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BEVERAGE INNOVATION

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Microbial Stabilization of Non-Alcoholic Beverages International Discussion

April 26th, 2022

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Outline

Background

Fermented Beverages and Microbial Ecology
Hurdle Technologies

Microbial Stabilization Techniques
Additive Techniques
Physical Techniques

Market Demand and Trends

BevZero South Africa
Gustav Fouche, Managing Director
Dylan Dowell-Ellis, Production Manger

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Gregorio Blanco, Quality and R&D Manager

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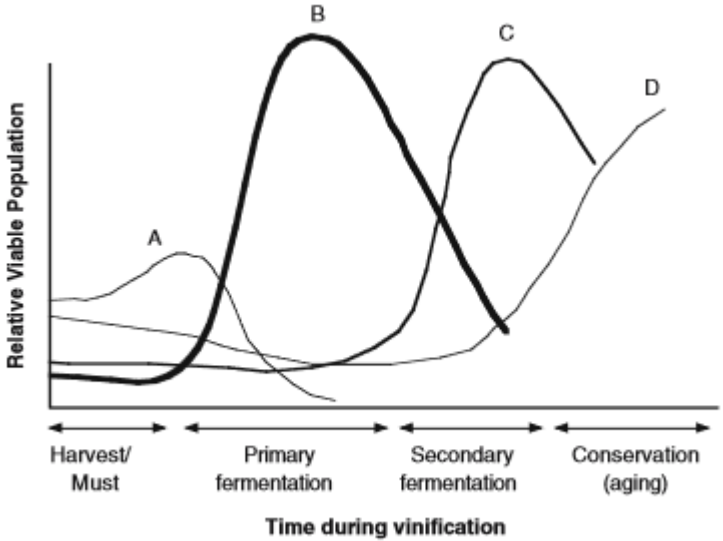
Fermented Beverages and Microbial Ecology

BACKGROUND

Fermented Beverages and Microbial Ecology

- Fermentation helps to reduce microbial diversity where only adapted, niche, relatively safe microorganisms can survive compared to other non-fermented beverages (i.e., juices).
- Fermented beverages contain antimicrobial metabolites (i.e., ethanol, organic acids, microbial peptides and SO_2) which have an inhibitory effect against spoilage and pathogenic microbes.
- Log Reduction (i.e.,10^{-1}:10, 10^{-6}:1,000,000)

Microbial Evolution During Vinification



General growth of (A) *non-Saccharomyces*, (B*) Saccharomyces*, (C*) Oenococcus oeni* and (D) spoilage yeast and bacteria during vinification. Extracted from (Fugelsang and Edwards 2006).

(Lavefve et al., 2019)

BACKGROUND

Hurdle Technologies

- Hurdle technology is a set of methods used for inactivation of microorganisms in food preservation.

- Hurdles are food preservation factors, which are combined to achieve certain food quality and stability, considering:
  - Temperature
  - pH
  - Redox potential
  - Water activity
  - Preservatives
  - Competitive microorganisms

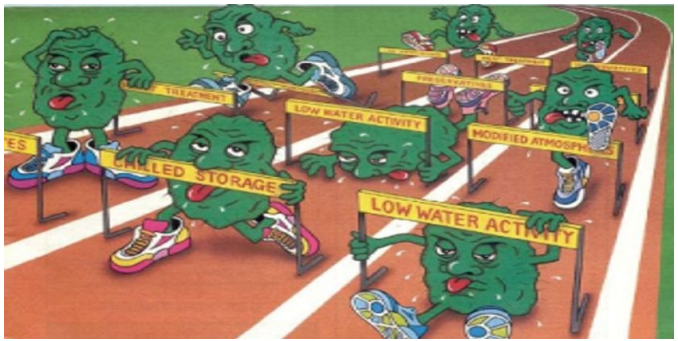


Image from Disha Sinha, Hurdle Technology, July 24,2020, PMG Engineering.com

(Putnik et al.,2020)

Microbial Stabilization Techniques and Considerations

Multitargeted Preservation

Hurdle Technologies

Physical Techniques

Thermal and Non-thermal

Additive Techniques

Chemical and Clean Label Preservatives

Chemical Additive Preservation

Additive Preservatives	Regulatory Reference	Advantages	Disadvantages
Sulfur Dioxide (SO_2)	E220, 21 CFR §182.3637, 27 CFR § 24.246	• Widely available • Effective at low pH • Antimicrobial • Antioxidant • Inexpensive	• Allergen labeling required • Microbial resistance • High levels of SO_2can contribute to can liner degradation and impact sensory • Less effective at higher pH (>3.50)
Velcorin (Dimethyl decarbonate, DMDC, $C_4H_6O_5$) ***Processing Aid**	E242, 21 CFR §172.133, 27 CFR § 24.246	• Antimicrobial • Effective at low pH • Classified by the FDA as a direct secondary food additive, no label requirement	• Specialized equipment and personal • Expensive • Yeast cell population should be below 500 cells/mL • Not as effective against lactic and acetic acid bacteria • Recommended to combine with other chemical preservatives (i.e., SO_2) • Highly toxic within active time range (up to 48 hours after addition)

