3rd International Conference and Exhibition on
Food Processing & Technology
July 21-23, 2014 Las Vegas, USA

universidade de aveiro

Storage of foods under mild pressure (hyperbaric storage) at variable (uncontrolled) room temperature – a possible new preservation concept and an alternative to refrigeration

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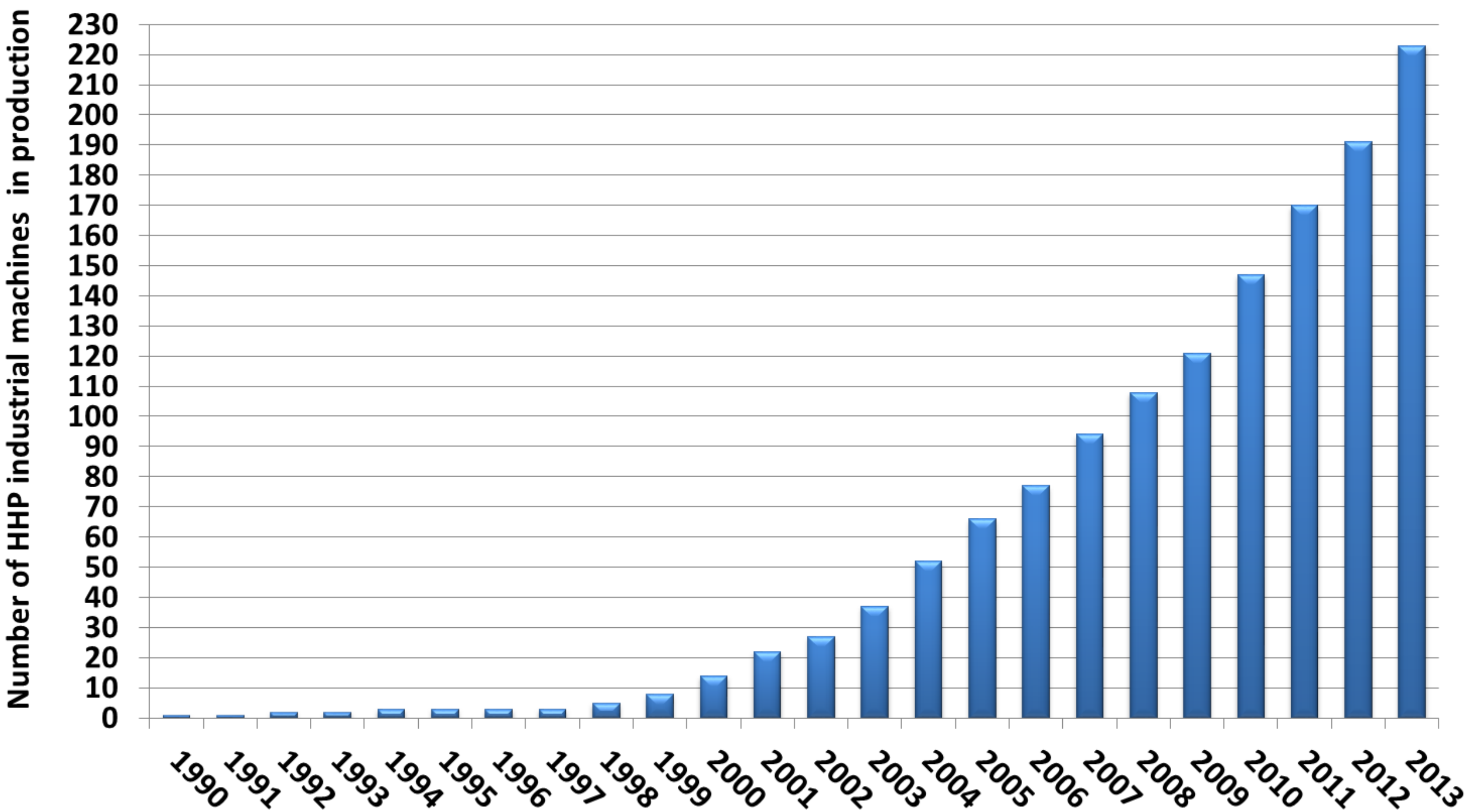
University of Aveiro

Introduction

High pressure room temperature/cold pasteurization by microbial inactivation



Introduction

First observations:

40 years ago the Sub-marine Alvin sank to a depth of ~ 1,540 m (~ 15 MPa at ~4 ^{o}C)

- ✓ When rescued 10 months later, well-preserved foods (bouillon, sandwiches and apples) were recovered
- ✓ Possible improvement of refrigeration by additional microbial growth inhibition
- ✓ Still energy consumption throughout the storage period

Introduction

What about storage under pressure at ~ room temperature?

Advantages

- ✓ No energy consumption during storage
- ✓ Energy needed only for compression and decompression
- ✓ Reduced ecological footprint and better environmental sustainability

Introduction

Questions

- ✓ Q1 - Can food storage **under pressure** (**Hyperbaric Storage - HS**) be used as a food preservation methodology by **slowing down/inhibiting microbial growth** similarly to refrigeration?

- ✓ Q2 - Can HS work **at and above room temperature** conditions and so under naturally variable (uncontrolled) room temperature conditions and **basically energetically costless**?

