

Carbon dioxide and the food processing sector

By [Sam A. Rushing](#) on Sep 10, 2010

Unlike other commodity gases supplied from merchant plants, carbon dioxide is unique in that it is essentially sold and delivered in three forms or phases; first the applications in the food plant for a gaseous product, such as with gas flush usage for MAP (Modified Atmosphere Packaging); secondly in usage for dry ice, usually rice style dry ice or pellets; thirdly as the largest form of CO₂ in the food sector, that being liquid.

The liquid is delivered to the plant site via over-the-road trailers or railcars, and piped into the freezer, blender, and other application's equipment. This liquid is then flashed to a snow, or a cold gas, and the refrigeration value does its job for the cooling and freezing of the food product. There is also the added benefit of creating somewhat of an anaerobic environment, at least for the short-term.

The lion's share of food applications, as found in the developed world, would be for processing all types of meat products and frozen specialties. Within the meat sector in the US, in the US Mid South and the Southeast, there are huge regions where poultry processors use significant CO₂ tonnage for the preservation of boxed whole or pre-cut birds as dry ice pellets, rice ice, or CO₂ snow.

Liquid product is piped into such plants and, usually via automated machines, a select sum of CO₂ liquid is flashed into a snow and dropped into the boxes as they travel across the conveyor. This can also be via manually-operated snow horns, or similar devices. Similar applications exist in red meat and pork operations.

CO₂ liquid for cryogenic freezing and pre or post-cooling applications to enhance the refrigeration value of a food product is a significant, and perhaps dominant, application for CO₂ in some markets; where CO₂ is dominant compared to liquid nitrogen (LIN).

MAP gases would be intended to remove the oxygen content, and replace this with CO₂ alone, or a mixture of CO₂ and inert gases, such as argon or nitrogen. The modified gas atmosphere is used to extend the shelf life and appearance of many packaged food products. In this case, CO₂ is stored in microbulk tanks or large low pressure liquid vessels, and often vaporized, when stored as a liquid.

In fact, CO₂ gas is also a choice agent for pneumatic systems, since a dry CO₂ is often of choice, rather than air which holds moisture and leads to rusty systems. CO₂ snow has commonly been a significant factor in niche markets, such as the frozen French fry market, where snow in rail car bunkers would steadily sublime as the rail cars travel to their destinations; and CO₂ snow has been used in trailers hauled over the road, to help preserve the meat or food product.

In all these applications, the refrigeration content found when dry ice or snow sublimates, or liquid is flashed into a gas and snow, represents a significant factor in the requirement for small-to-large scale commercial refrigeration jobs throughout the world.

In the developed economies, usually there is a broad range of applications for CO₂ ranging from food and beverage to industrial of all sorts; and in the developing economies most of the CO₂ sold happens to be directed to soft drinks alone.

As the economies develop further, and as electric power plants are built and automation progresses, new food plants are built and existing food operations evolve to include cryogenic freezing and other CO₂- based applications. In developed economies, it is common to find perhaps 30-40% of all merchant usage to be food related.

No doubt, the applications for CO₂ are somewhat unique in each food plant, and custom-engineered to fit each plant and refrigeration job – and specific to the BTU removal demands of each food type. From peas to beef, the water content, freezing point, specific heat and latent heat vary.

Therefore, the values are calculated to understand the CO₂ and BTU requirements for each job, as well as the residence time required, should this be for applications in a cryogenic freezer – from multiple pass, to single pass, to a spiral configuration. For the very small cryogenic freezing jobs, batch freezers serve well.

Cryogenic freezing

Cryogenic food freezing processes, techniques and equipment types have been developed and implemented to provide rapid freezing, a reduction of moisture loss for the food product, and a improved yield and appearance for economic viability.

Quite simply, many meat products have an improved 'bloom' when using cryogenic freezing methods rather than mechanical means.

When using this method there is less damage to the cellular walls in the meat's composition, less water and fluid loss, increased weight sold to the consumer, and thus better profit margins for the processor. In this scenario, everyone wins.