Chemical Additive Preservation

Additive Preservatives	Regulatory Reference	Advantages	Disadvantages
Sodium Benzoate ($C_7H_5NaO_2$)	E212, 21 CFR §582.3733	• Widely available • Antimicrobial • Effective at low pH • Effective on yeast and molds • Inexpensive	• Microbial resistance (Zygosaccharomyces, Brettanomyces) • Bacteria inhibition requires higher dosages • Decreased solubility at lower pH. • Benzoate and ascorbic acid (vitamin C) should not be used together, as they may react to form benzene, which is a known carcinogen • Labeling required
Potassium Sorbate ($C_6H_7KO_2$)	E202, 21 CFR §182.3640, 27 CFR § 24.246	• Widely available • Antimicrobial • Effective on yeast and molds • Inexpensive	• Poor solubility in water • Not effective against acetic and lactic acid bacteria. • Risk of “geranium” taint from bacterial metabolism • Microbial resistance (Lactic acid bacteria, Zygosaccharomyces, Brettanomyces) • Oxidation of sorbate can produce browning and aldehydes; free SO_2 concentrations should be between 30-40 ppm to protect from oxidation. • It’s recommended to combine with other chemical preservatives (Benzoates & SO_2) • Labeling required

Additive Preservation and Clean Label Ingredients

1. **Natural ingredients:** No artificial flavors, artificial colors, artificial, preservatives, or synthetic additives.

2. **Simplicity:** Less chemicals and recognizable ingredients that do not sound chemical or artificial.

3. **Transparency:** Information on how ingredients are sourced and how products are manufactured.

4. **Minimal processing:** Processing using techniques that consumers don't understand to be artificial.

CONSIDER:

- Compatibility, Efficiency and Sensory Impact
- FDA Food Additive Status List
- FDA Generally Recognized as Safe (Gras)
- FDA Natural vs. USDA Organic Program
- Supplier SDS, COA, Third Party Data.

Microbial Stabilization Techniques and Considerations

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Thermal Technologies

- **Low temperature long time (LTLT)**
  - Spray or in batch tunnel pasteurization at 60-100°C/140-212 °F for 15-30 minutes with pasteurization in package.
  - **Benefits:** Ensures in package stability, is widely available and commonly used.
  - **Challenges:** Negative sensory impact (cooked flavors), color and nutrient degradation, time consuming, water usage, energy usage, space.

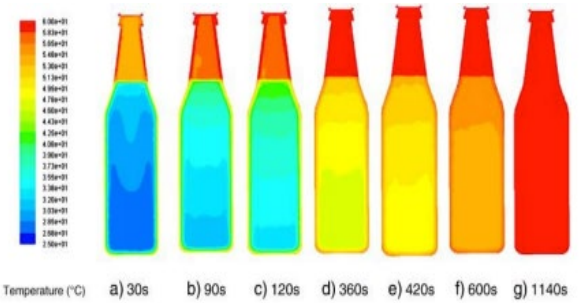


Image from Bhuvaneswari E, Anandharamakrishnan C. Heat transfer analysis of pasteurization of bottled beer in a tunnel pasteurizer using computational fluid dynamics. Innovative Food Science & Emerging Technologies. 2014 Jun 1;23:156–63.

Ed Michalski Tunnel and Batch Pasteurization vs. Artificial Preservatives to Food and Beverages April 1st 2021, prowm.com

(Krebs et al., 2019)

PHYSICAL TECHNIQUES

Thermal Technologies

- **Aseptic Processing (AP)**
  - Product is sterilized prior separately from packaging where products is packaged in sterilize containers under extremely clean environments. Products do not need
- **High temperature short time (HTST)**
  - Flash Pasteurization (~75°C/167°F for 15-30 seconds with rapid cooling).
  - Continuous system, “Hot filling” usually combined with aseptic packaging. .
- **Ultra-high temperature (UHT)**
  - (135-150°C/275-302°F for 3-5 seconds with rapid cooling).
  - Continuous system, “Hot filling” usually combined with aseptic packaging.

Image from Pablo Coronel, Strategies for Aseptic Food Processing, foodquality andsafety.com, 2021

Benefits: Readily available, increased shelf life, less sensory alterations than tunnel and shorter processing.
Challenges: Expensive, risk for overheating, sensory alterations (light struck and scorched faults), color and nutrient degradation, water and energy consumption, risk of contamination at packaging.

