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REHIS – Food Update 2022

# Determining Shelf Life and Hurdle Technology for Food Preservation

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# Overview

- Shelf life evaluation
- Food preservation
- Hurdle technology

# Introduction

- "A products shelf life is a verification of the stabilising systems designed into the product."
  - M Antoninus (2011) – New Food Product Development

- You need to know how shelf stable your product is

This is very difficult to predict – but the following (taken from Curiale, 1991), will help to advise on how to go about doing this.

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# Selecting criteria to assess shelf life

- Must be measurable

- Must be something that degrades over time – not useful to have it degrade abruptly or suddenly

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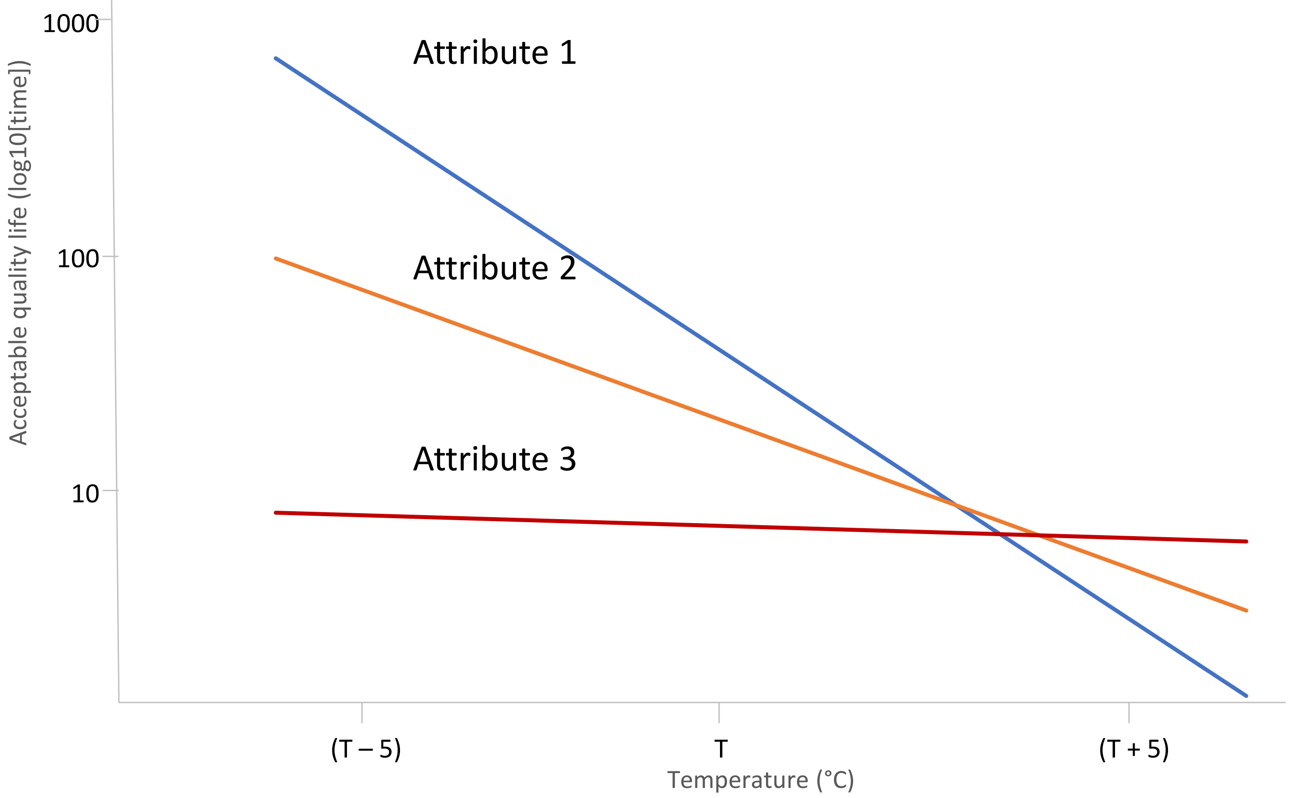
# Selecting criteria to assess shelf life

- Microbiological changes
  - Total plate counts, psychrophilic counts, or counts of specific microorganisms of public health or economic significance
- Nutritional changes
  - The loss of nutrients (like Vitamin C), this nutrient should be one for which the food product is a significant source
- Visual changes
  - The loss or change of colour, or the production of breakdown colour compounds can be followed. Other changes could be exudation or drip loss, moisture transfer, shrinkage.
- Functional property changes
  - i.e. the ability to ship, to colour, flavour, to foam, to leaven, or to set.
- Textural changes
  - Hardening, softening, staling, loss of crispness, development of graininess, viscosity

