Food future: improving sustainability in the food and beverage industry

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AIR PRODUCTS

Executive Summary

Since launching our Freshline® Food Solutions range over 30 years ago, Air Products has transformed the way retailers and customers receive and consume packaged foods across the world.

The Freshline® range of products was conceived to create sustainable solutions for the food and beverage industry while ensuring the highest quality of product. Modified Atmosphere Packaging (MAP) for example has increased the shelf life of foods, improved taste and texture, and played a vital role in supporting global food supply chains.

However, one significant aspect of this line of products is yet to be fully understood: its significant impact on sustainability. The food and beverage sector makes up about a third of total anthropogenic emissions.[1] With a 70% increase in food production expected by 2050, implementing sustainable solutions across the industry is now a priority for all stakeholders.[2]

This White Paper demonstrates how our Freshline® range has used innovation in cryogenic freezing, MAP, and beverage bottling technologies to lower food waste, reduce the use of plastics, and avoid emissions from transport, storage and production.

In showcasing how this technology has made an impact, we intend to demonstrate how Air Products is working with food and beverage manufacturers to ensure they can meet sustainability targets, while remaining competitive and providing the best possible product for their customers.

[1] Carbon 4 Finance, Report on the food and beverage sector, 2020

[2] State of Green, The food and beverage industry, December 2020

Industry concerns and issues

Uptake of innovation has been difficult for the food and beverage industry over the past few years. Recent global events have created a host of problems such as the rising cost of raw materials and instability in supply chains. Scaling up new technology has therefore been a challenge.

Despite these challenges, the sector has emerged in good financial shape. Fifty-five percent of business leaders surveyed reported increased investment in environmental sustainability processes and procedures, driven by a growing awareness that the industry is responsible for a sizable amount of anthropogenic emissions.[3]

Around 21% of emissions generated by the food industry relate to energy used in transport, packaging and processing.[4] Innovations in food packaging and freezing have been identified as one of the ways to reduce the carbon impact of food production and transportation. Reducing package weight or bulk can translate into savings in raw materials, landfill impacts, as well as energy related to transport and storage.[5]

Air Products' Freshline® range aims to move beyond meeting productivity targets to actively working to change how the industry sees its role in protecting our planet. This comes amid growing expectations among stakeholders for companies to better understand and improve their sustainability performance.

There is a growing network of non-governmental organizations (NGOs) and academics working with businesses to carry out third party research to ensure that sustainability initiatives are part of a coherent and robust strategy to tackle emissions and reduce waste.

The research presented in this paper is part of that need for companies to present evidence-backed solutions. The aim is twofold. Firstly, to reiterate trust in both customers and stakeholders after recent events to ensure that the food and beverage industry is working towards its sustainability goals. Secondly, to help the industry work together to share best practices and take seriously its vital role in protecting our planet.

[3] Forbes, Environmental Sustainability Is Serious Business For The Food And Beverage Industry, October 2021

[4] Carbon 4 Finance, Report on the food and beverage sector, 2020

[5] CleanMetrics Corporation, Food transportation issues and reducing carbon footprint, 2012

The impact of Air Products' technologies on the food and beverage industry: Concerns and issues

The global frozen food market size was worth $177 billion in 2021. As the popularity of shelf-stable food among consumers, restaurants, hotels and resorts grows, the frozen food market is expected to increase by 5.2% per year until 2030.[6] There are also similar trends in the global canning industry (predicted 4.8% compound annual growth rate (CAGR) between 2022 and 2032)[7] and the global beverage packaging market (predicted 4.8% CAGR growth in the period from 2022 to 2028).[8]

With this significant increase in demand expected, manufacturers upgrading or extending their freezing, chilling, and packaging lines can choose from a number of different technologies offering various benefits. Managers need to evaluate these technologies based on the product and application, including its impact on product quality and throughput; factory management; and financial considerations such as capital outlay, operating costs, and labor. Significantly, environmental factors are now becoming an important consideration and changes in processes are reflecting this.

Beverage and water bottling

Carbon dioxide and nitrogen are increasingly used for inert purging, bubble breaking and container pressurization in beverage and water bottling. These applications can extend the shelf life of products such as juices or smoothies, ensure a safe, inert environment prior to filling or sealing, or avoid undesired spillage when packaging carbonated drinks.

When bottling non-carbonated beverages, for example, dosing with nitrogen provides the right pressure to enable the use of thinner bottles while still maintaining rigidity needed for stacking and transportation. Liquid nitrogen is also inert and provides protection against product spoiling and waste. Carbon emissions are avoided through the use of thinner bottles with lower PET (polyethylene terephthalate) polymers.