Introduction

First observations:

Tilapia fillets at controlled 25 ºC

- ✓ 12 h at 101 MPa total plate counts **similar** to the initial (~ 4.7 Log CFU/g); at 203 MPa a **reduction** to 2.0 Log CFU/g
- ✓ Same results for **psychrophilic** bacteria 101 and 203 MPa
- ✓ K value - at 203 MPa showed a higher freshness than control (0.1 MPa)
- ✓ Posthyperbaric storage for 12 h at 25 ºC - enzymes were active and microorganisms could grow
  - ✓ inhibitory effect caused by pressure was not caused by microbial inactivation but by growth inhibition

Ko WC, Hsu KC (2001). J Food Protect 64(1):94–98

Introduction

Recent observations:

Strawberry juice (acid food) at controlled 20ºC for 15 days

- ✓ At 0.1 MPa after - microbial loads **increased by > 3 Logs** (total aerobic mesophiles and yeasts/moulds), with **unpleasant smell** and **gas production**
- ✓ Under refrigeration (5 º) C - **2 Log units increase** for total aerobic mesophiles
- ✓ Under pressure (25, 100 and 220 MPa) - microbial loads **below the detection limits**

Segovia-Bravo et al. (**2012**) Innov Food Sci Emerg Technol 15:14–22

Experimental Strategy and Methods

Our experiments:

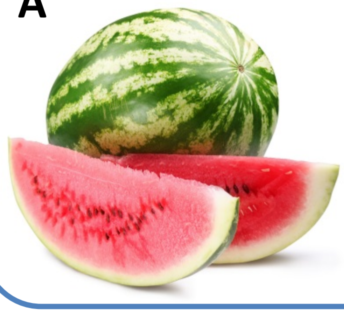
Constrains

- ✓ Very long experimental times to compare with refrigeration results
  - ✓ Long use of pressure equipments needed for other experiments

- ✓ **Strategy**
  - ✓ Highly perishable foods (non acid & high a_w) as proof-of-concept case-studies
  - ✓ <u>First experiments with watermelon and melon juices</u>
  - ✓ Followed by other foods at and above room temperature
  - ✓ First experiments in an industrial high pressure equipment

Methodology

A



8, 16, 24 and 60 hours:

- 0.1 MPa at 5 ºC
- 100 MPa at ≈ 20 ºC

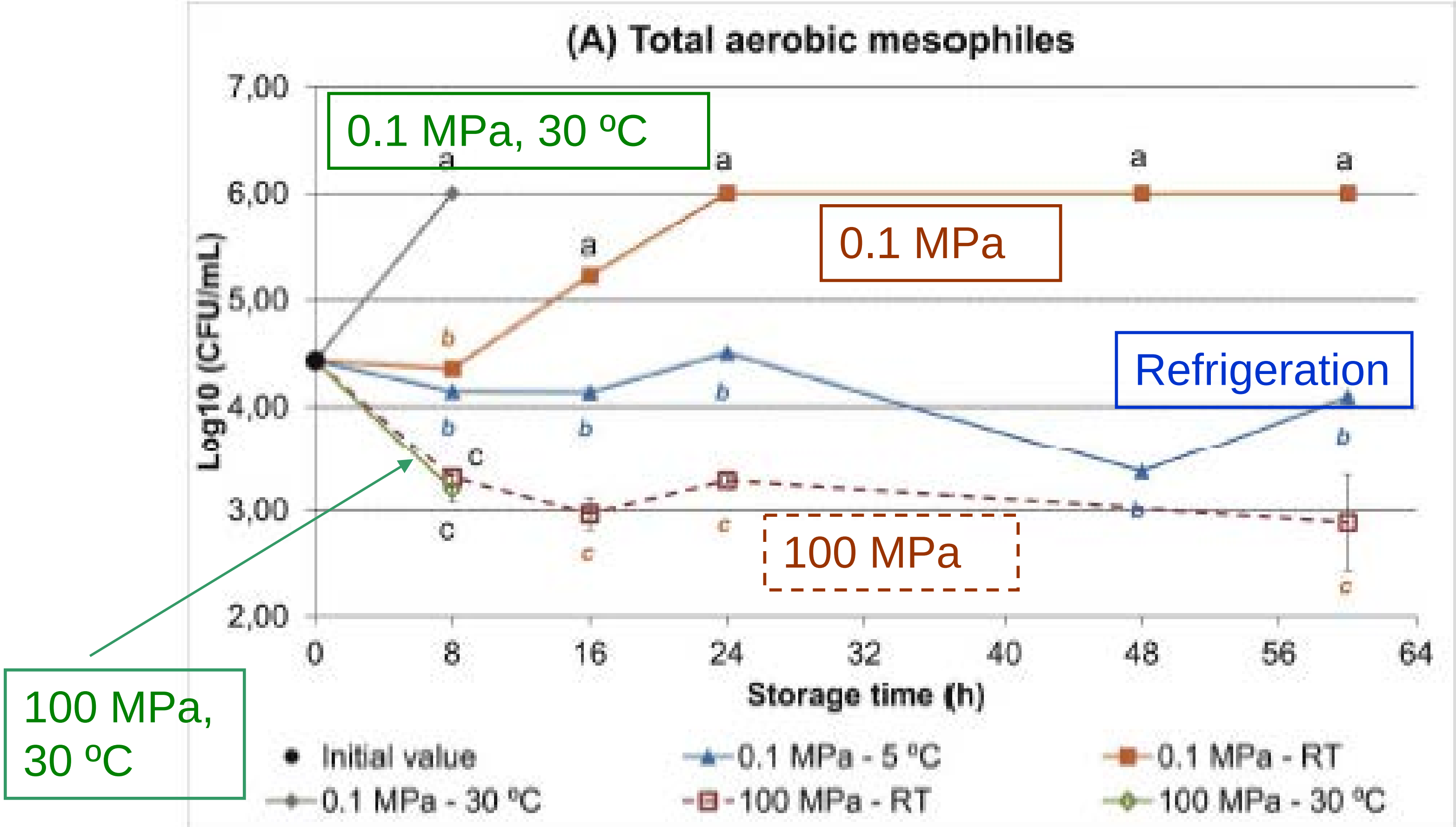
Microbiological Analyses:

- Total aerobic mesophiles
- *Enterobacteriaceae*
- Yeasts and moulds

Physicochemical Analyses:

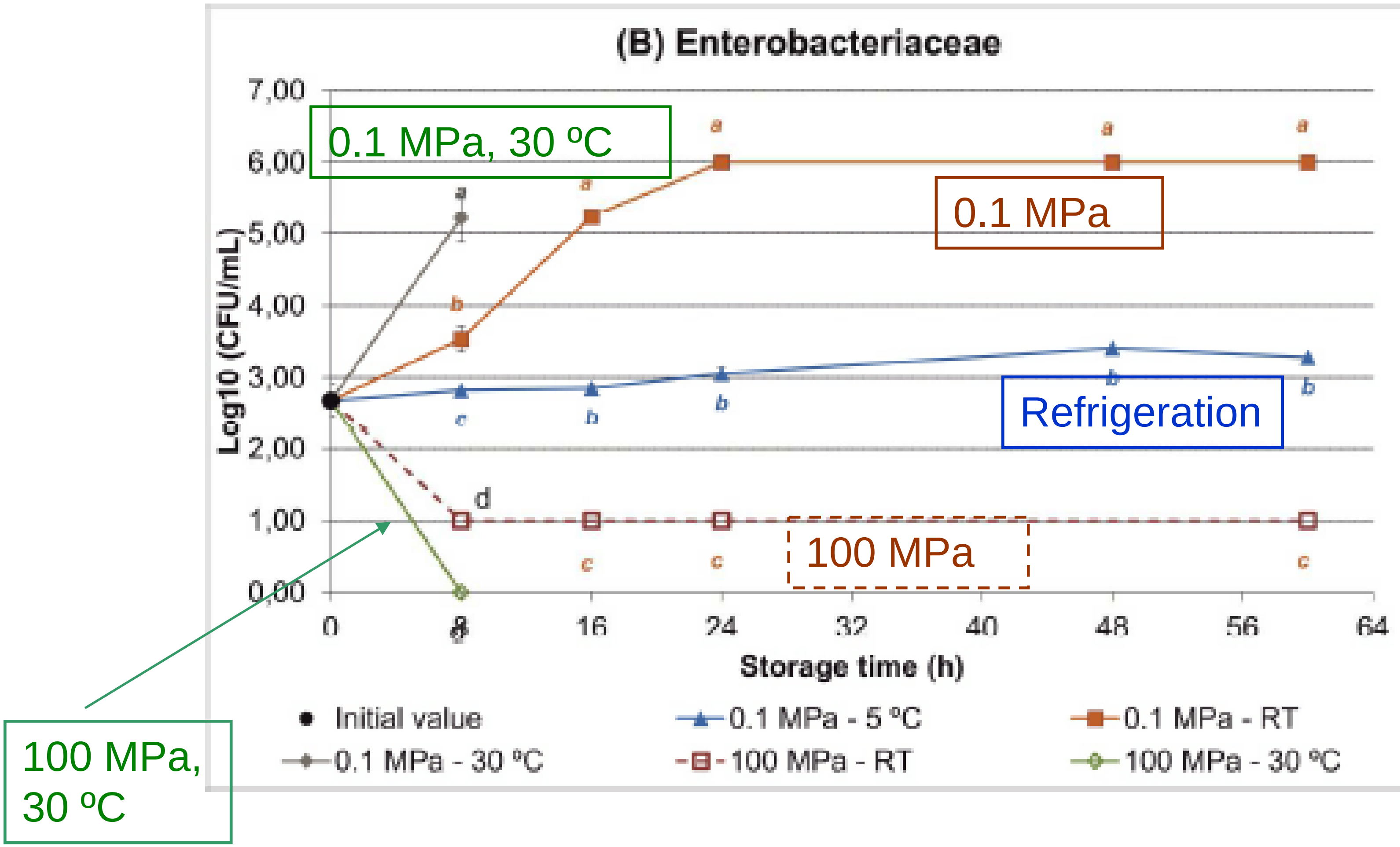
- pH
- Titratable acidity
- Browning degree
- Cloudiness
- Total soluble solids

A. Microbiological Analyses



Values shown as 6 and 1 log units are meant to be higher than 6 and lower than 1 log units, respectively.