# Complexity of shelf life testing in foods

- Complexity in foods
- Attributes can deteriorate at different rates and at different degrees




Comparison of different rates of deterioration of quality parameters for a hypothetical food product with respects to increasing temperature

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- A judgement or decision needs to be made on the loss of a quality issue.
  - How much is bad?
  - With whom has this decision?
  - An off flavour to one may be acceptable to another

- If a label declaration is made, then this is the point at which the shelf life is chosen. i.e.
  - Ribena states: Typical values per 100ml: Energy 88kJ (21kcal), Carbohydrate 4.7g, Sugars 4.6g, Salt 0.06g, Vitamin C 32mg (40% RI)
  - At the end of shelf life this is the minimum that must be within the product.

  - **If not you can face prosecution and heavy fines, media frenzy and loss of sales.**

- **No tolerance for loss of safety**

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# 2/3rd rule

- ‘Rule of thumb’ suggests that the 2/3rd rule is useful

- If the shelf life tests show that is 90 days before the quality is so low that it is unacceptable to the consumer, then the 2/3rd rule states that you put 60 days as the shelf life.

- Not scientifically proven or any practical evidence, however it is a commonly used within the food industry

- **Not recommended to be used.**

# Selecting conditions for the test

- Under what conditions will the shelf life test be carried out?

- For frozen and chilled foods:
  - Temperature changes encountered in the factory / transport / supply chain
  - Inadequate temperatures in display cases or during retailing
  - During vending machines
  - During transport from retailer to home and during home storage

- Do you test you product in nonabusive storage or abusive storage conditions?

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# How to determine the test conditions

- The preservative systems designed into the food product (hurdles)
- The physical abuse the product will undergo from factory floor to consumption
- Environmental abuse the product will undergo from factory floor to consumption
- Microbiological load on the food after processing and prior to packaging (should be part of the HACCP plan).

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# Factors that can influence shelf life

- Temperature
  - Influences the rate of chemical reactions (every 10°C increase the rate of these chemical reactions are 2 to 4 fold).
  - Breakdown of food structures and loss of quality
  - Alter growth rates or patterns of microorganisms
  - Activity of enzymes

- UV
  - Light can increase oxidative rancidity
  - Changes in colour of the product

- Atmosphere
  - Presence of oxygen can change colour
  - The absense of oxygen can change colour

Labuza, T.P. and Riboh, D., 1982. Theory and application of Arrhenius kinetics to the prediction of nutrient losses in foods [Degradation, keeping, quality, temperature, quality controls, analysis, models]. Food Technology.

# Types of tests available

- Three general approaches
  - Static tests – the product is stored under a set of environmental conditions selected as most representative of the conditions of which it will be subjected
  - Accelerated tests – the product is stored under a range of environmental variables (for example temperature)
  - Use / abuse test – the product is cycled through a range of different environmental variables.
- At intervals of these tests samples are taken and subjected to sensory, chemical and / or microbiological assessments.

# Static tests for quality


- Very long winded
- Costly
- Provides no kinetic data
- Likened to one point viscosity measurement or a one point moisture sorption curve (i.e. useless)
- Ideally suited to frustrate the marketing program of most companies

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# Accelerated tests for quality

- Most preferred by researchers
- Provide information about the kinetics of a products deterioration.
- A range of conditions of some environmental variables are carefully chosen to cover the range that could be anticipated in distribution
- A range of temperature for instances can be used and the data fed into the Arrhenius equation….

# Use/Abuse tests

- Use / abuse tests are as varied as an imaginative mind can make them as a tool in assessing the shelf life of the food and its packaging as a unit.

- Frozen food manufactures often cycle foods through -20°C to 6°C, which gives an approximate freeze-thaw cycle.

- Remember that once a product is made, abuse can happen from the delivery or warehousing, or retailer.

# Guidelines to determine shelf life

- Shelf life is a prerequisite of a food manufacture by government, co-packer or buyer, or retailer.
- No easy answer, and a lot of information is currently missing from science.
- No one can say what the shelf life of a given product will be. Instead consider what it should be if…

- If, being the big unanswered question **It** should encompass all the precautions that should be taken during manufacturing, distribution, warehousing, retailing and home storage and preparation

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# Be aware

- Samples completed on a pilot plant or kitchen scale have very little resemblance to those made during full production.

