Module 3 - Innovative processing of fish discards to BARF

Developed by:

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Warm-up

Before you go to the next slide,

- Write down **3-5 keywords** explaining why proper handling and processing of the bycatch/discarded fish is essential
- Write **1-2 sentence(s)** about your expectations for this module

Module Content

- Introduction
- Fish discards - properties and stability
- Catching technology and on-board handling
- Innovative processing concepts
- BARF processing technologies
- Packaging and distribution of BARF

Introduction

"The present module gives an overview of handling procedures, strategies, and technologies to maintain or improve today's discarded fish/bycatch's quality, stability, safety, and nutritional profile. Thereby enabling the biomass to be transferred into valuable nutritious MARPET BARF products"

E.g.,

- Strategies for onboard preservation of BARF raw material (discarded fish/bycatch)
- Strategies for BARF processing and distribution

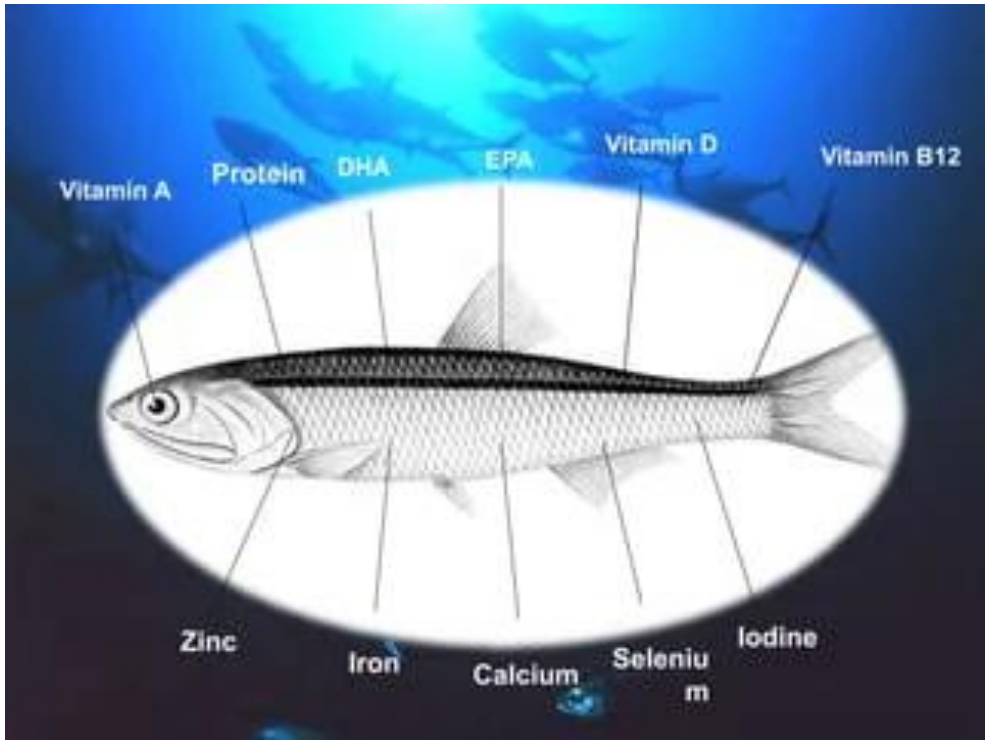
Part 1 - Fish discards - properties and stability

- Nutritional composition and trace elements
- Fish spoilage: Autolytical, microbial and chemical changes

Nutritional composition and trace elements

Proximate composition of fish

Components	
Water	70-84 %
Proteins	15-24 %
Lipids	0.1-22 %
Minerals	1-2 %
Carbohydrates	0.1-1 %