With respect to cryogenic freezing or chilling via CO₂, this form of refrigeration offers wide flexibility compared to mechanical refrigeration; and is perfect for anything from a large, fully-fledged freezing job in a food operation, all the way down to small batch freezing operations.

Many plants begin freezing via CO₂ in lieu of the huge mechanical refrigeration investment, meaning the capital cost with a CO₂ system is a fraction of the cost of the mechanical system. It is therefore an excellent option when funding is low or unavailable for a major capital investment.

This is particularly crucial in a poor economic environment. Further, CO₂ systems are often used to enhance or augment freezing operations in a plant, such as a pre or post-cooling CO₂ operation, in conjunction with a larger mechanical refrigeration system.

In the end, there are strong economic values – from enhanced quality of food products with cryogenic methods rather than mechanical, to a more affordable capital investment than the expensive mechanical refrigeration option.

CO₂ snow and dry ice

The application of CO₂ snow and dry ice is very similar, in terms of how it may be used. CO₂ is unique, in terms of offering three phases – the solid phase, dry ice, sublimating, and allowing the advantages of a portable refrigerant and the ability to create an anaerobic environment, perfect for the control of select aerobic bacteria.

As for CO₂ snow, this being similar to rice dry ice, and pellets; the snow would be more of a longer-term application via a permanently installed liquid system delivered via pipeline, then flashed into the snow state.

Along with the snow generated when delivered in a liquid state, would be CO₂ gases which, if large enough in quantity, conceivably could be recovered, condensed and liquefied – and therefore return liquid to the system.

Commonly, modern dry ice production plants use CO₂ vapour recovery plants, which in many ways are similar to the larger liquefaction plant in a commercial CO₂ operation, but much smaller.

The gas companies generally do not evaluate this option in a large commercial food freezing operation, since, in short, it represents an ultimate reduction in liquid sales and should recovery take place, less CO₂ volume would be sold to the customer. This challenge to produce a viable recovery system in a food plant is not easy, and the long-term investment can often exceed the potential gain.

Otherwise, some customers have explored this option and in the end, it may be for the gas company to work with the customer to explore such conservation of the commodity rather than losing the account entirely to mechanical refrigeration or other options.

CO₂ solids in the form of snow produced or dry ice pressed represent a unique cooling solution which have the strong double advantage over other forms of refrigeration, that being an anaerobic agent to control bacteria; plus the portability factor – so these ingredients present a unique solution available for the food processor.

CO₂ gas

CO₂ gas applications in the food processing plant have generally strong niches for MAP – often CO₂ is used alone or mixed with inert atmospheric gases such as argon or nitrogen. The goal, essentially, is to increase the shelf life of packaged food products, and improve the appearance; thus gain economically.

The physical application of CO₂ is often intended to reduce the oxygen content from near 20% to near 0% and therefore create an anaerobic atmosphere. Another small and occasional application for CO₂, much smaller than MAP, would be to charge and operate pneumatic systems in a plant, thereby reducing humidity in the system and giving it a longer life with less maintenance.

The application for CO₂ gas use is often from microbulk tanks, or from large bulk storage; the gas is drawn off the top of the vessel where the gaseous state exists, or is vaporised, from the liquid phase.

Of course if we think of CO₂ usage in the beverage industry, in the developed economies, about 30% of many markets represent soft drink, brewery, and champagne carbonation. Many of the breweries use merchant CO₂ only for the supplement of their own CO₂ produced from fermentation; and the product is sometimes used to back-pressure a system.

CO₂ in the mind of many consumers tends to evoke thoughts of CO₂ as a gas that we find in the air. However, when considering the applications in the food industry, for example, many goals are achieved via liquid and dry ice forms of this most versatile product.

About the author

Sam A. Rushing is President of Advanced Cryogenics, Ltd, a chemist, and a global consultant to all sectors of the CO₂ industry, as well as cryogenic gases. If you have a CO₂-related or cryogenic project, and need expertise, please call upon the company. Advanced Cryogenics also supplies a full menu of CO₂ and cryogenic equipment, new and used.

+001 305 825 2597, rushing@terranova.net www.carbondioxideconsultants.com