- *Case Study 1.*

- A potato processor wanted to develop a line of chilled pre-packaged pre-peeled potatoes.
  - Shelf life determined to be 30 days by using pristine pilot plant samples
  - In full plant production the shelf life was actually 10 to 15 days
  - Mainly due to the microbiological load through contamination during production when compared with those produced in the sanitised pilot plant.

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- *Case Study 2*.

- A manufacturer of canned 'herbed' bread crumbs.
  - The canning supplier ran out of ends for the product during testing, so the researcher chose to use a plastic lid, it was breathable so therefore would give good results in terms of abuse.
  - Shelf life was successfully tested and incorporated into the product.
  - Complaints started coming in when the final product was using metal lids. Off flavours were noted, rusting was observed.
  - Constituents (principally citral) in the spice and herb blend reacted with the metal ends to cause a breakdown of the flavour and initiated detinning.

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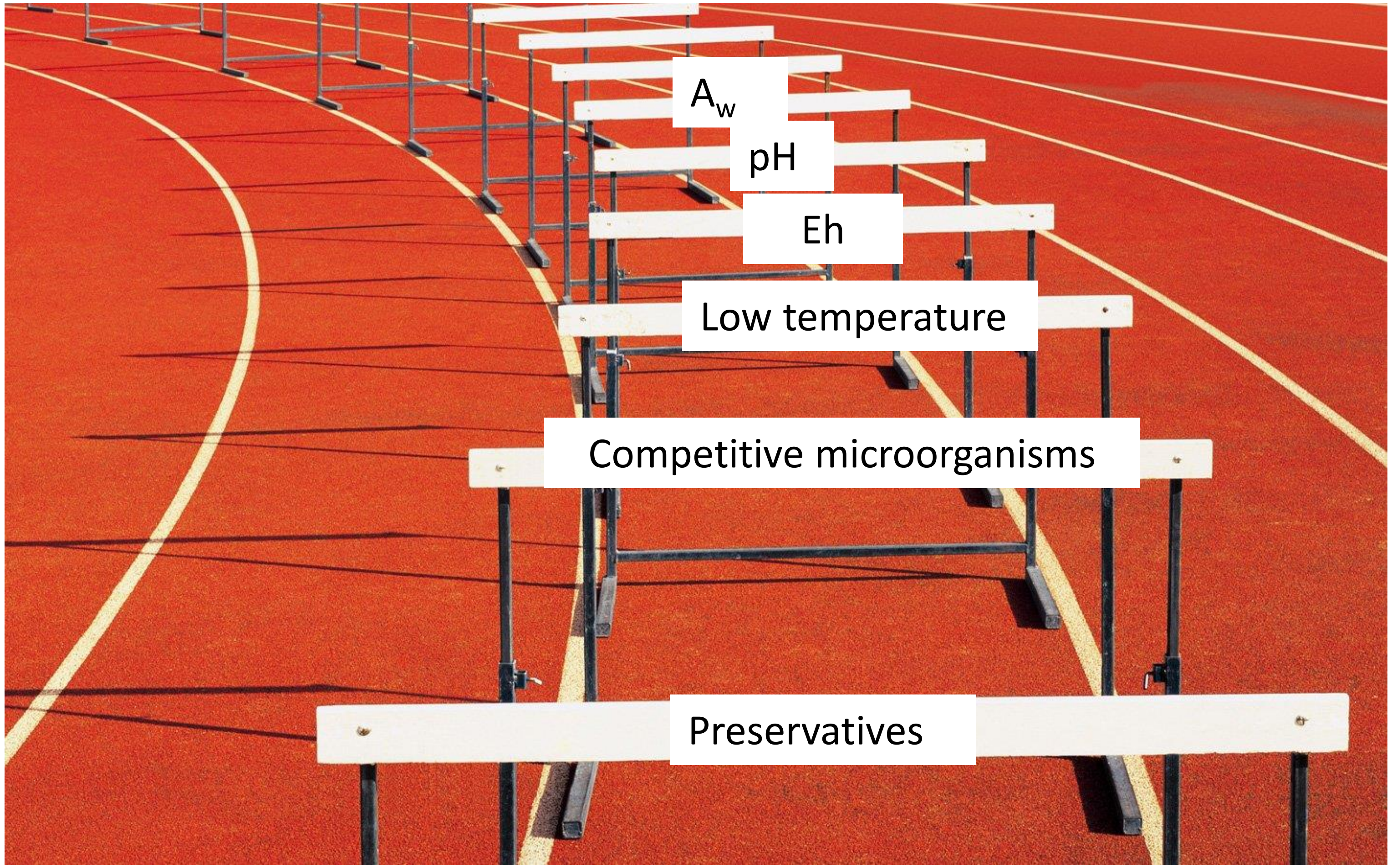
# Intrinsic factors to control microorganisms