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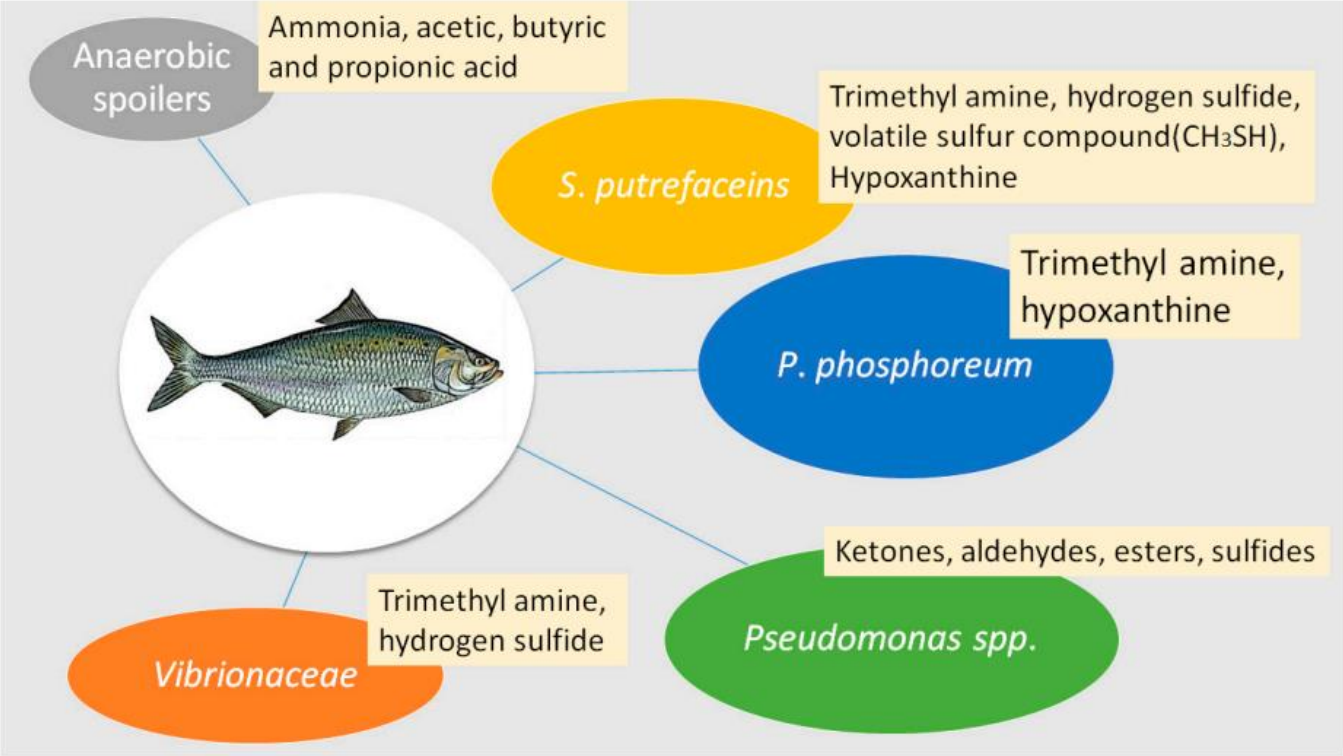
TURKISH NATIONAL AGENCY

Fish spoilage is based on three mechanisms: (1) enzymatic autolysis, (2) microbial growth and metabolism, and (3) oxidation reactions.

Types of Fish Spoilage	Causes	Changes
Biological		
➢ Enzymatic	Glycolytic enzymes Autolytic enzymes Cathepsins Chymotrypsin, trypsin, carboxy-peptidases Calpain Collagenases Trimethylamine Oxide (TMAO) demethylase	Lactic acid production, flavour changes in fish flesh (nucleotide degradation), belly-bursting, colour change (black discoloration, yellowing of fish flesh, brown discoloration)
➢ Microbial	Specific Spoilage Organisms (SSO) (*Pseudomonas, Shewanella, Photobacterium, Acinetobacter, Aeromonas, Moraxella,* H_2S producing bacteria) Pathogenic bacteria: - Indigenous bacteria (*Clostridium, Vibrio* sp., etc.) - Non-indigenous bacteria (*Salmonella* sp., *Escherichia coli*, Shigella)	Loss of juiciness, firm texture, discolouration, and formation of ammonia-like off-flavours due to TMA production
Chemical	Oxidative rancidity	Rancid flavour and odour, texture changes
	Non- enzymatic oxidation	Discolouration

Speranza, B., Racioppo, A., Bevilacqua, A., Buzzo, V., Marigliano, P., Mocerino, E., Scognamiglio, R., Corbo, M. R., Scognamiglio, G., & Sinigaglia, M. (2021). Innovative Preservation Methods Improving the Quality and Safety of Fish Products: Beneficial Effects and Limits. *Foods*, *10*(11). https://doi.org/10.3390/foods10112854

Typical spoilage bacteria metabolites produces during fish spoilage



Source: Rathod, N. B., Nirmal, N. P., Pagarkar, A., Özogul, F., & Rocha, J. M. (2022). Antimicrobial Impacts of Microbial Metabolites on the Preservation of Fish and Fishery Products: A Review with Current Knowledge. Microorganisms, 10(4), 773. https://doi.org/10.3390/microorganisms10040773

Questions to Part 1:

- Why are fish and seafood regarded as “nutritious”
- Discuss briefly the different mechanisms that reduce the MARIPET BARF raw material`s quality and safety

