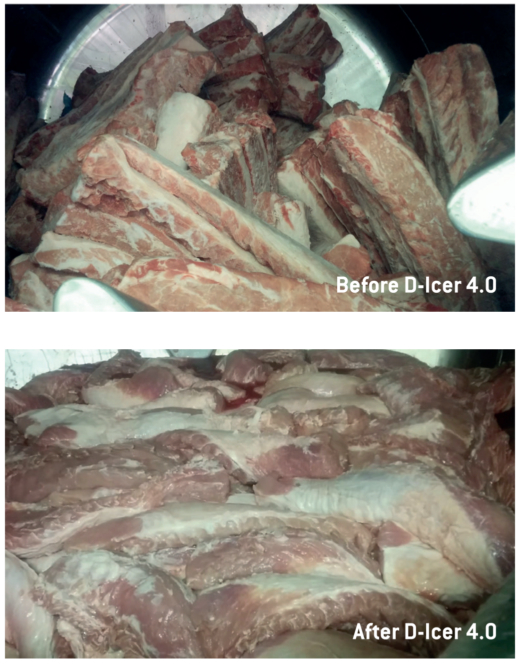
This is a process in which thawing blocks of meat takes place within a massaging chamber, using steam and surface heat to create a suitable environment for thawing. The tilting of the drum serves to homogenize temperatures and separate the blocks.

Thawing in a drum is a process that requires reliable and widely tested technology to obtain optimal raw material for industrial processing. This technology has many advantages compared to the majority of technologies used for thawing, since its success relies on shorter process time and complete monitoring of all phases of thawing, for the product and the factors involved in the process.

There are different types of drums, and though they may appear similar, they do not all have suitable technology or the necessary control parameters. To achieve thawing in short times and with optimal final temperatures, it is essential to have absolute control over all factors and ensure that the elements necessary for thawing come into play to the right extent and at the exact right time throughout the process.

To meet all these needs, Metalquimia has developed the D-ICER drum, capable of thawing any raw material, applying the principles of thermodynamics and energy transfer. The entire process is carried out by controlling the input of steam into a vacuum, avoiding the denaturation of proteins or overcooking the surface of the product, and regulating the environmental temperature using thermal insulation. The movement of the drum promotes the homogenisation of the product. D-Icer thawing has severable settings that can be controlled and adjusted so that the final product is as close to fresh or statically-thawed raw material as possible, but in less time and with fewer losses.

▲ **Photo 1:** Turkey breast before and after thawing with D-Icer.



▲ **Photo 2:** Pork loin before and after thawing with D-Icer.

To start the process, it is necessary to know the characteristics of the product: what the blocks are like, meat type, initial temperature, and industrial aim of the product (injection, grinding, cutting, etc.). The importance of these factors will determine the total thawing time, which is shorter when the blocks are smaller or have been previously tempered (internal temperature between -10°C to -6°C). There are different options or complementary technologies to accelerate thawing: either tempering the product in a MW or RF tunnel, or separating the pieces that make up the block by using a press. And if the final product allows it, using a guillotine to split the blocks into sheets or smaller blocks. All of this will depend on the final aim of the raw material in question.

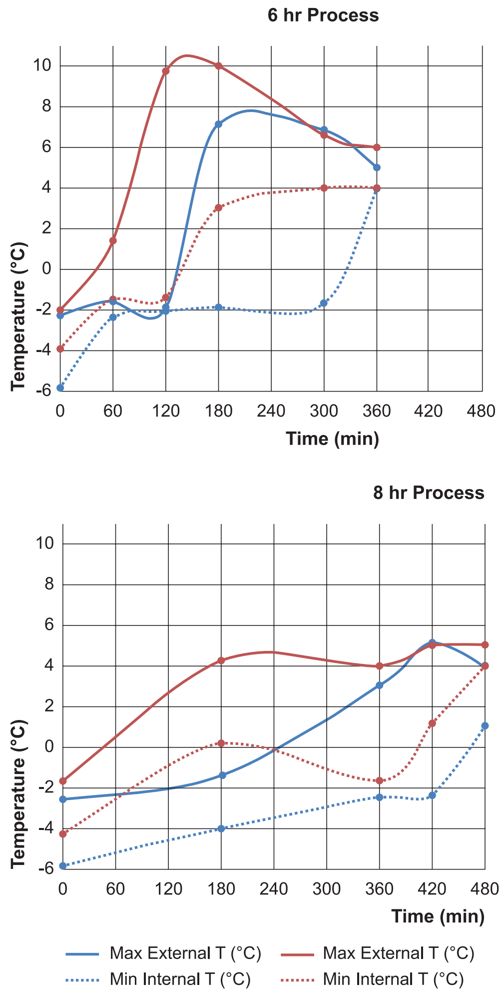
During the development of the D-Icer drum, the variables that directly affect the thawing process were considered, and monitoring systems were applied to each of them to obtain total control and oversight at any point in the process. These variables are described below.

