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Food processes and food preservation : An old necessity with a promising future

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Ingénierie, expertise et recherche

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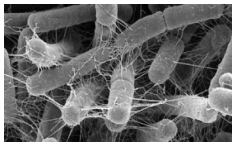
What common point ?




Live to transmit life and to perpetuate the species !

The first food preservation techniques were based on drying (reduction of water content and activity)

And as soon as man domesticated fire, he used it to preserve sensible food (smoking)
(reduction of water content and activity + chemical agents deposition)

Man had to wait the middle ages to develop new preservation techniques as salting and candying …
(reduction of water activity by addition of an adequate solute)

… or fermentation
(colonization of the food by the selected microorganisms, preventing the development of pathogens and/or spoilage germs)

… sometimes combining different basic principle

(non exhaustive list …)

Surströmming
(salting + lactic fermentation)

Pickling
(inactivation of microorganisms and enzymes with acids)

Kilishi
(coating with spices and drying)

Pemmican
(smoking + spicing + drying)

1795 : the revolution of canned food

N. Appert, 1749 - 1841

Sterilization and thermal inactivation of enzymes responsible of the natural evolution of food components

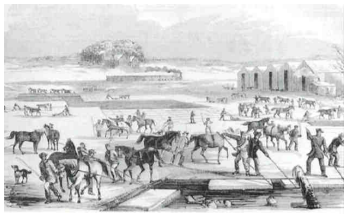
But what difference between a fresh product and a product preserved with one of these technique !






Of course, very early, cold as been identified as being an efficient way to preserve food

From the ancient ages to the mid of the XIXth
The golden age of natural ice and of ice caves



as soon as the development of science and technology permitted it, refrigeration has been used for food preservation.

From the middle of XIXth to the middle of XXth
- First industrial developments
- Artificial water ice

An exponential development during the 1930's (thanks to the discovery of CFC)

The food cold chain today …

- Domestic refrigeration
  - Over 1 billion household appliances
- Food distribution
  - 350 000 supermarkets
  - 20 000 supermarkets
  - 33 millions of refrigerated display cabinets
  - Probably over 2 million traditional trade offices and over 6 million catering establishments.
- Storage
  - Over 300 million m^3 of controlled temperature warehouses
- Transport
  - 1,2 millions controlled temperature vehicles
  - 550 thousand refrigerated sea freight container
  - 80 thousand refrigerated rail cars
  - 900 refeers

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And refrigeration applied to food is also …

- Freezing (of course !)
- Texturation and process
  Butter, fat, chocolate, cheese, milk-based desserts, ice creams, , …
- Cryoconcentration – cryoseparation
  Fruit juices, grape must, tartric acid (white wines, Champaign)
- Fermentation control
  Wine, beer, Champaign
- Lyophilisation
  Baby food, coffee, prepared meat, powders, …

Can we imagine a today's and tomorrow's food supply without refrigeration ?

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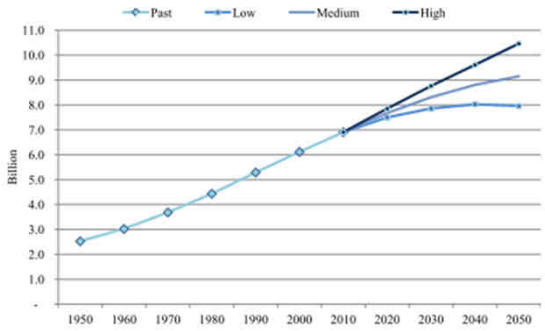
1- Food need will increase with the increase of world population

Figure 2.3 World population: 1950-2010 and projections (three variants)



Source: UN (2009).