A. Microbiological Analyses



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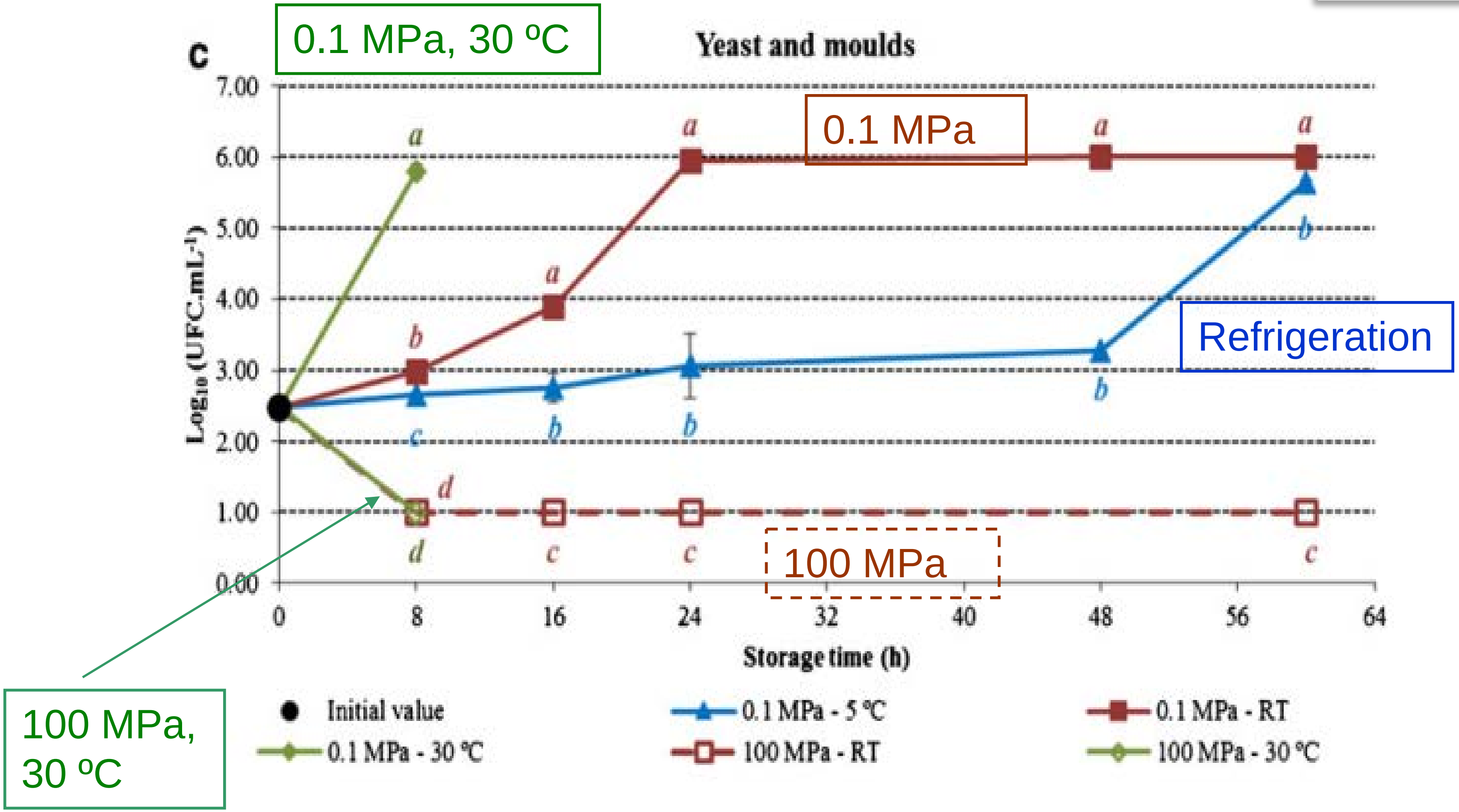
A. Microbiological Analyses



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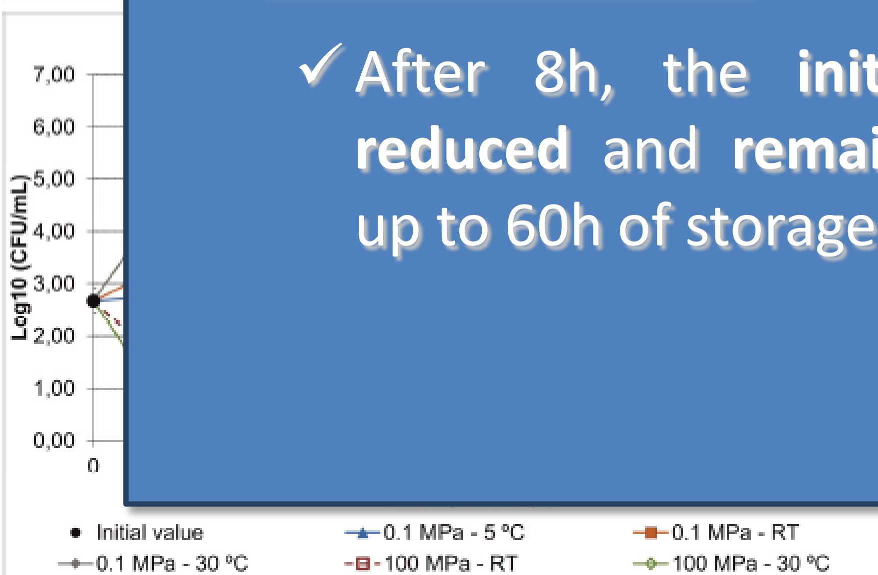
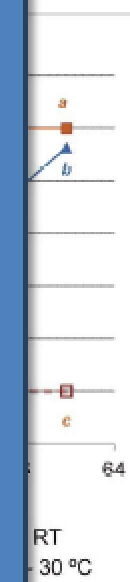
A. Microbiological Analyses

- ✓ Storage at atmospheric pressure (0.1 MPa; 20 ºC):
  - ✓ After 24h, **microbial levels** were already **aboved quantification levels** and **unacceptable for consumption**
- ✓ Hyperbaric storage (100 MPa; 20 ºC):
  - ✓ After 8h, the **initial microbial loads were reduced** and **remained thereafter unchanged** up to 60h of storage