Food freezing

While food manufacturing accounts for only 10% of energy related emissions in the food chain – according to estimates by the Food and Drink Federation and the Carbon Trust – around 60% of these emissions are linked to refrigeration and freezing by large frozen food manufacturers.[9]

Traditional mechanical freezers use a recirculating refrigerant with an air cooler that exchanges heat from the air circulating within the freezer to reduce the temperature of the food. Although food freezing using liquid nitrogen (LIN) requires more energy when the production of the refrigerant is taken into consideration, this method of freezing reduces food losses. The carbon embodied in this waste is greater than the additional energy required for cryogenic freezing.

Importantly, because cryogenic freezing rates are faster, it results in lower levels of product dehydration, which means higher quality, optimized product yields, and therefore less waste.[10] Cryogenic freezing also allows greater flexibility in response to changing demand through simple changes to flow rates and fluid temperatures.

Modified Atmosphere Packaging

Modified Atmosphere Packaging (MAP) is a safe method of extending the shelf life and improving the quality of food products, using a specific single gas or mixture of gases to create a protective atmosphere around the food. It replaces conventional air packaging with the protective atmosphere. With appropriate packaging material and often lower temperatures, MAP preserves the taste, safety, and appearance of food for longer, extending the shelf life and, in turn, reducing food waste and avoiding embodied carbon emissions.

[6] Grand View Research, Frozen Food Market Size, Share & Trends Analysis Report By Product (Fruits & Vegetables, Potatoes, Ready Meals), By Distribution Channel (Offline, Online), By Region, And Segment Forecasts, 2022 – 2030

[7] Future Market Insights, Canned Food Packaging Market Size, Share & Trends – 2032, August 2022

[8] Vantage Market Research, Beverage Packaging Market Size, Share & COVID-19 Impact Analysis, by Packaging Type (Bottle, Can, Carton, Pouch, and Others), Material Type (Metal, Plastic, Glass, Paper & paperboard, and Others), and Application (Alcoholic Beverages, Non-alcoholic Beverages, and Dairy Beverages) by Region (North America, Europe, Asia Pacific, Latin America and Middle East & Africa) - Global Industry Assessment (2016 - 2021) & Forecast (2022 - 2028), April 2022

[9] Cold feat: choosing the right freezing technology for your production line, Dr Chris Kennedy, 2009.

[10] Novel cryogenic technologies for the freezing of food products, Silvia Estrada-Flores Ph.D., The Official Journal of Airah, July 2002

Study methods and results

As part of the development of Air Products' wider corporate sustainability initiatives, our researchers examined three examples where foodgases technology has led to reduced carbon emissions. The team looked at data and insights from existing academic papers, as well as studies conducted with research partners, and experiments undertaken in laboratory conditions by Air Products' Advanced Technology teams.

The following section summarizes the findings of those three examples.

Juice bottling

A review of a study published in the Journal of Food Engineering[11] assessed the environmental performance of hot filling systems and aseptic systems to fill high acid beverages (pH 4.6 and below) such as fruit juices and purees, calculating the environmental impact using the Life Cycle Assessment (LCA) methodology.

The study concluded that aseptic packaging systems, which use nitrogen to create a sterile atmosphere during juice packaging, have a lower environmental impact than hot filling systems. Reduced carbon emissions are achieved through the use of lower weight PET bottles (hot filling systems require a thicker bottle that can withstand the higher temperatures needed), and a lower energy requirement.

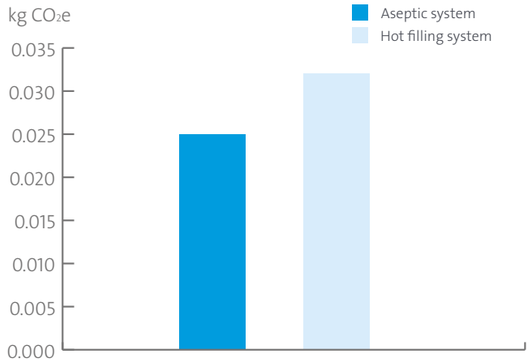
The study found that to produce half a liter of juice requires 0.0028 Nm^3 of nitrogen (0.003 kg). This equates to a carbon dioxide equivalent of 0.025 kg compared with 0.032 kg CO_2e required for a hot filling system (Fig.1). Avoided emissions from an aseptic system are therefore 0.006kg CO_2e for every 0.5 liter of juice unit.

Source: Calculations based on Manfredi, et al, Journal of Food Engineering, February 2015

Fig.1 Carbon intensity of an aseptic versus hot filling system (kg CO_2e/0.5 liter of juice)

Aseptic system	0.025 kg
Hot filling system	0.032 kg

Source: Manfredi, et al, Journal of Food Engineering, February 2015



Food freezing (burgers)

Various studies have assessed the impact of meat production and plant-based protein products across their life cycles (using LCA methodology), including the cumulative energy demand, water and land use.[12]

Our researchers reviewed published data on these environmental impacts, comparing the use of liquid nitrogen food freezing systems versus traditional mechanical freezing in one of the most common frozen meat products - burgers - making informed assumptions on the volume of food waste from each process.