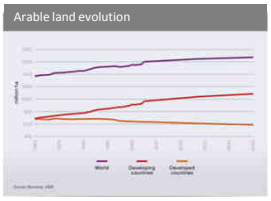
FAO, Global agriculture towards 2050

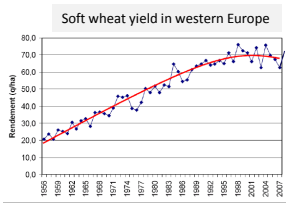
+ 79 million oh inhabitants / year
probable stabilization around 10 billion persons in 2100

1bis - Concentration of population in megalopolis will increase food transportation needs and retail needs

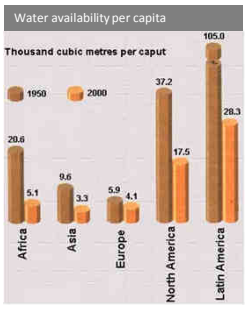
Today : 54% of the world population lives in urban areas
in 2050 : 66%
in 2100 : ?

2- Even if the world food production should have a growing capacity, food waste and spoilage has to be reduced (sustainabilty)





FAO



=> Refrigeration has a major role, especially for animal products and fruit and vegetables (but a limited interest for grains that remains the mankind's basic food source)

3- The need of food refrigeration will depend on what we will eat tomorrow

Some old demons …

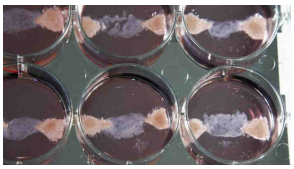
"Fast oysters"

No one believe in it anymore …

"Instant asparagus"

3- The need of food refrigeration will depend on what we will eat tomorrow

But what will be the future ?



3- The need of food refrigeration will depend on what we will eat tomorrow

But what will be the future ?

The tentative of “culinary constructivism” being (at the moment) unable to provide mass feeding

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Taste are in constant evolution

We could not eat the delights of our ancestors, and our faraway descendants will probably be disgusted by what we eat today.

Necessity knows no law …

(Soylent green, R. Fleisher, 1973)

But man is so programed that it is difficult to imagine a rupture in its food needs, habits and desires…

=> For the forthcoming decades (centuries), refrigeration and its food applications still have a nice future

4- The use of refrigeration will depend on the development of new technologies

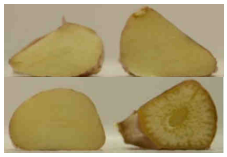
Some examples centered on food product

Superchilling (partial freezing of the product)
(SINTEF)
Applicable to fish and other meat products (pork and chicken)

Supercooling
(FRPERC)
Cooling down just below the freezing point, without ice formation

Garlic cloves

Fresh Refrigerated



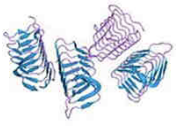
Supercooled Frozen

4- The use of refrigeration will depend on the development of new technologies

Some examples centered on food product

Ice nucleation proteins
That limits supercooling phenomena

Pseudomonas syringae Beta-helical ice nucleation protein



Antifreeze proteins
That retards the apparition an the size of ice crystals

Tenebrio molitor beta-helical antifreeze protein

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4- The use of refrigeration will depend on the development of new technologies

Some examples centered on food product

Perfusion chilling of carcasses
(FRPERC)

Dehydration – impregnation by immersion
Water removal of the product (up to 50 – 60%) and solute intake by immersion in a concentrated solution.

4- The use of refrigeration will depend on the development of new technologies

Some examples centered on food product

Controlled atmosphere

Intelligent packaging
(including encapsulated PCM)

High pressure (pascalization)

Irradiation

Pulsed light

Etc …

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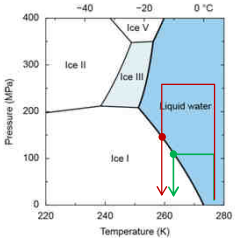
4- The use of refrigeration will depend on the development of new technologies

Some examples centered on food process

Hydrofluidisation
(Technical University of Sofia)

Dehydrofreezing
Immersion freezing / cooling
(IRSTEA, CIRAD)

