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Cryogenic Heat and Mass Transfer
CHMT 2019

Key factors of water loss during freezing

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Summary

1
Introduction

1 Introduction

- **Heat transfer in freezers: under control**
  - In a freezer, the heat transfer coefficient is linked to its freezing capacity. To reach higher freezing capacities, most of the freezers have been optimised in terms of ventilation to produce a higher and consistent heat transfer all over the surface of the freezer.
- **Mass transfer in freezers: poorly controlled**
  - In a freezer, the mass transfer is linked to the product weight loss, the water loss or dehydration. In food industry, this can cause from 1 to 6% of frozen product weight loss and the same in terms of sales. Obviously, this is a major point for this industry but also a poorly controlled point. Many users of freezers do not have a clear view of the key factors that impact dehydration during freezing.

2
Methods and Materials

2 Methods

- **What is our target?**

  –We want to better understand the mass transfer (dehydration) that occurs during freezing of food products and define what are the key influencing factors.

  –If the factors that impact the most the dehydration are identified, it is possible to reduce the food weight loss during freezing. The user knows which parameters he should adjust and in which direction.

2 Methods

- **Methods:**
  - –To define the key factors of dehydration, we decided to do practical tests.
  - –These tests consist in freezing similar and reproducible samples (Tylose).
  - –The freezing process duration was defined to achieve always the same final average temperature of -20°C.
  - –For each freezing test, only one parameter was changed and its impact on the weight loss was measured.
  - –We chose to investigate the impact of these parameters:
    - –Air temperature
    - –Air velocity
    - –Product initial temperature
    - –Product surface shape

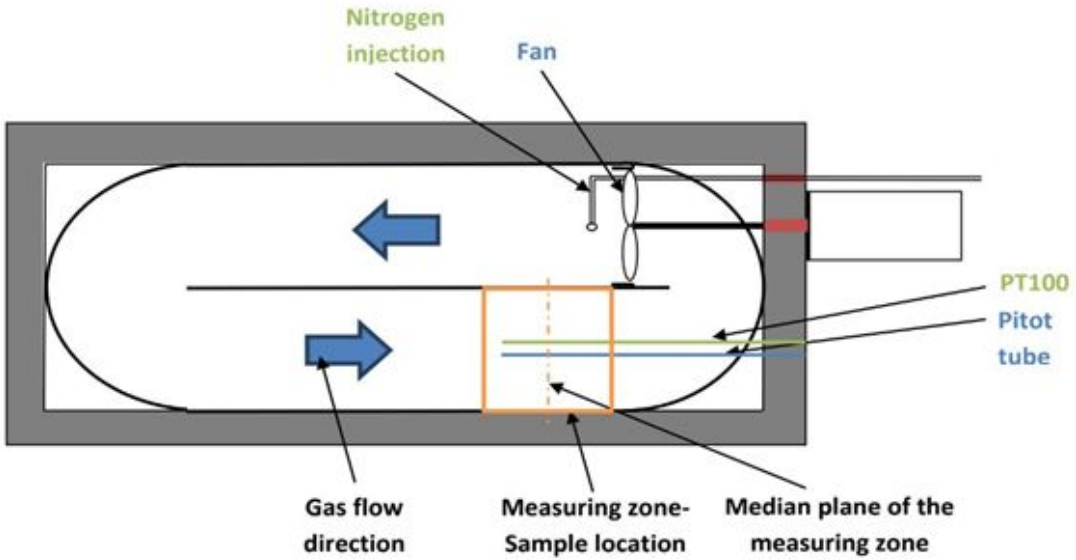
2 Materials

Picture of the lab freezer used to simulate a wide range of freezers.

Laboratory DOHMEYER freezing cabinet

2 Materials

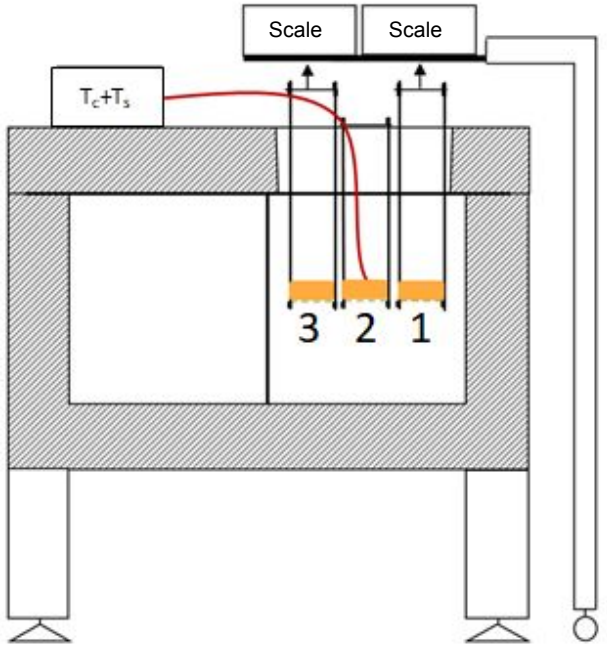
We used a lab freezer that can simulate a wide range of freezers.