- Ingredient or changes to the product
  - Water activity ($A_w$)
  - pH
  - Chemical preservatives
  - Oxidation-reduction potential

# Oxidative / reductive potential

- A measurement of the likely or tendency for a chemical or molecule to attract or expel an electron
  - Also referred to as Eh or OR
- In some cases – particularly in food microbiology this is the potential to attract oxygen.
  - Positive Eh Favours that of aerobic bacteria and vice versa

# Hurdle Technology



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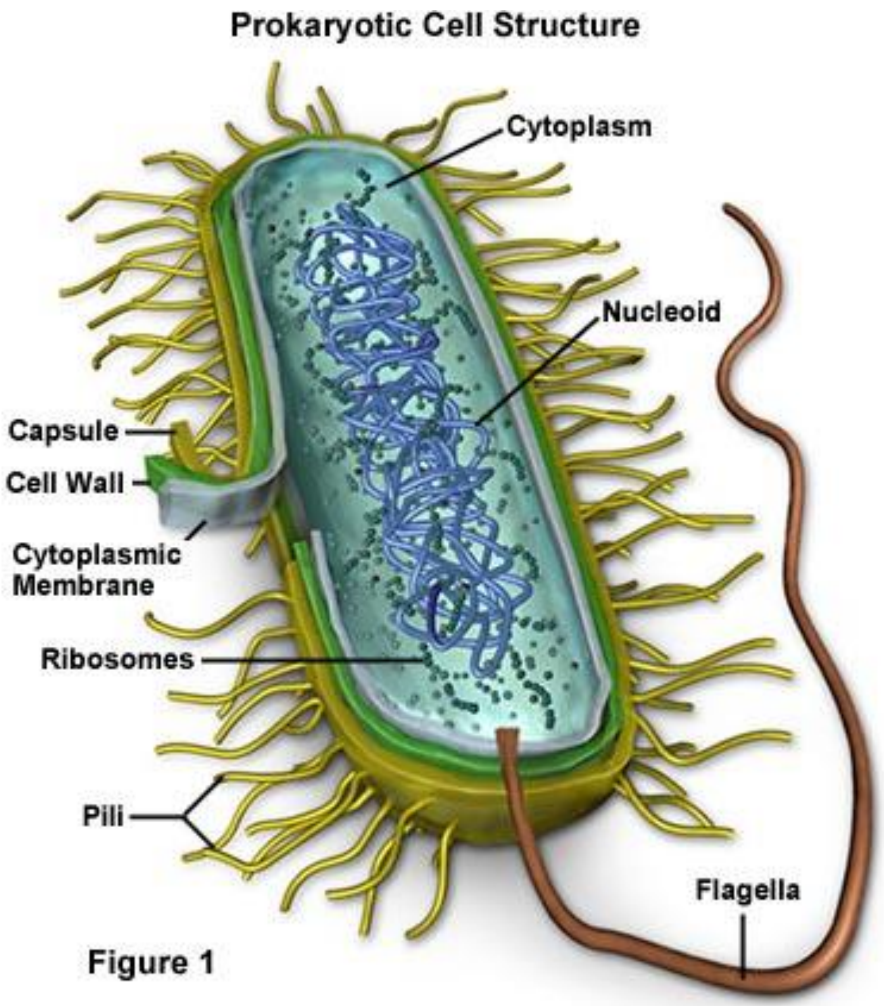
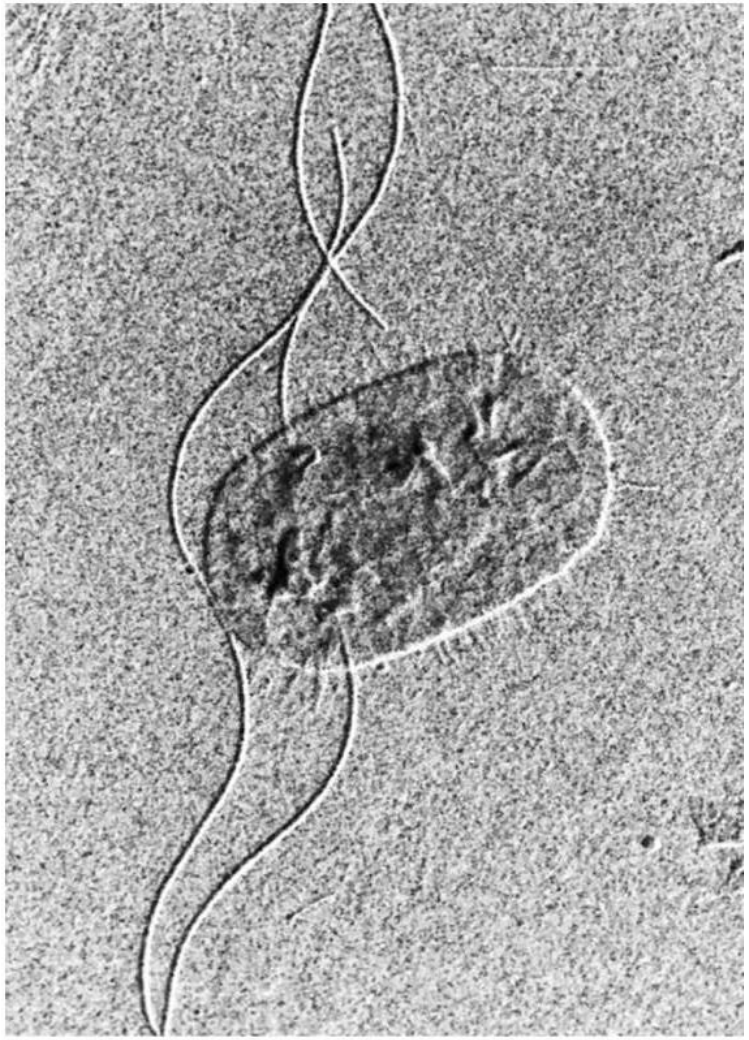
# Definition