Pressure shift freezing
(ONIRIS)
HP assisted freezing
HP shift freezing



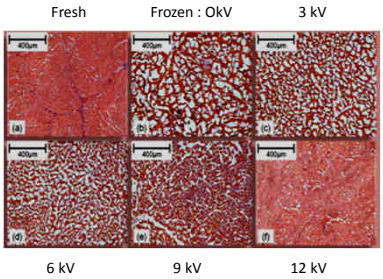
HPSF

HPAF

4- The use of refrigeration will depend on the development of new technologies

Some examples centered on food process

Freezing under electric field
Pork tenderloin



Magnetic and/or pulsed electric fields
(ONIRIS)
Action on ice crystalisation

Impingement
(20-30 m s^{-1}, especially for crusting)

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Two major questions about these (interesting) new developments :

- What will be their future (acceptability, costs, sustainability, … ?)
- Could they be used for mass feeding of worldwide population ?

See conclusion of short course

3rd IIR International Conference on Sustainability and the Cold Chain

frisbee

An exemplary research project : the frisbee EU project

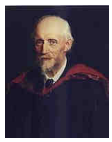
http://www.frisbee-project.eu/fr/deliverables.html

Refrigeration and food preservation modelling : what is new ?

Basics remains he same

For heat and mass transfer modelling …

Jean Baptiste Joseph Fourier
(1768 – 1830)



Osborne Reynolds
(1842 – 1912)

Ludwig Prandtl
(1875 – 1953)

Ernst Kraft Wilhem Nusselt
(1882 – 1957)

Jean-Baptiste Biot
(1774-1862)

Svante August Arrhenius
(1859- 1927)

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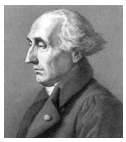
Refrigeration and food preservation modelling : what is new ?

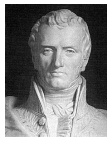
Basics remains he same …

… and for calculation algorithms principles

Jakob Emmanuel Euler
(1707 – 1783)



Joseph Louis Lagrange
(1736 – 1813)



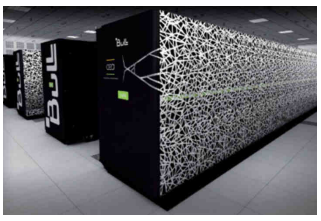
Louis Marie Henri Navier
(1785- 1836)

Sir George Gabriel Stokes
(1819-1903)

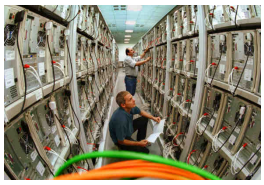
Ludwig Eduard Boltzmann
(1844-1906)

Refrigeration and food preservation modelling : what is new ?

Computing made tremendous progress



Teratec, CEA



=> The prediction of food properties and food evolution became more and more accurate and reliable

Refrigeration and food preservation modelling : what is new ?

To face the complexity and the computational time required, a present trend is to "reduce" the complexity of the model in order to use them in process management, design and control.
(input parameters of the model being calibrated with experimental data and/or outputs of complex modeling)

Typical examples :
(non exhaustive list)

Simplified modelling :
- Similarity Thermic – electric, for flows
- Basic first order differential equation with delay time for temperature profiles
- Arrhenius-like equation for coupling temperature and quality evolution
- Cardinal modeling for microbial growth and destruction

Exploitation of simplified models :
- Optimization based on quadratic functions
- Monte-Carlo simulation
- Genetic algorithms

Refrigeration and food preservation modelling : what is new ?

A typical example

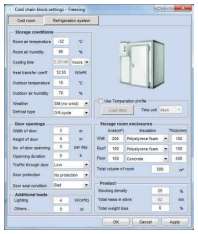
frisbee

Frisbee QEEAT tool

Quality, Energy and Environmental Assessment Tool

Coupling cold chain modeling with food quality evolution (incl. previsional microbiology), energy use and TEWI

Downloadable on Frisbee website



Conclusion

- Refrigeration of tomorrow will have to take into account new constraints (sustainability)
- There will probably be less refrigeration (but more targeted and reasoned)
- It will be used in addition of other preservation principles (notion of hurdle technologies)
- Refrigeration still has a nice future
- It's our and IIR challenge for the forthcoming years

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Enjoy your congress !

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