DISCUSSION ACTIVITY

Part 2 - Catching technology and onboard handling

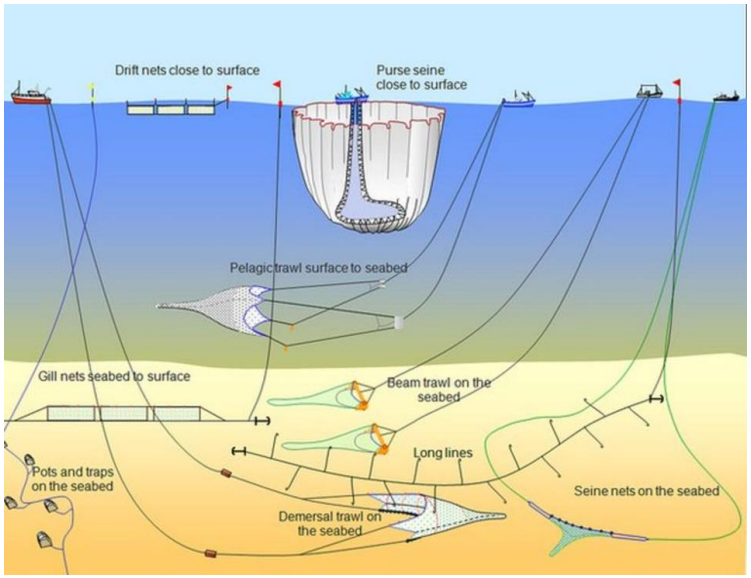
- Catching technology
- Onboard chilling (ice-, sub-, and super-chilling)
- Onboard freezing (and pre-processing thawing)
- Bulk storage and packaging concepts

Catching technologies

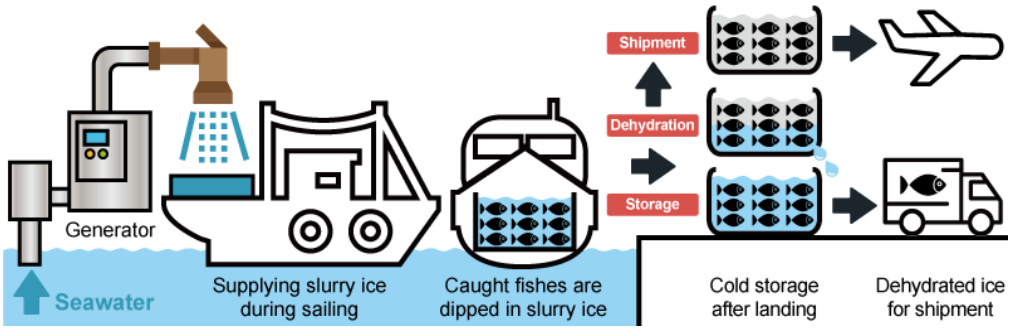
Could a technological revolution end the controversial practice of discarding fish?

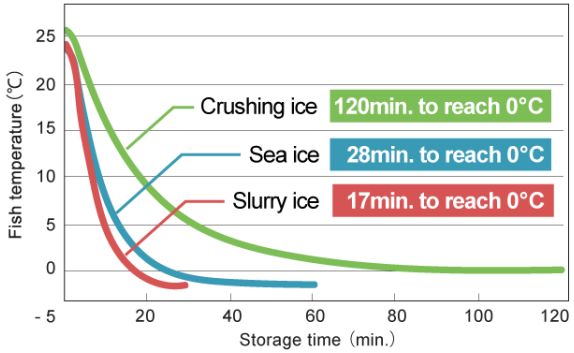
- Improved fishing net design
- Use of cameras and sensors
- Landing obligations independent of fish size and species

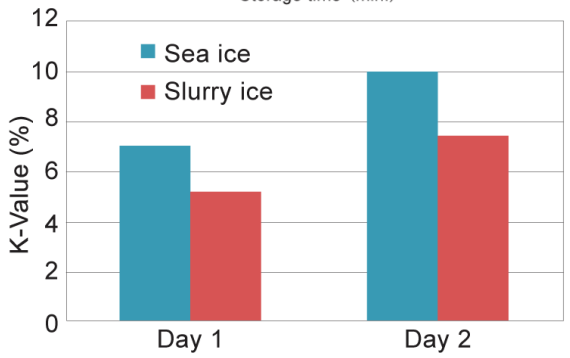
However, it is important with intensives that subsidize the cost of new technology for small boats



On-board chilling – small (<12 m) and medium size vessels (12-24 m)