(Milani and Silvia, 2021)

PHYSICAL TECHNIQUES

Non-Thermal Technologies

Non-Thermal technologies use lethal agents other than heat to reduce or eliminate microorganisms that might be harmful or cause spoilage.

- Demonstrates “pasteurization” effects
- Variable efficacy on enzymes
- Combination with heat for commercial sterilization
- Milder treatments result in refrigerated/cold chain foods with less cooked flavor
- Clean labeling

1. **Sterile Filtration (0.2µm)**
2. **High Hydrostatic Pressure**
3. **Pulsed electric fields**
4. **Ultrasound**
5. **Ultraviolet**

Ultra High Pressure (UHPH) and High Dynamic Homogenization (HDH)

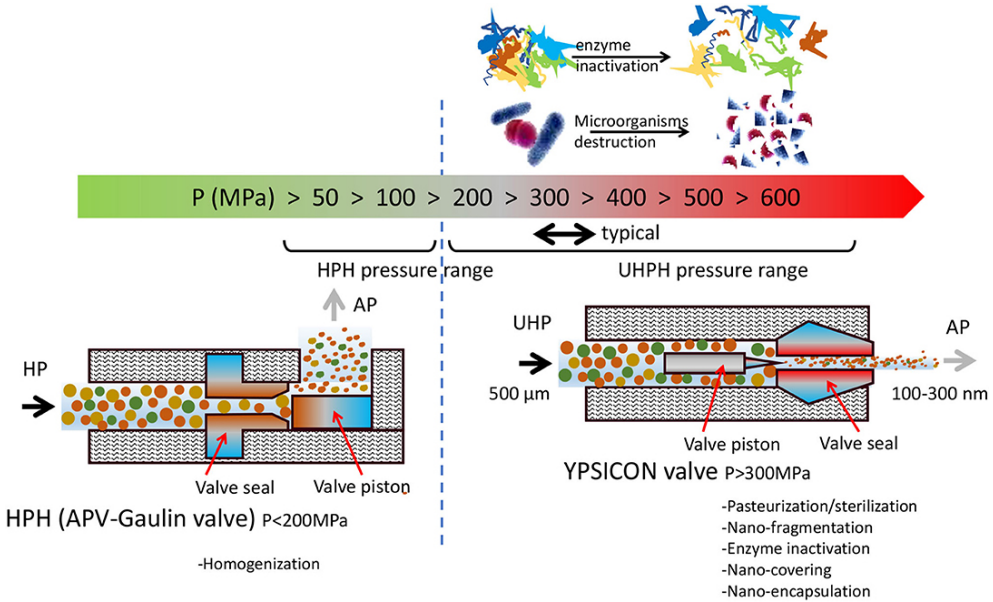


Image from Morata, A., & Guamis, B. (2020). Use of UHPH to obtain juices with better nutritional quality and healthier wines with low levels of SO2. Frontiers in nutrition, 241.

- **Benefits:** UHPH is continuous, gentle, with high antimicrobial effect (6-log reduction), has a short processing time, with no significant impact on sensory and bioactive compounds even with multiple treatments.
- **Challenges:** HDH is in batch and has limited effect on enzyme deactivation. Both may require multiple passes and higher in valve temperature to inactivate bacteria and spores. Not as readily available commercially.

(*Morata, A., & Guamis, B. 2020;* Silva & van Wyk 2021; Zulkurnain et al., 2021)

High Pressure Processing (HPP)

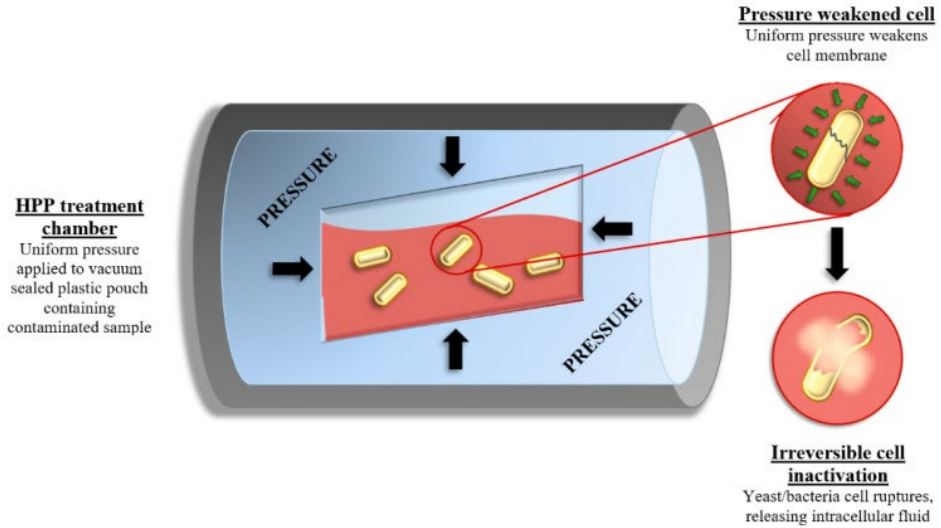


Image from Silva, F. V., & van Wyk, S. (2021). Emerging non-thermal technologies as alternative to SO2 for the production of wine. Foods, 10(9), 2175.