- "Hurdle technology is a technology by which a preservation parameter can be used at an optimum level in order to get a maximum lethality against micro-organisms by a combination of two or more such parameters so that the damage to the sensory parameters of the food is kept to the minimum."
    - Singh and Shalini (2016)

# The cell



Prokaryotic Cell Structure
Cytoplasm
Nucleoid
Capsule
Cell Wall
Cytoplasmic Membrane
Ribosomes
Pili
Flagella
Figure 1

# Homeostasis

- Is the tendency to uniformity and stability in the internal status of organisms.
  - i.e. the maintenance of pH is a prerequisite and feature of living cells

- Homeostasis is a key phenomenon in food preservation
  - If disturbed by preservative factors, they will not multiply i.e. remain in lag phase or even die

# Metabolic exhaustion

- Can cause ‘autosterilisation’ of a food
- Micro-organisms in stable hurdle-technology foods strain every possible repair mechanisms for their homeostasis to overcome the hostile environment, by doing this they completely use up their energy and die

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- An example:
  - Salmonellae that survive the ripening process in fermented sausages will vanish more quickly if the products are stored at ambient temperature, and they will survive longer and possibly cause foodborne illness if the products are stored under refrigeration.

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- Unilever laboratories found:
  - Listeria innocua in mayonnaise – vanished faster at ambient temperatures than refrigeration
  - In fine emulsions than coarse emulsions
  - Under anaerobic conditions quicker than aerobic conditions.

- The more hurdles you have the faster metabolic exhaustion occurs

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- Refrigeration is not always beneficial for the microbial safety and stability of foods

- However, only true if the hurdles in a food inhibit the growth of microorganisms
  - If this is not the case, refrigeration is beneficial.