Based on this data, we carried out an LCA and concluded that in the case of burgers, while the carbon footprint of cryogenic freezing is greater than mechanical freezing (0.381 kg CO_2e/kg burger frozen versus 0.025 kg), the impact of food waste resulting from dehydration is three times greater for other technologies compared with cryogenic freezing (0.979 kg CO_2e/kg, versus 0.326 kg CO_2e) (Fig.2). The equivalent of 3% of the total product is wasted with other technologies versus 1% with cryogenic freezing.

Furthermore, as mechanical freezing equipment uses refrigerant gases in the cooling coil, the freezers must always be powered on and therefore consuming electricity. On the other hand, cryogenic freezing can be deployed when required, and has a lower energy requirement, with liquid nitrogen the main source of consumption.

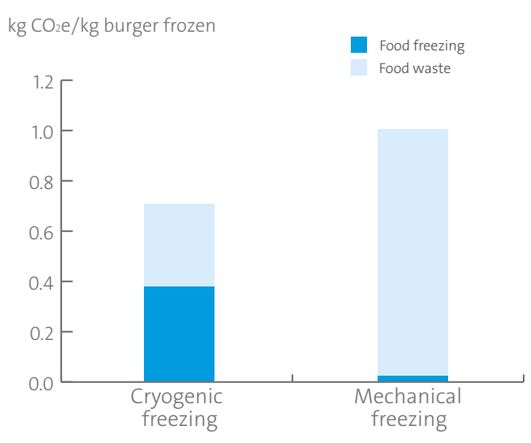
In the case of burgers, cryogenic freezing therefore avoids 0.297 kg CO_2e/kg burger frozen compared with mechanical freezing.

Fig.2: Carbon intensity of cryogenic versus mechanical freezing (kg CO_2e/kg burger frozen)

Emissions (kg CO_2e/kg burger)	Cryogenic freezing	Mechanical freezing
Food freezing*	0.381	0.025
Food waste**	0.326	0.979
Total	**0.707**	**1.004**

* 1.158 kg N_2/kg burger (Air Products data)

** Food wastage of 1% for cryogenic freezing and 3% for mechanical freezing



Modified Atmosphere Packaging in various products

Using MAP techniques, the shelf life of fresh food products can be safely extended by between 50% and 500%, depending on the product. This enables retail customers to manage their food purchases better and reduce food waste.

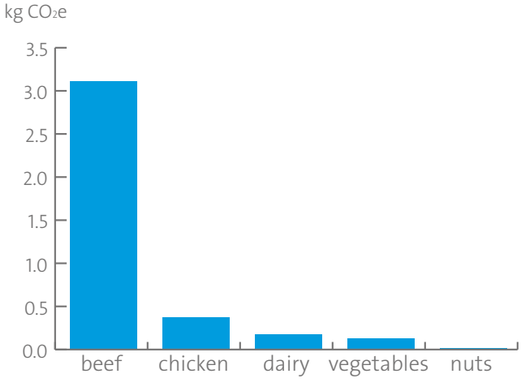
Air Products collaborates closely with leading research centers, including the Institute of Agrifood Research and Technology (IRTA), the research institute owned by the Government of Catalonia, and Campden BRI, the largest membership-based food and drink research center in Europe. Working with these partners and conducting tests at our own laboratory facilities has led to the development of the Food Packaging Calculator, which enables carbon footprints and waste to be calculated according to different food and packaging types.

Using the calculator, our studies found that avoided emissions range from 3.11 kg CO_2e/kg for beef to 0.018 kg CO_2e/kg for nuts (Fig.3).

Fig.3 Avoided emissions using MAP techniques by food type (kg CO_2e/kg packaged)

Beef	3.114 kg CO_2e/kg packaged
Chicken	0.375 kg CO_2e/kg packaged
Dairy	0.172 kg CO_2e/kg packaged
Vegetables	0.127 kg CO_2e/kg packaged
Nuts	0.0178 kg CO_2e/kg packaged

NB The production of MAP gases does not have a significant impact compared to food waste savings (<1% of savings). The impact of food packaging is also insignificant in comparison to the savings from avoided food waste.



Source: Air Products Food Packaging Calculator

[11] Comparative Life Cycle Assessment of hot filling and aseptic packaging systems used for beverages, Manfredi, et al, Journal of Food Engineering, February 2015

[12] Comparative Life Cycle Assessment of freezing technologies, Blejman et al, May 2013 (Air Products internal LCA)

The value of the research to the industry

According to the UN Food and Agriculture Organization, one-third of food produced for human consumption is wasted, with consumer studies showing that the general public is becoming increasingly concerned about the issue. Food waste and wasteful packaging were cited as leading environmental issues by half of the global respondents in Tetra Pak's latest annual consumer index for example, with consumers calling on manufacturers to limit the amount of waste being generated.[13]

Alongside the clear environmental benefits, there are also financial and reputational rewards to be gained from managing food preparation and waste. By publishing this data, we hope to provide the food and beverage industry with insights to support sustainability reporting and guide future decision making around the most appropriate freezing and packaging technologies to optimize quality and reduce environmental impact.