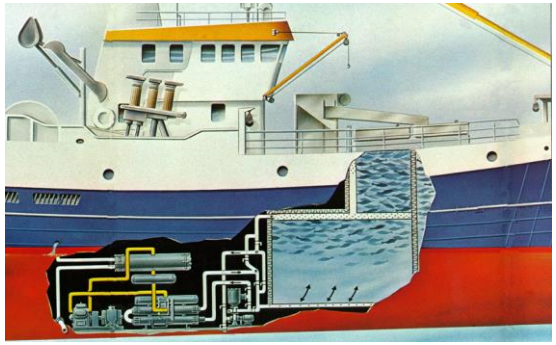


https://saramac.co.jp/technology/slurry-ice/

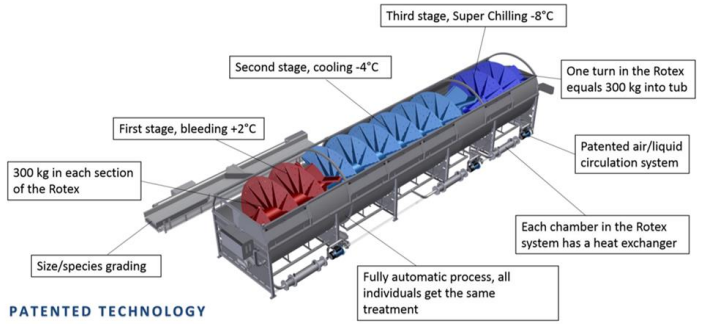
The use of slurry ice is the best option for chilling fish on board small and medium size fishing vessels

- Shorter chilling time compared to crushing wet ice and sea ice
- Slurry ice shows lower autolysis rates and improved freshness score

On-board chilling - larger fishing vessels (>24 m)



https://www.teknotherm.no/fisheries/fisheries-systems/rsw-systems/attachment/rsw-system2/



https://www.skaginn3x.com/sub-chilling-onboard

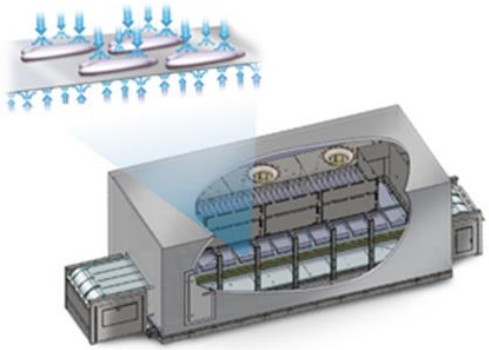
Refrigerated seawater – RSW

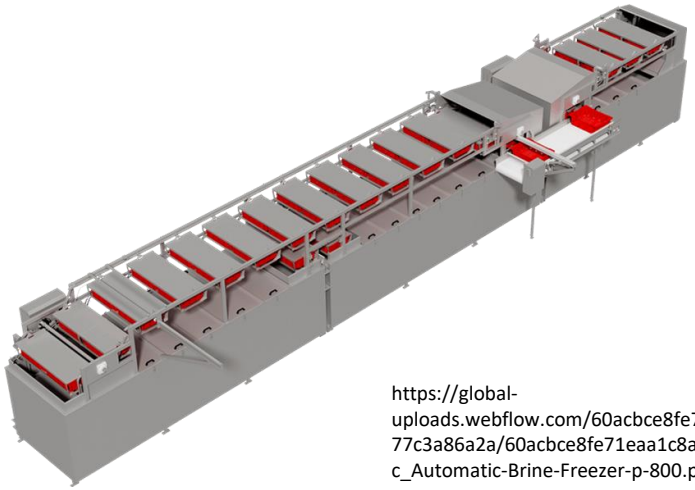
- Have the potential to chill the fish to approximately -0.5 °C without challenging the RSW compressor
- Fish could be stored sub-chilled for days if water cleaning systems are installed
- However, the chilling capacity is limited to the compressor's capacity, and the fish volume
- The fish must be sorted when landed

Sub-/super chilling

- Combine bleeding at low temperatures with a second and third cooling step (7% brine), decreasing the temperature to super chilled conditions (fish temperature of -2 °C)
- Improved autolytic and microbial stability
- Separate fish storage rooms allowing sorting or processing of fish on-board
- Improved sustainability due to less need for ice or RSW water for maintaining a low temperature (20% less transport weight)

On-board freezing options





https://global-uploads.webflow.com/60acbce8fe71ea77c3a86a2a/60acbce8fe71eaa1c8a86fec_Automatic-Brine-Freezer-p-800.png

Impingement freezer

- Impingement technology increases the surface heat transfer in air chilling
- Velocity impingement air jets break up the static surface boundary layer of air around the fish product. The resulting medium around the product is more turbulent, and the heat exchange becomes very effective

Brine freezer

- The Automatic Brine Freezer is an ideal freezing solution for seafood products tolerating high salinity. The freezer uses a strong brine solution chilled down to -17 °C with a heat exchanger.
- Immersion freezing is highly efficient as the heat transmission is 100% without any thermal barrier, resulting in an extremely short freezing time.