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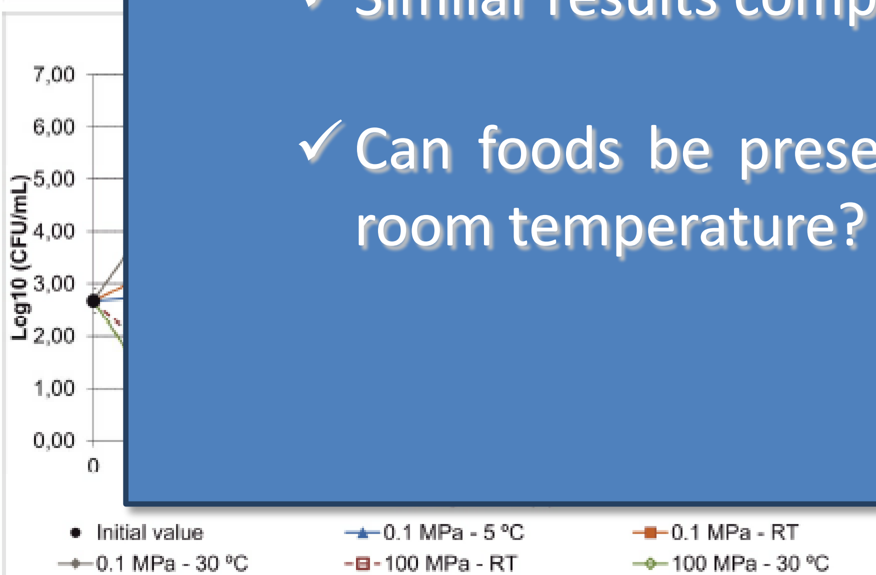
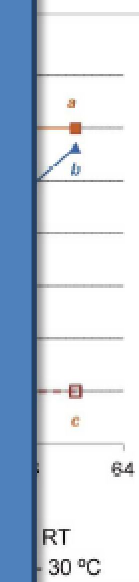
A. Microbiological Analyses

- ✓ Storage at atmospheric pressure (0.1 MPa; **30 ºC**):
  - ✓ Faster microbial growth after 8h, **compared to 20 ºC**
- ✓ Hyperbaric storage (100 MPa; **30 ºC**):
  - ✓ Similar results compared to 20 ºC
  - ✓ Can foods be preserved under pressure above room temperature?





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A. Physicochemical Analyses

Hyperbaric storage:

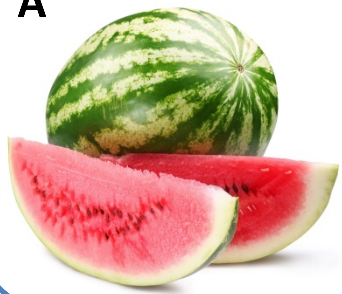
- ✓ Attenuates the increase of **titratable acidity** (verified at 0.1 MPa);
- ✓ Higher **colour** changes (than 0.1 MPa):
  - ✓ Higher lightness;
- ✓ Lower **browning degree** (than 0.1 MPa).

The other parameters analyzed showed generally **no statistical differences** between the different samples.

Fidalgo et al. (2013). *Food and Bioprocess Technol*ogy. DOI 10.1007/s11947-013-1201-x

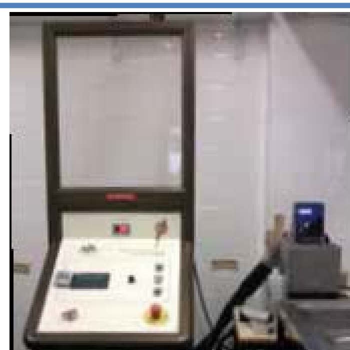
Methodology

A



8, 16, 24 and 60 hours:

- 0.1 MPa at 5 ºC
- 100 MPa at ≈ 20 ºC



B

8 hours:

•0.1 MPa at 4 ºC

•0.1, **50, 75** and 150 MPa at **25 ºC**

•0.1, **25, 50, 75** and 150 MPa at **30 ºC**

•0.1 and 100 MPa at **37 ºC**

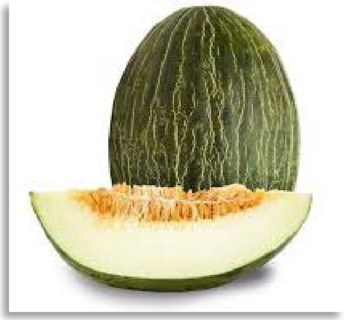
Microbiological Analyses:

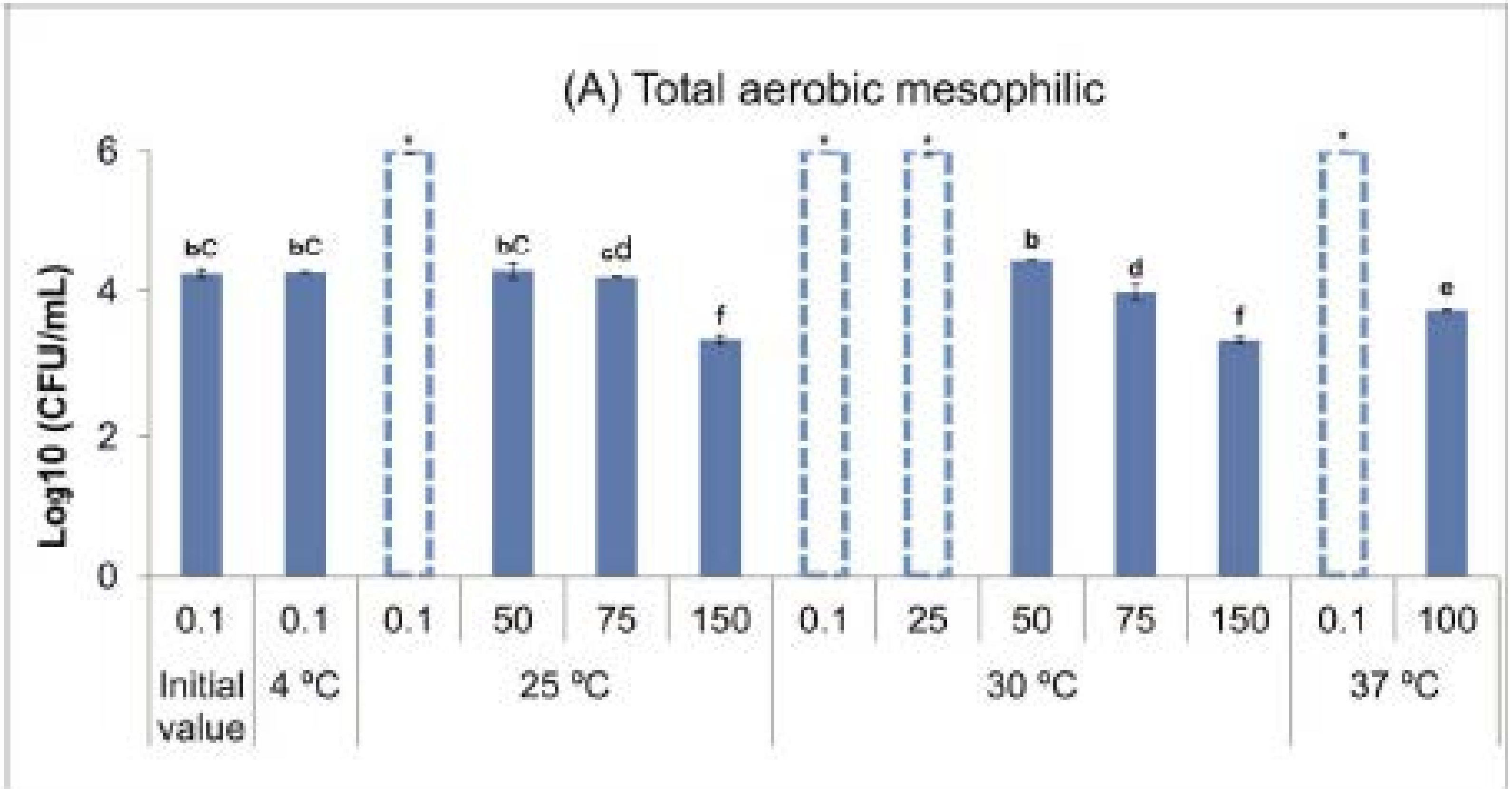
- Total aerobic mesophiles
- *Enterobacteriaceae*
- Yeasts and moulds

Physicochemical Analyses:

- pH
- Titratable acidity
- Browning degree
- Cloudiness
- Total soluble solids

B. Microbiological Analyses





Bars with * and # are indicative of values higher than 6 and lower than 1 Log10(CFU/mL), respectively.

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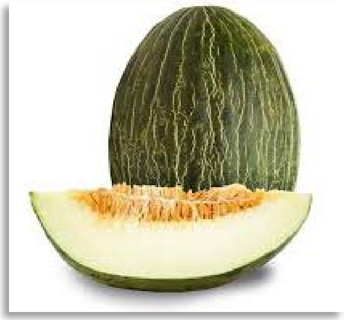