Temperature control

For fair comparison, the processes were studied starting with an internal block temperature of -18°C / -15°C in all cases. The final desired temperature at the end of the thawing process is set at 2°C / 5°C, ensuring that once the process is complete, all the meat is suitable for injection. If the final product is intended for cutting, it is recommended not to fully thaw it all, attaining a temperature of -1°C/-2°C for optimal cutting without smearing.

During the first phases, high energy input is required to obtain a temperature increase of the product, until reaching an internal temperature of -2°C/-3°C, controlling the surface temperature through the thermal insulation. To obtain this effect, it is necessary to maintain an optimal environment, so in the first phases the thermal insulation requires higher temperatures, constantly controlled by sensors installed in the drum.

This time can be considered a critical point for thawing: when more energy is required to go from negative to positive temperature in the product (Chen, C.S.1985).



▲ **Graph 1:** Time - temperature ratio according to the process.

This process is the one in which most time is invested, as the heat energy needed to achieve this change in state must be added. Being an endothermic process, the energy input in heat form is absorbed by the meat without increasing its temperature. As not all meat mass has the same "timing", block thawing is carried out from the surface inward and therefore the surface of the product will thaw first, making total external temperature control of the mass essential.

In subsequent phases, the use of the thermal insulation is needed to maintain the temperature of the mass at the optimal point. The homogenisation of the temperature of the meat mass is also promoted by the rotation and tilting movements carried out throughout the entire process and avoids prolonged contact of the pieces with the thermal insulation.

Steam input to the vacuum

Steam input is a basic factor to obtain an efficient process. But this steam could not be used without a vacuum environment inside the drum. Therefore, the vacuum is the key point for the added steam to go from 100°C at atmospheric pressure to under 33°C upon coming into contact with a strong vacuum (0.05 Pa).

The energy provided by the steam upon condensing on the surface of the product starts the product's thawing. The application of steam in the process is generally carried out in the first half of the process, when the product is at negative temperatures and has not yet reached the melting point. This steam must be food quality, so the line must use specific filters to eliminate impurities.

The amount of steam added must be controlled during the process to avoid an excess input of water in the form of steam. This control is carried out with established steam pressure and the load cells upon which the drum is supported. The majority of meat types, by their nature, tend to absorb the added steam (parts from chicken, turkey, pork shoulder, etc.), while some barely absorb any water (pork loin, pork shank).

In the majority of products, the final yield tends to be positive, between 1-4% relative to the frozen weight, while in other thawing systems, these numbers are negative.

4.0 Connectivity

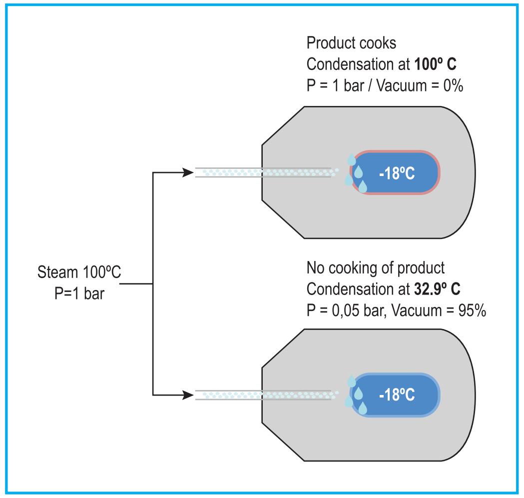
All the variables involved in the process are visible on the display and can be exported in a report form on any device. If a SCADA-type production information system is available, when connected to the equipment, the current status of the process can be viewed from any device. This is the major advantage of having 4.0 technology in any equipment, being able to verify and check any intermediate step of the whole process minute by minute.

ADVANTAGES OF THE D-ICER THAWING SYSTEM

All these factors help obtain a quality final product in a short process time. The advantages of using a D-Icer drum for the thawing process are summarised in the following points:

• Shorter thawing time

The reduction in thawing time is one of its major



▲ **Figure 1:** Entry of steam into the drum with and without vacuum.

Product to inject	kg Block	Non-tempered [1][2]	Tempered [1][2]
Poultry Parts (Legs/Breast)	10 kg	5-7 hrs.	3-6 hrs.
Boneless Turkey Breast	10-15 kg	6-8 hrs.	5-7 hrs.
Entire Boneless Pork Shoulder	17-20 kg	8-10 hrs.	7-8 hrs.
Boneless Ham	18-20 kg	11-13 hrs.	8-10 hrs.
Pork Loin	12-15 kg	9-11 hrs.	7-8 hrs.
Bacon	15-20 kg	7-9 hrs.	6-7 hrs.
Whole Beef Muscle	8-9 kg	12-14 hrs.	9-11 hrs.