- **Benefits:** In Batch and In Packaging options, strong microbial inactivation (7 log reduction), can operate below room temperature, instantaneous transfer of pressure regardless of liquid characteristics.
- **Challenges:** In packaging (discontinuous) is more widely available but present packaging. There is a high capital investment but are become more available. Limited availability with in-batch options.

(Silva & van Wyk 2021; Zulkurnain et al., 2021)

Pulsed Electric Fields (PEF)

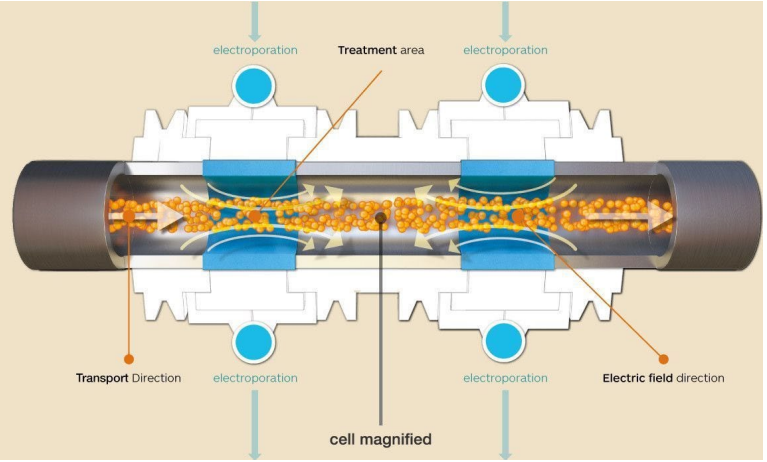


Image from Pulsed Electric Field preservation i3-food project.eu 2020.

- **Benefits:** Continuous, fast, effective antimicrobial (log reduction 5)l ow energy consumption, minimal alterations to wine chemistry. Minimal effect on wine and beer chemistry.
- **Challenges:** Liquids should be de-gassed, not as effective with bacteria, high voltage safety risks, can develop light-struck character in beer.

(Silva & van Wyk 2021; Zulkurnain et al., 2021)

PHYSICAL TECHNIQUES

Non- Thermal Technologies

- ## Ultrasound
  - **Benefits:** In batch and continuous process, versatile (homogenization, extraction, emulsion, de-gassing).
  - **Challenges**: Time consuming, cavitation can modify to color, sensory, antioxidants and polysaccharides. Less effective against certain yeast and bacteria.

- ## Ultraviolet Radiation
  - **Benefits:** Minimal loss of nutrients, sensory and low energy consumption compared to other thermal techniques.
  - **Challenges:** UV penetrability (absorbance, solids, color, density) enzyme deactivation is limited, Less effective in red wines, can develop light-struck character in beer.

(Milani & Silvia, 2021; Silva & van Wyk 2021)

Non-Alcoholic Beverage Preservation Market Trends and Demands

BevZero South Africa

Gustav Fouche, Managing Director
Dylan Dowell-Ellis, Production Manger


Gustav

BevZero Spain

Silvia Cedeno Daguerre, General Manager

Gregorio Blanco, Quality and R&D Manager



BevZero United States

Kayla Winter, Director of Product Services
Chris Anderson, Head of Brewing Operations


Lauren Barrett

Summary

Multitarget Preservation

Hurdle Technologies

- UHPP and PEF
- US and PEF
- Thermal and PEF
- Thermal and HPP

Physical Techniques

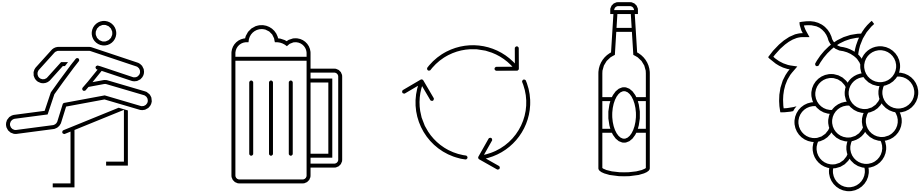
Non-Thermal

- HPP
- PEF
- UHPP
- UV

Additive Techniques

Chemical and Clean Label

- SO_2
- Velcorin (DMDC)
- Antioxidant/Antimicrobial tannins



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Thank you for your time!

Q & A

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