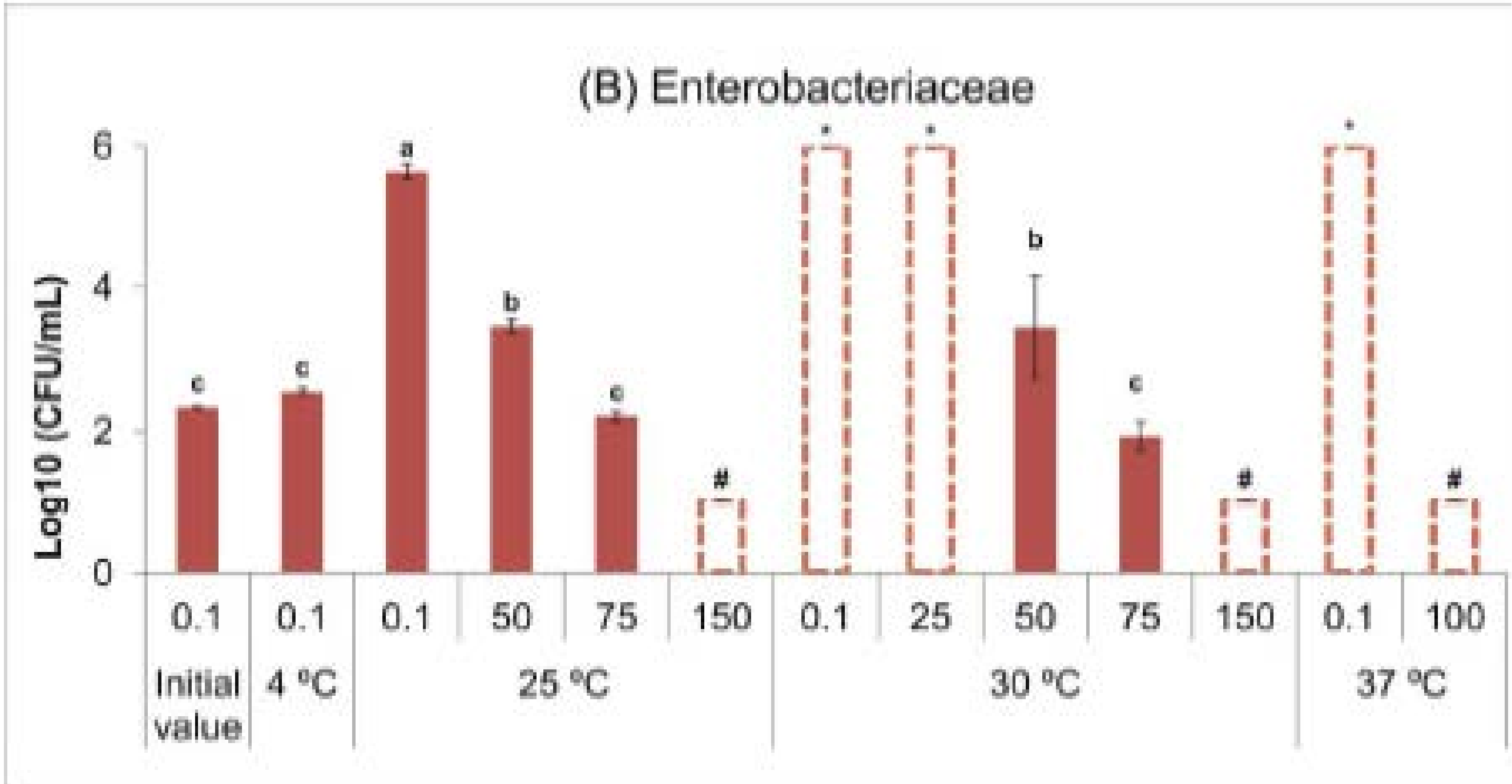

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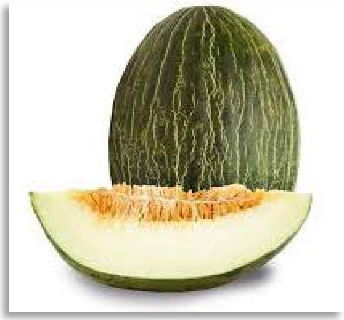

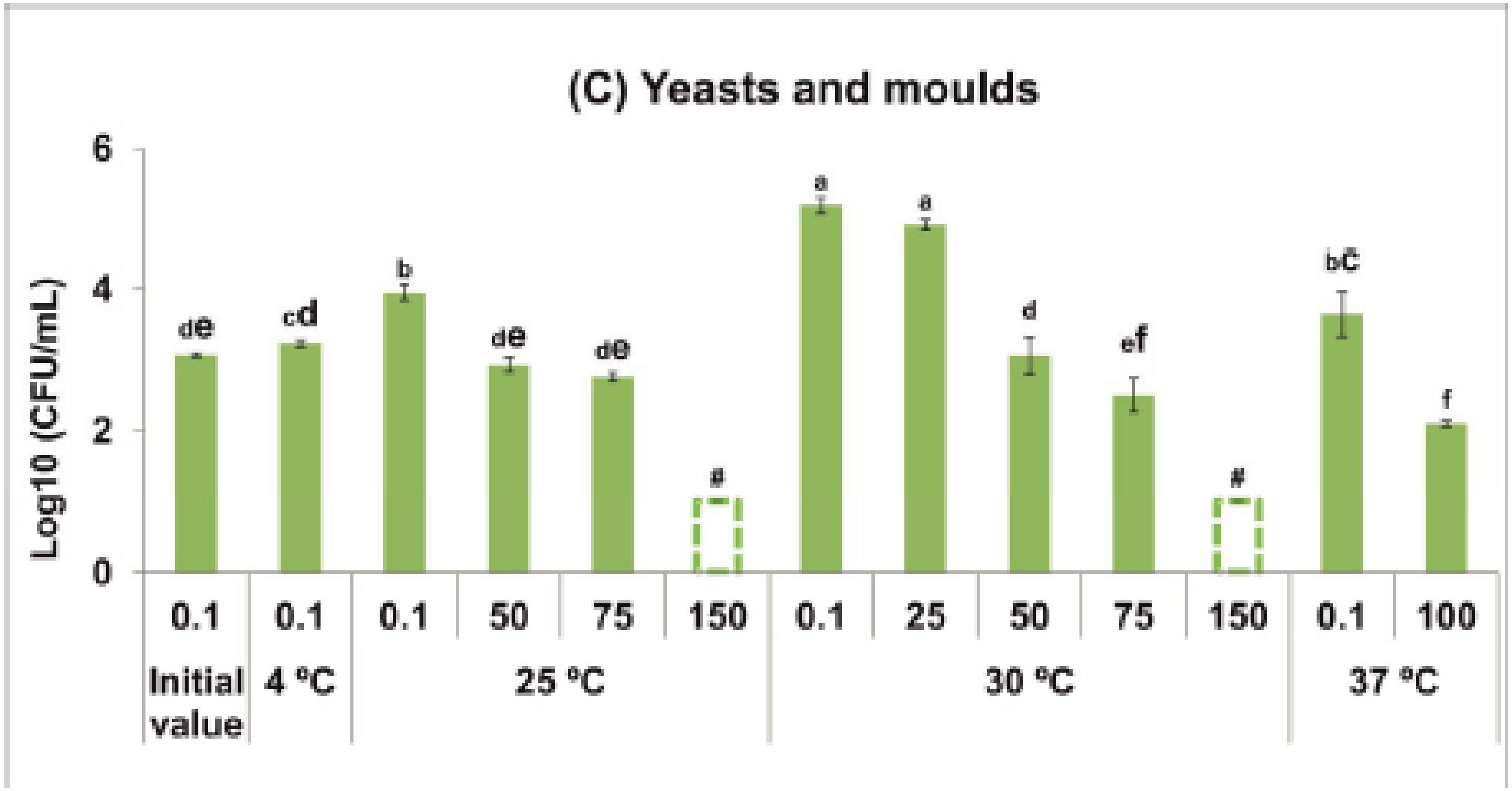

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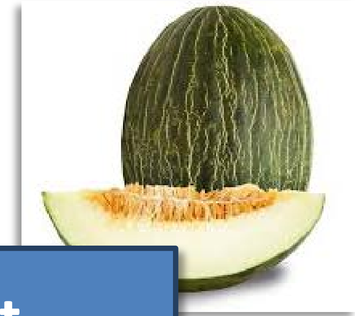
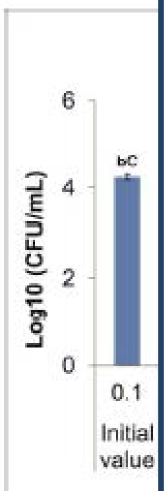
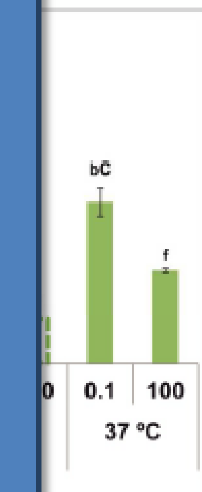
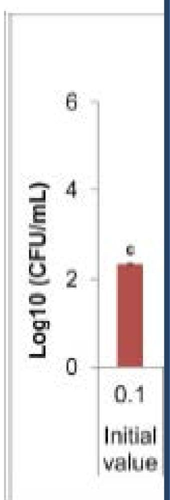
B. Microbiological Analyses