Laboratory DOHMEYER freezing cabinet

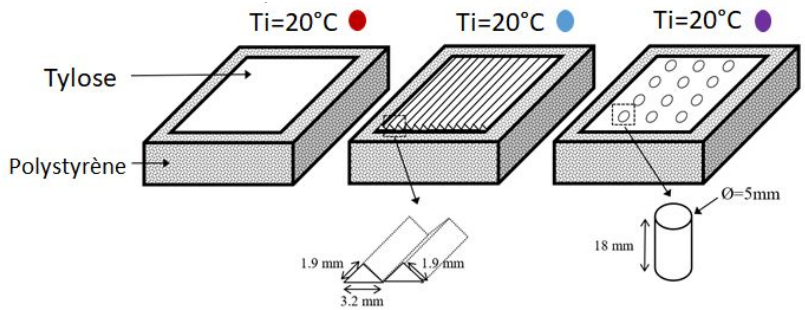
2 Materials

- **Freezer parameters.**
  - –3 samples (Tilose blocks) for each test:
    - –N°1 and 3 for weight measurement
    - –N°2 for temperature measurement
  - –Air speed:
    - –3.9 and 7.7 m/s
  - –Air temperature
    - –-30, -50 and -100°C



2 Materials

- **Tylose.**
  - –Model food material made of 76.4% water, 23% methylcellulose and 0.5% NaCl
  - –Dimensions in mm: 80(L)x45(W)x18(H)
  - –Weight: 70,7 to 73,8g
  - –1D transfer thanks to polystyren edges insulation
  - –Surface:
    - –Smooth: starting temperature: +20°C (and +5°C)
    - –Grooved: starting temperature: +20°C
    - –Perforated: starting temperature: +20°C



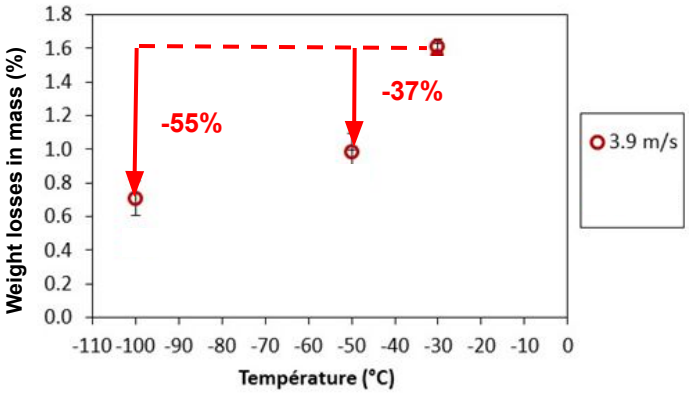
3

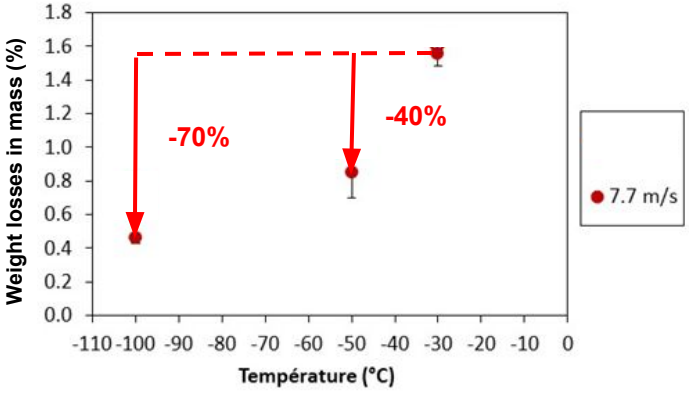
Impact of Air Temperature

3 Impact of air temperature

- **The air temperature strongly impacts dehydration**

  –For both air speeds, a freezer running at -100°C makes 55 to 70% less dehydration than a freezer running at -30°C





