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Focus on Food

Refrigeration and food security

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Nature is wonderful: it provides us with the food and raw materials we need to eat and to live. But nature is impish: it yields an irregular production, depending on the season and the climate. In the past, abundance of food alternated with periods of scarcity. Thus, humans have always tried to preserve their food to ensure one of their vital needs: a regular supply of food.

Very early in history, our ancestors noticed that the cold made it possible to slow down the decaying of food products and to keep them as close as possible to their original state. Thus, from prehistory until the beginning of the 20th century, the natural cold, in the form of ice, was used to preserve some foods, especially animal products (meat, fish and dairy).

The first refrigeration machines were developed around 1830-1850. Very quickly, the industrial developments were based on vapour compression cycles using the change of phase of a refrigerant. Making use of these cycles has indeed proved to be the most efficient technique, providing temperatures required for food preservation. The refrigerants used at that time (diethylether, ethyl chloride, sulphur dioxide, among others) were produced by industry using basic chemistry. Those refrigerants were more or less efficient for the production of cold, but they were quite difficult to handle because of their toxicity and/or flammability.

The discovery of refrigerants belonging to the family of halogenated hydrocarbons in 1930, including chlorinated hydrocarbons (CFC, HCFC), enabled a tremendous development of artificial refrigeration. Indeed, these new refrigerants had the advantage of being non-toxic, non-flammable and very efficient from a thermodynamic point of view. These properties allowed the development of refrigeration in industry, transport, and retail as well as in domestic applications, with the onset of household refrigerators in 1932.

Since then, the benefits of refrigeration have continued to be confirmed. It is acknowledged that refrigeration contributes significantly to the diversification of our food intake, to the reduction of food losses and to the improvement of the quality and safety of the food we eat. Thus refrigeration definitely has a significant impact on our quality of life and on our living conditions, as shown by the extension of shelf life observed in recent decades.

Refrigeration and its applications in food preservation and conservation has played and will continue to play a major role in our societies. Refrigeration has to reconcile the three aspects defining the concept of sustainable development:

- The economic development pillar: the refrigeration industry supports more than 2 million jobs worldwide. Refrigeration is also essential for the development of many craft and industrial activities that are directly or indirectly related to the food chain.

- The social pillar: refrigeration contributes to a significant reduction in food losses, thus enabling healthy and diverse food products to be supplied to growing populations in crowded cities and rural areas.

- The environmental pillar: the refrigeration industry has the potential to have a negligible effect on climate change through the manufacture of low global warming and alternative technologies.

This last point is probably the major challenge that will impact the future of refrigeration as we know it today, but which can be achieved through technology development and technologies for managing current refrigerants, supported by the 2016 Kigali Amendment to the Montreal Protocol. Indeed, the refrigeration technologies and the refrigerants developed since the 1930s have had a significant impact on our environment:

- Chlorinated fluids (CFCs, HCFCs) are recognized as having a detrimental effect on the stratospheric ozone layer, and as such are prohibited from production and use by the Montreal Protocol. Thus, after the elimination of CFCs in 1998, the further production of the very effective refrigerant, HCFC-22, which is currently used in over 60% of industrial plants, has been prohibited in Europe since the end of 2014.

- The fluorinated fluids (HFCs) used to replace CFCs and HCFCs have a high global warming potential and as such, are part of the list of greenhouse gases controlled by the Kyoto Protocol. The newly ratified Kigali Amendment to the Montreal Protocol will oversee the phase-down of the HFCs as of 2019.

But the energy consumption of refrigerating equipment working with these fluids is higher than those obtained with other refrigerants, and except with ammonia, hycdrocarbons and possibly carbon dioxide. Unfortunately, the generalization of the use of these "natural" refrigerants cannot be proposed yet, due to their toxicity and/or flammability (or to their poor energy performances for carbon dioxyde in hot countries).

But even if the food cold chain has a non-negligible environmental impact it has to be developed. Indeed, it avoids food losses by extending the shelf life of food products, and permits safe and healthy food to the world's population. Therefore, refrigeration is indispensable for present and future food supply.

Refrigeration and food preservation

Refrigeration lowers the temperature of food to a temperature above its freezing point, making it possible to increase shelf life

- **For products of plant origin (fruits, vegetables), which are living products with their own metabolic reactions (e.g., respiration, oxidation), refrigeration slows down the metabolism. Consequently, the depletion of the reserves of nutrients contained in the plant tissues is reduced, thus increasing the practical duration of conservation. Combined with other techniques (controlled atmosphere, for example), shelf life can reach to a few weeks, and up to a few months, depending on the type of product.**
- **For products of animal origin (meat and meat products, fish), where the metabolic activity is stopped after slaughter, as well as for prepared or processed food, refrigeration slows the growth and multiplication of pathogenic germs that may be present in the product. Thus, these products can remain safe and edible during some weeks.**

For frozen food, the low temperature, combined with the immobilization of water as ice, drastically slows the decaying of the products and stops (except for some micro-organisms) biological activity of the product. Practical storage times can sometimes reach a few years.