[1] Depending on piece size

[2] 1%-5% steam added depending on meat type and final product

▲ **Table 1:** Approximate number of thawing hours in D-Icer drum for different products.

advantages, speeding up the process from days to hours, resulting in greater productivity that translates into greater efficiency and safety. As can be seen in *Table 1*, the times can vary between three and fourteen hours, depending on the product and its initial temperature. There are many factors that influence the total time, such as the size of the blocks and pieces. All of this is adjustable by modifying the programme and adapting it as needed. Other thawing systems are standardised and do not allow for variation based on the product, which does not allow for thawing optimisation as with the D-Icer system.

A clear example of the time variation caused by different initial conditions lies in beef products. Large block pieces require longer times, unless tempered before the process or thawed as individual pieces. These changes can lead to reductions of up to 4 hours in final time. There are other examples based on the size of blocks made up of smaller pieces like chicken breasts. Smaller blocks help with easier separation of the pieces, leading to clearly reduced final times.

• Positive yields

The process yields can present an increase of 1 to 4% above the initial weight, as opposed to what occurs in other thawing methods. These increases can vary depending mainly on the thawed product. There are exceptions, such as pork loin, which tends to have negative yields.

• Optimisation of space and resources

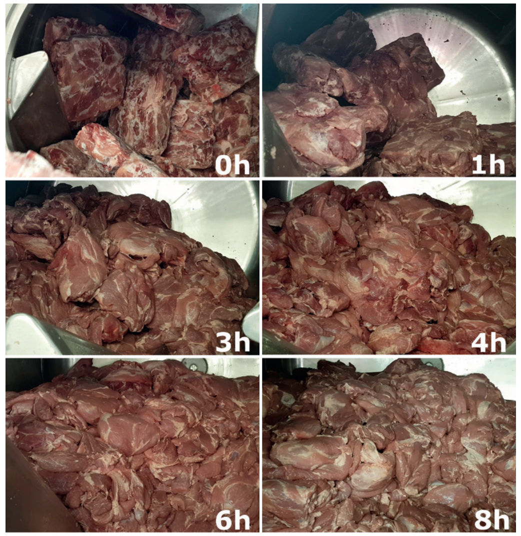
The use of the D-Icer drum allows the reduction of space needed by having high productivity, both for the process times used as well as the useful load capacity of the various models of D-Icer (from 500 to 5,000 kg). Importantly, it also allows for the possibility of modular growth, adapted to the manufacturer's needs.

• Food safety and hygiene

The use at all times of a vacuum environment, together with short process times and product temperature control, avoids excess temperatures at the surface of the product. The ease of cleaning thanks to the polished interior and CIP system reduces cleaning time and aids in sanitisation.

• Versatility

The versatility of the equipment is not only based on the possibility of defrosting any kind of meat with different formats and initial temperatures, but also



▲ **Photo 3:** Thawing process with pork shoulder.

the possibility to use the drum as a marinade by absorption after thawing, optimising the process without interruptions or moving the product. Brine can be loaded into the vacuum or directly added and then the marinating programme starts.

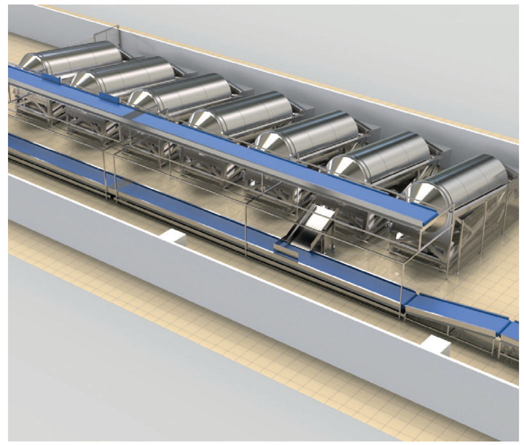
• Return on investment

The reduction in process time and positive yield from thawing allows a greater volume of thawed meat to be obtained per day than other systems mentioned, leading to production increases and profitability from the investment.

CONCLUSIONS

As it was already mentioned at the start of this article, the large demand for products, combined with price variability across the year and the globalisation of the market, has increased the need to use and store frozen meat to maintain stable production or reduce raw material costs. To be able to guarantee a standardised, quality product, as well as a continuous supply for industrial production, there must be a fast, efficient, and reliable thawing process in place.

From the thawing systems reviewed, including static thawing, immersion, or MW/RF, these do not offer complete solutions that can satisfy the control



▲ **Figure 2:** Thawing plant with D-Icer and quality requirements of the majority of today's enterprises. Resulting in: long processing times, large plant surfaces, loss of proteins and/or surface cooking in some cases, structural losses, and moreover, the loss of control over the process and the product itself.

In contrast, the use of the D-Icer system offers major advantages relative to the rest of the processes: speed, homogeneity, space optimisation, high productivity, food safety, and total control over any phase of the thawing process; its variables, parameters, and control of the internal and external temperature of the product. The process with the D-Icer system in place is a clear alternative to existing systems in order to meet the market's needs.

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