Other available freezing technologies

Blast freezers

- Stream of cold air is circulated at high speed over the fish, usually in a small room or a tunnel

https://global-uploads.webflow.com/60acbce8fe71ea955ca86a28/60acbce8fe71ea052ba86ce9_IQF_Freezer_singlelane_1000.png

Contact or plate freezing

- Direct contact between the fish and the refrigerated surface

https://global-uploads.webflow.com/60acbce8fe71ea77c3a86a2a/60acbce8fe71ea44aba870f9_Automatic-Contact-Freezer.png

Cryogenic freezing

- Refrigerated liquid is sprayed over the surface of the fish

https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.messer-us.com%2Ffood-freezing&psig=AOvVaw0ejJaWm8cY3g9e7qODZDLh&ust=1684934239051000&source=images&cd=vfe&ved=0CBEQjRxqFwoTCKjL_afDi_8CFQAAAAAdAAAAABAE

Bulk packaging and storage concepts

Packaging and storage concepts of discarded fish must consider available onboard technology for primary handling. However, handling the fish like the main product is essential to avoid deterioration and loss of quality. Some critical factors to consider are:

- Fish discards must be chilled properly
  - Either stored in slurry ice, on wet ice, RSW, or bulk packaged in a vacuum or a modified atmosphere (and further stored on ice or in a cold room)
- Freezing will improve flexibility related to further processing as BARF
  - Frozen fish blocks need to be stored in a freezing room
  - Blocks of frozen fish discards could be packaged in corrugated cardboard
  - Compared to vacuum plastic, the use of cardboard will reduce the CO_2 footprint

Questions to Part 2:

- Why is it important to chill the MARIPET BARF raw material as fast as possible?
- Which chilling technology would you choose onboard a small fishing boat, and why?

DISCUSSION ACTIVITY

Onboard preservation of BARF raw material (link to the CASE Pdf file)