[13] Tetra Pak Index 2021

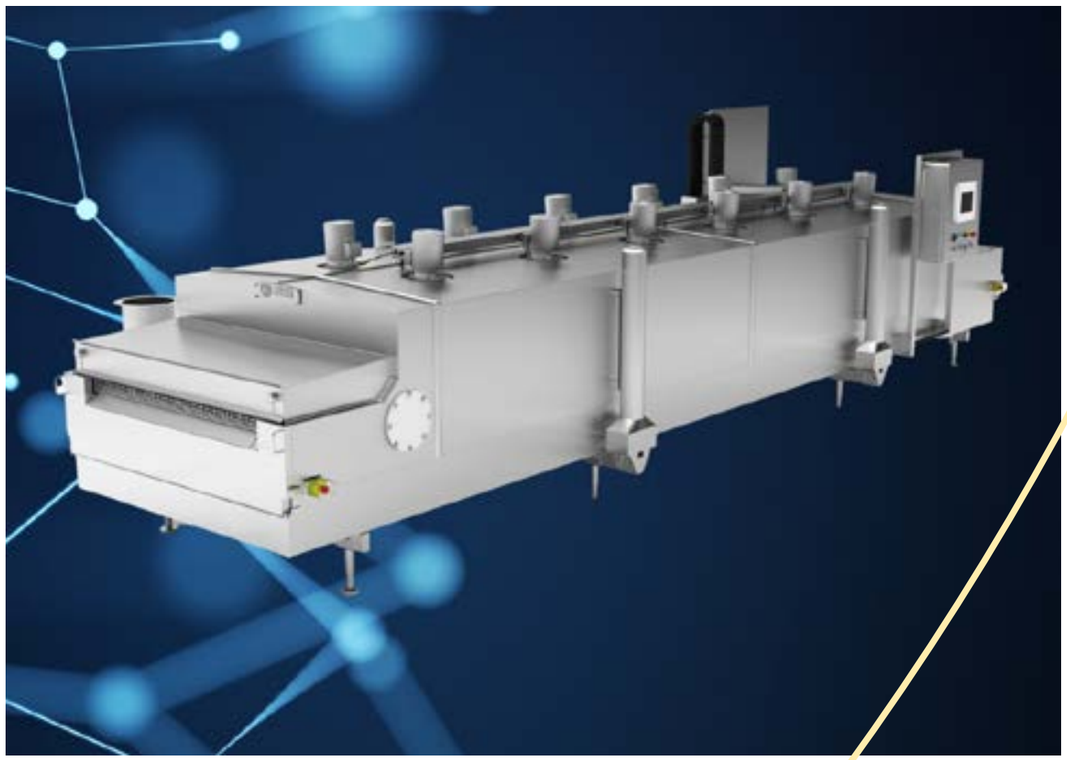
The future of food and beverage freezing and packaging technologies

As the food and beverage industry seeks to continually improve its production processes, increase efficiency and reduce its impact on the environment from packaging and waste, new technology is emerging to support production managers.

Smart cryogenic freezing for example uses wireless sensors, artificial intelligence, and cloud technology to continually monitor process parameters taking data from the production system and the liquid nitrogen tank, suggest improvements, and improve efficiency, ensuring every drop of liquid nitrogen is used effectively.

Through innovations such as these, Air Products is working to ensure sustainability can be compatible with growing future demand across the food and beverage industry.

For more information see our Freshline® Smart Technology.



About the author

Ann Callens is Food Segment Manager at Air Products in Europe. She is responsible for developing and managing the company's application strategy for customers in the food, biochemical and water industry, leading the company's sustainable and digital developments for these sectors. She has a Master of Science in Bioscience Engineering from the University of Ghent, degrees in finance and management from the University of Leuven, and a Master of Arts in Philosophy and Moral Sciences from the University of Brussels.

For more information on how Air Products' broader technologies help reduce the environmental impact and improve the sustainability of our customers' processes, see our latest Sustainability Report.

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For more information about Air Products or freezing technologies

The Air Products Food Packaging Calculator is a helpful tool that helps you calculate the carbon footprint and potential savings for your food packaging choice and product, taking into account both plastic and food waste.

To discuss the best freezing technology for your production facility, or for a free review of your current freezing process, please arrange an appointment with one of Air Products' specialists.

For more information, please email your local Air Products contact or visit our sustainability page.

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