4

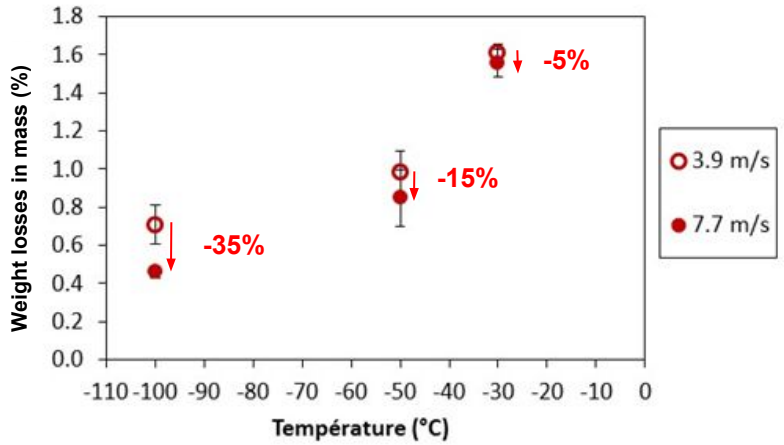
Impact of Air Velocity

4 Impact of air velocity

- **The air velocity only has an impact on dehydration at very low temperature**

  –At -30°C, doubling the air velocity has almost no impact on dehydration

  –Whereas at -100°C, doubling the air velocity makes 35% less dehydration



5

Impact of Product Initial Temperature

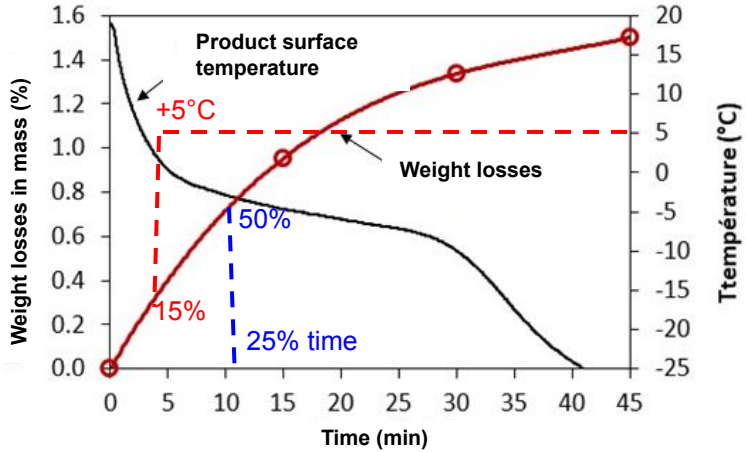
5 Impact of product initial temperature

- **The product initial temperature has an impact on dehydration**

  –Dehydration rate starts high and decreases during the freezing process

  –50% of the dehydration occurs during the first 25% of time the freezing process

  –Between +20 and +5°C, 15% of the dehydration occurs.



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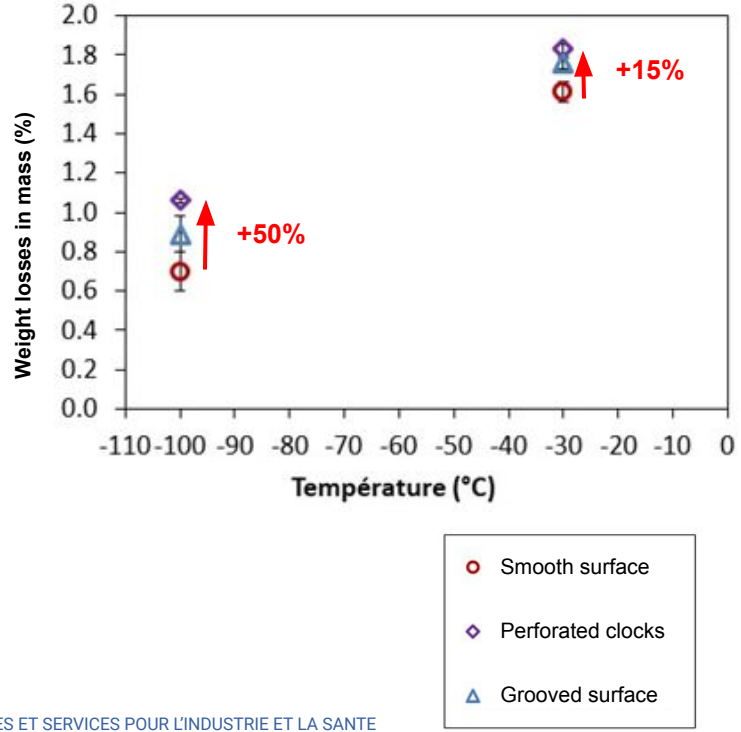
Impact of Product Surface Shape

6 Impact of product surface shape

- **The surface shape has an impact on dehydration**

  –A smooth surface keeps the water inside the food while a grooved surface or perforated shape generates more dehydration

  –The lower the temperature, the higher the impact of the surface shape: 15% more dehydration between smooth and perforated block at -30°C and 50% more at -100°C



7
Conclusion

7 CONCLUSION

- **If we want to reduce the weight loss during food freezing, the key factors are:**

  –**Running the freezer at a very low temperature**. In our tests, changing the freezer temperature from -30 to -100°C generates 55 to 70% less dehydration.

  –**The product should be as cold as possible when it enters the freezer**. In our tests, changing the initial temperature of the food from +20 to +5°C reduces the weight loss by 15% (difficult in practice).

  –**Increase the air velocity of the freezer** especially if it runs very cold. In our tests, doubling the air velocity generates 5 to 35% less dehydration.

  –Produce **food as smooth as possible**. In our tests, an uneven surface dehydrates 15 to 50% more than a smooth one (difficult in practice).

Thank you for your attention

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