- ✓Hyperbaric storage at **25 MPa** showed **no relevant microbial inhibition**;
- ✓After 8 hours of hyperbaric storage at **50/75 MPa**, the **microbial counts** were **similar to refrigeration**
- ✓After 8 hours of hyperbaric storage at **100/150 MPa**, the **microbial counts** were **lower than refrigeration**, due to microbial inactivation and microbial growth inhibition
- ✓Temperature at 20-37 ºC seems to be irrelevant
  - ✓ Food preservation under naturally variable (uncontrolled) room temperature and above





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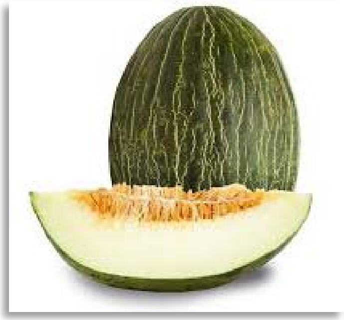
B. Physicochemical Analyses



- pH
- Titratable acidity
- Browning degree
- Cloudiness
- Total soluble solids

→ These parameters did not show a clear variation trend with pressure

Hyperbaric storage effects on physicochemical parameters were **similar** to those observed with **refrigeration**

Queirós et al. (2014). *Food Chemistry*, 147, 209–214.

High Pressure@University of Aveiro

University of Aveiro High Pressure Based Multidisciplinary Technological Platform:

universidade de aveiro
um campus que pensa
1973.2013

Com base nos equipamentos de Alta Pressão e nas competências e capital humano da Universidade de Aveiro, a Plataforma Tecnológica Multidisciplinar de Alta Pressão visa dinamizar e catalisar a investigação fundamental e desenvolvimento industrial de aplicações de Alta Pressão, nomeadamente a pasteurização a frio de alimentos, o melhoramento e criação de alimentos com características inovadoras e novos processos de esterilização de alimentos.

Platform website: http://www.ua.pt/ptaltapressao/

High Pressure@University of Aveiro

University of Aveiro High Pressure Based Multidisciplinary Technological Platform:

Portfolio of **three equipments**:

Laboratorial scale

Pilot scale

Industrial scale

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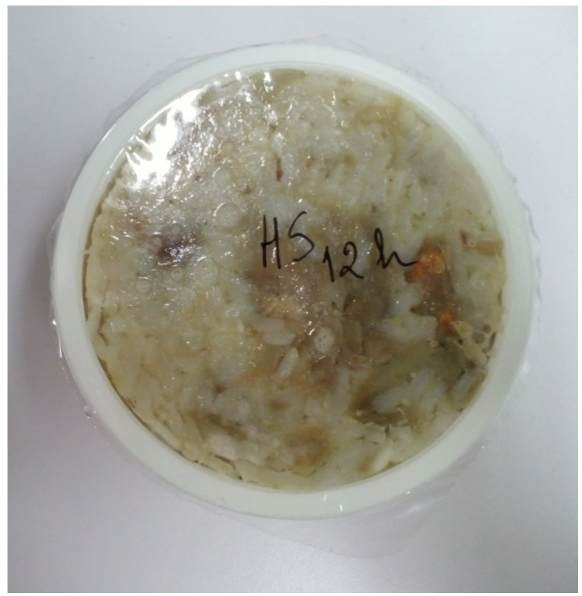
Studies with different products

Minced meat



RTE meal (duck rice)

Sliced cooked ham

RTE meal (cod fish with potatoes and cream

RTE Soup

Conclusions

Food preservation by microbial growth inhibition under pressure - hyperbaric storage (HS)

- ✓ Minimum of 50-75 MPa to have microbial growth inhibition
- ✓ At 100-150 MPa, additional inactivation effect, resulting in microbial loads lower than refrigeration
- ✓ At 20-37 ^{o}C no relevant effect of temperature

Pressure can be used as a variable to slowdown/inhibit microbial proliferation – a novel conceptual food preservation methodology?

Fernandes et al. (2014). Food preservation under pressure (hyperbaric storage) as a possible improvement/alternative to refrigeration: a review. Food Engineering Reviews. DOI 10.1007/s12393-014-9083-x

Further Research

As a novel recent possibility for food preservation, study:

- ✓ Other microrganims, e. g., pathogens
- ✓ Other quality parameters, e. g., enzymes
- ✓ Other food matrixes (with different pH and a_w)
- ✓ Quantitative effect and mathematical modeling of pressure/temperature on microbial growth inhibition and inactivation as influenced by food characteristics (pH, a_w, etc)
- ✓ Longer storage experiments for shelf life determination
- ✓ Sensorial analyses
- ✓ Economical data to compare with refrigeration, including sustainability issues and ecological footprint

40 years old University, ≈15 000 students

Aveiro – the Portuguese Venice

High Pressure Research Team

(Food and Biotechnological Applications)