# Stress reactions

- When bacteria are stressed they produce stress proteins
- These proteins can help the bacteria to become more tolerant to the stress
- They also use up a lot of metabolic energy, and therefore can speed up metabolic exhaustion

# Multi-target preservation

- For gentle – most effective preservation of foods
- Sets up small hurdles that affect the homeostasis of the bacteria at the same time
  - i.e. pH, cell membranes, DNA, enzyme systems, $A_w$ and redox potential, processing

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- Therefore repair of homeostasis and the production of shock proteins become difficult

- i.e. better to employ difference preservative factors of small intensity than one preservative factor

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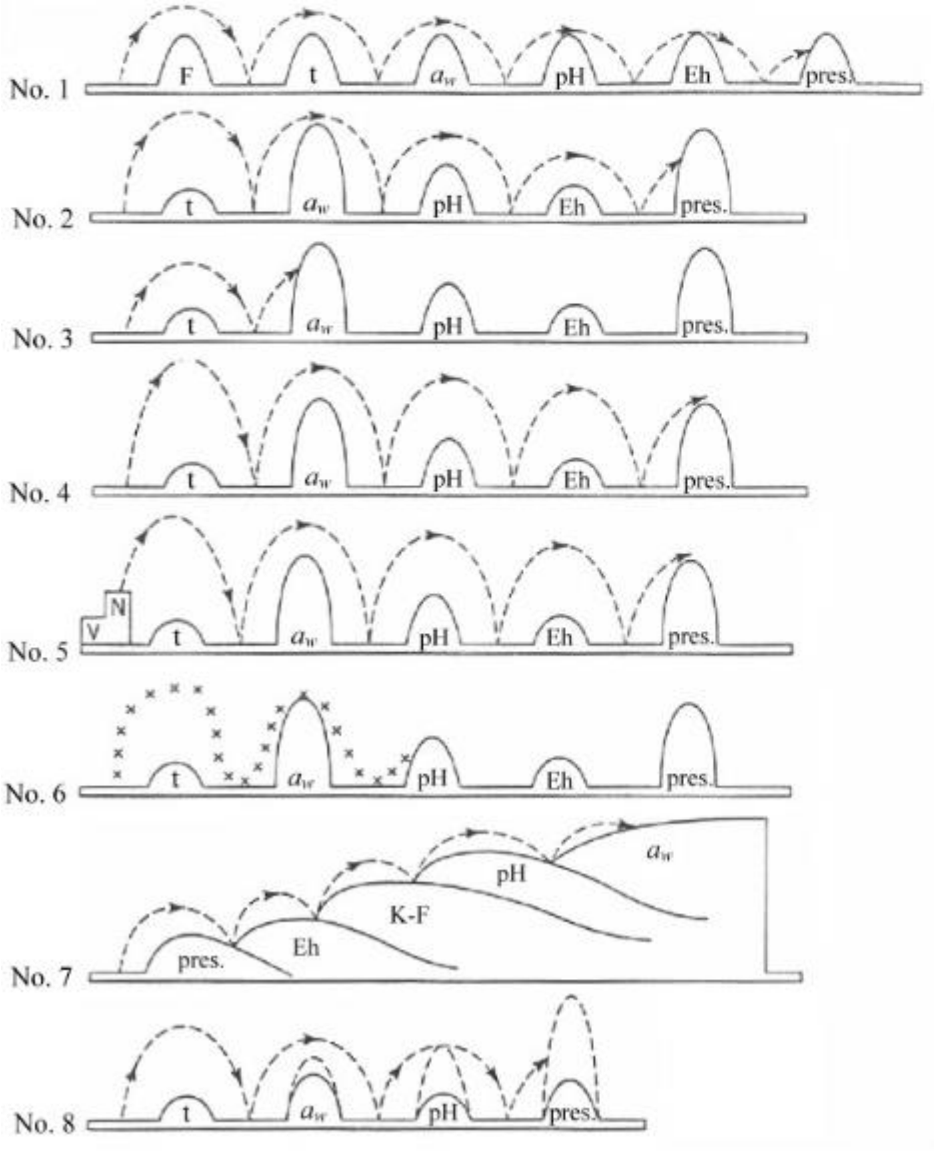
1. Theoretical example
2. Low Aw + preservatives
3. Very clean conditions
4. Not clean conditions
5. Food rich in vitamins and nutrients
6. Spores – lack of vitality
7. Fermented sausages
8. Synergistic effects of hurdles



- By using an intelligent mix of hurdles, it is possible to improve not only the microbial stability and safety, but also the sensory and nutritional quality of a food.

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# Useful swaps

- Refrigeration and freezing high energy demands – consider understanding $A_w$ and pH to preserve foods

- Reducing or replacing preservatives in foods then consider competitive microorganisms, refrigeration, pH and $A_w$

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# Thank you

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- Erkmen, O. and Bozoglu, T.F., 2016. Food Microbiology, 2 Volume Set: Principles into Practice. John Wiley & Sons.
- https://discoverfoodtech.com/hurdle-technology-in-food-preservation/ A great blog on Hurdle Tech