Refrigeration (or freezing) does not sanitize the food product : it keeps the product close to its original state. Thus, it is necessary to apply a fast and early refrigeration for a reliable and safe product, with minimal delays in the cold chain in order to guarantee optimal preservation of food products.

For more information:
Cold Chain Technology Brief: Refrigeration in food production and processing.
http://www.unep.fr/ozonaction/information/mmc/lib_detail.asp?r=5873

Sustainable refrigeration for food and nutrition security in an increasingly urban world

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According to UN Statistics, in 2016 an estimated 54.5% of the world's population lived in urban settlements. By 2030, urban areas are projected to house 60% of people globally and one in every three people will live in cities with at least half a million inhabitants[1]. Rural-to-urban migration is a key driver of this increasing urbanisation, accounting for about 25% of urban population growth,[2] which means that there are less people in rural areas to produce food and that the majority of food is consumed in urban areas. Despite the benefits of urban food production, which is being promoted across the world with varying degrees of success, the majority of food will continue to be produced in rural areas and supply chains have to adapt to accommodate these new realities. As an increase in urbanisation is at its most extreme in the developing and emerging economies, the development of infrastructure will have to be accelerated to meet the need for more efficient food supply chains.

Refrigeration – in particular, the food cold chain, is a key element of food supply chains and critical to ensuring food and nutrition security. Today's world actually produces enough food to feed all 7.2 billion human beings, yet the poor availability, preservation and access to this food means that food systems are failing to fulfil nutritional and environmental needs. There are profound imbalances in availability, consumption and diets, as seen by over 800 million people being hungry, two billion malnourished who lack the essential micronutrients needed to lead healthy lives, and more than 1.4 billion adults being overweight/obese.

The UN's Food and Agriculture Organisation (FAO) estimates that to satisfy the demand of a growing and richer population – who seek more meat in their diet – by 2050, food production will have to increase by at least 60% in the next few decades. However, this figure can be reduced by improving production efficiency, changing dietary trends and decreasing food losses and waste. Cold chains can play a significant role in this last process.

In developing regions such as sub-Saharan Africa, Asia and parts of Latin America, there is a high level of food loss (i.e., food that becomes unfit for human consumption due to spoilage). Fresh produce, such as dairy, fruits, vegetables, meat and fish can spoil easily – sometimes more than half the produce can go to waste. With the increased demand for resource intensively produced and resource-inefficient foods, such as livestock products, it is imperative that of the food that is harvested, as much as possible is consumed. This resource loss is even more important considering resource scarcity in these regions that are on the frontline when it comes to climate change and extreme weather events.

Studies show that increased cold storage facilities in developing countries can reduce about a quarter of the amount of food lost if levels of refrigeration were at a similar level as in developed

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1 http://www.un.org/en/development/desa/population/publications/pdf/urbanization/the_worlds_cities_in_2016_data_booklet.pdf Accessed 22.12.17

2 http://www.citiesalliance.org/node/2195 Accessed 22.12.17

countries. One of the most important steps in ensuring that fresh produce is consumed comes just after harvest. The shorter time it takes for food to be cooled after harvest the better its shelf life and nutritional quality. This, however, presents a significant challenge given that most food is produced in rural areas where electricity provisions are basic and/or that fuel to generate electricity is scarce and/or expensive. For example, 70% of people in Sub-Saharan Africa have no access to electricity and 80% of those are located in rural areas.

Refrigeration, including the food cold chain, is a sector that is experiencing rapid technological advancements, both in terms of obtaining better energy efficiency and also in responding to policy demands such as the phase-out of ozone depleting substances under the Montreal Protocol, and the future requirement to phase down hydrofluorocarbons (HFCs) under the 2016 Kigali Amendment to the Protocol. The developments and innovations in this fast moving sector are not limited to developed countries, with technical advancements also emerging from developing countries. The question is not why there should be a cold chain, but how to ensure that there is appropriate technology and energy to sustain it. In many parts of the developing world, renewable energy sources are abundant, but cannot be easily harnessed due to lack of infrastructure or expertise. More investments are needed in these aspects, or else massive volumes of food will continue to get spoilt and lost, and issues of food safety and food security will continue to affect millions, especially in the developing world.

This represents an incredible opportunity for targeted public and private sector investment in this area to contribute to achieving food security and nutrition. And with these investments there is an opportunity to ensure that new cold chain infrastructure is evolving with ozone- and climate-friendly refrigerants.

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