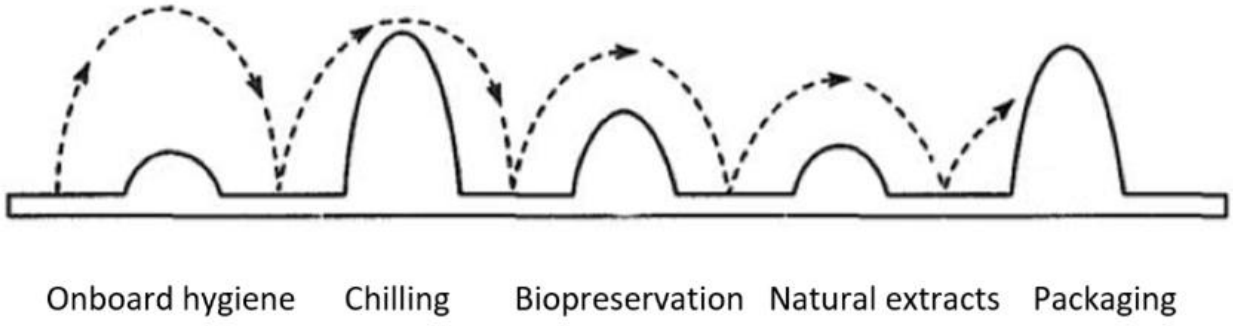
CASE STUDY ACTIVITY – CASE 1

Part 3 - Innovative processing concepts

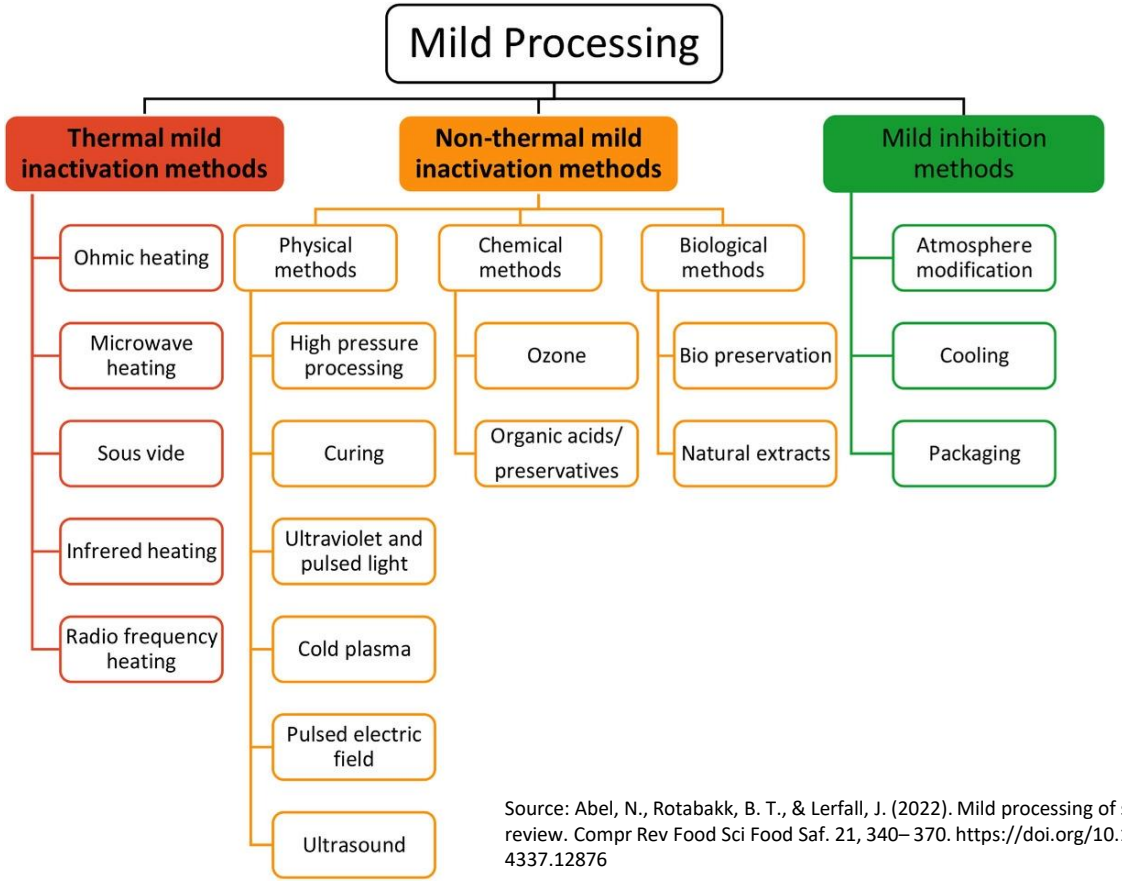
- The Hurdle concept
- Mild processing technologies

The hurdle concept

The concept of hurdle technology combines preservation technologies (called hurdles) to get maximum lethality against microorganisms and at the same time keep the damage to the food/feed nutritional quality at the minimum



Mild processing technologies



Source: Abel, N., Rotabakk, B. T., & Lerfall, J. (2022). Mild processing of seafood—A review. Compr Rev Food Sci Food Saf. 21, 340– 370. https://doi.org/10.1111/1541-4337.12876

Questions to Part 3:

- Discuss the concept of “Hurdle technology” briefly
- How can a “hurdle technology” concept be applied in producing a MARIPET BARF product?

DISCUSSION ACTIVITY

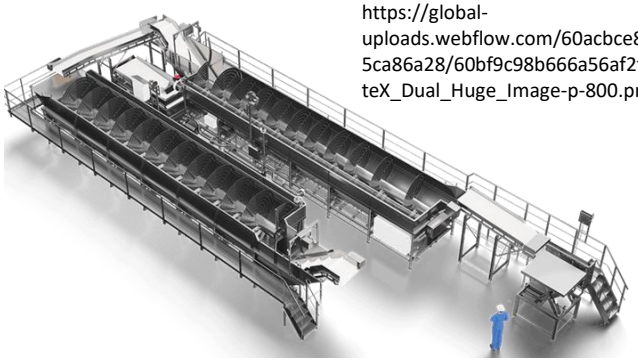
Part 4 - BARF processing technologies

- Thawing
- Additives (inorganic additives, organic acids, natural extracts)
- Fermentation and bio-preservation
- Drying and freeze-drying

Thawing of frozen fish discards for BARF production

Thawing is physically the opposite process to that of freezing. The heat flow is reversed and directed into it instead of extracting heat from the product. Although opposite processes, thawing is more difficult to carry out concerning predictability and controllability. Thawing consists of two phases:

- Tempering phase
- Latent zone



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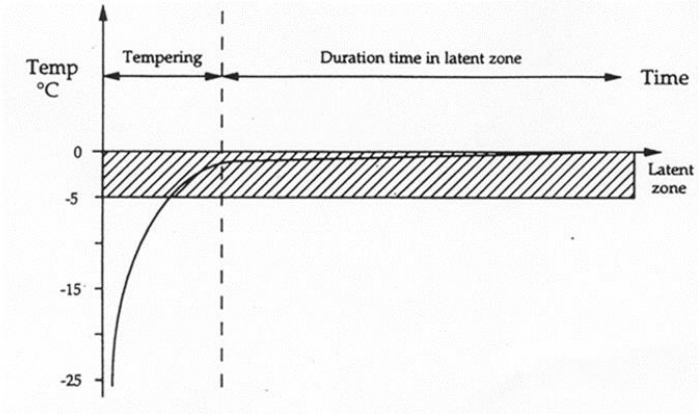


The clue is to use less time in the latent zone because of high enzyme activity. Enzymes will be active in the muscle water phase increasing autolysis and fish deterioration.

Additives

Inorganic additives

- Natural or synthetic made minerals
- NaCl
- Nitrites
- Sulphates

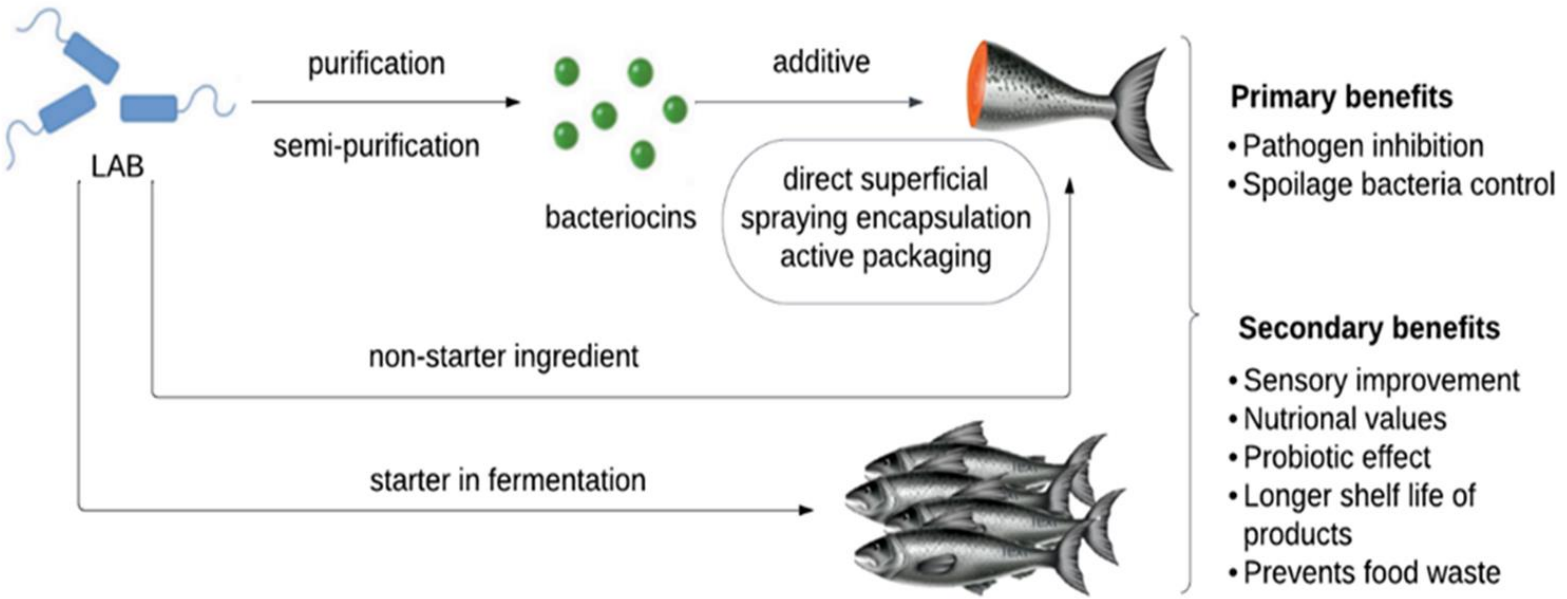
Organic acids

- Can occur naturally (by-product from fermentation (lactic acid)) or added during food processing
- Examples:
  - Lactic acid
  - Citric acid
  - Formic acid
  - Propionic acid
  - Sorbic acid
  - Benzoic acid

Natural extracts

- Derived from plant tissues like roots, leaved, fruits in a two stage extraction process
- Antimicrobial effect
- Example sources:
  - Fruit peels
  - Spices
  - Seaweed

Fermentation and biopreservation



Source: Modified from Barcenillaet al (2022) Application of lactic acid bacteria for the biopreservation of meat products: A systematic review, Meat Science, Volume 183 https://doi.org/10.1016/j.meatsci.2021.108661.

Requirement for strains used biopreservation of food and feed products

The figure is modified from Ghanbari et al (2013) LWT 54(2) 315-324https://doi.org/10.1016/j.lwt.2013.05.039.

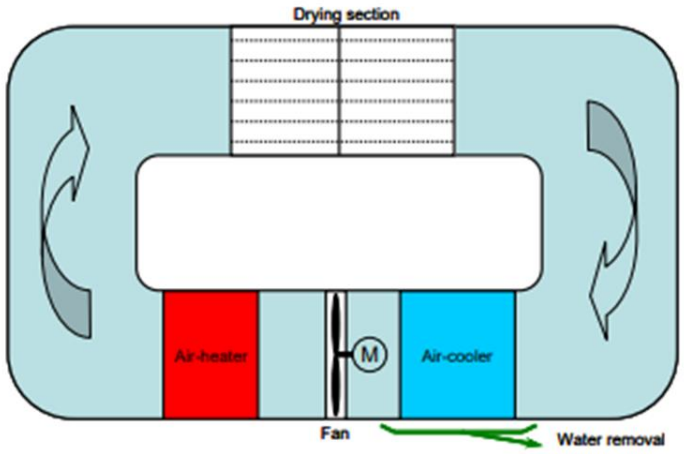
- *Safety:* GRAS-organisms safe for animals and humans
- *Stability and compatibility:* LAB must survive, grow and produce desired metabolites in the raw material, process and storage conditions used
- *Antimicrobial activity and effectivity:* LAB must produce desired antimicrobial metabolites effectively under the applied conditions

Tunnel drying

In tunnel drying, the raw material is placed at one end of an air-heated tunnel and dried continuously before being collected at the other end of the tunnel.

Parameters affecting the drying rate:

- Temperature
- Air moisture
- Rate of airflow



Advantages	Disadvantages
Easy to control the drying parameters	Time consuming => costly
Can dry large amounts of materials	Not suitable for thermolabile products

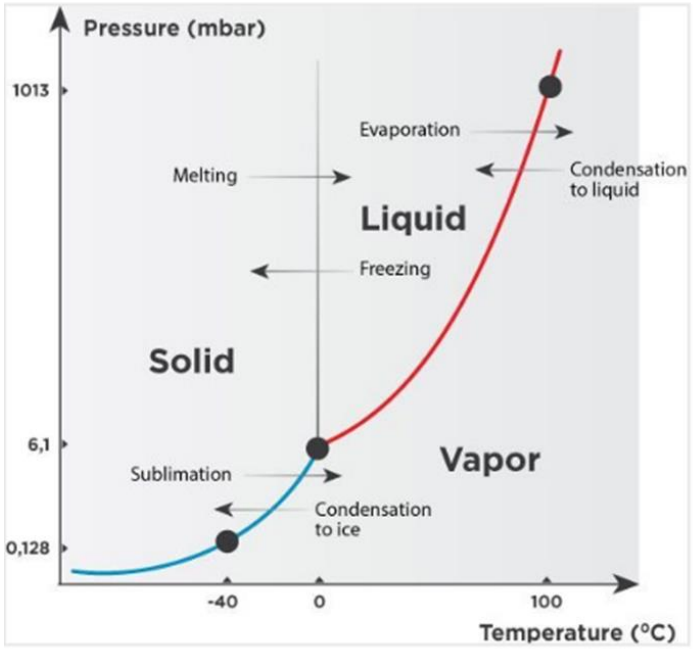
Freeze drying

Freeze drying is also called lyophilization and is a low-air drying process where the water is removed in the form of ice.

Three stages of freeze drying:

1. Freezing of raw material
2. Primary drying
3. Secondary drying

Advantages	Disadvantages
Prevents oxidation due to low temperature	Time consuming
Heat sensitive components such as vitamins, antibiotics, microbial culture can be preserved	Energy inefficient



Questions to Part 4:

- Considering a MARIPET BARF product that should be distributed as fresh – which processing technologies would you consider applying to obtain a product with a sufficient shelf-life of, e.g., 3-4 weeks?
- Discuss briefly the benefits and challenges related to
  - i) a frozen MARIPET BARF product
  - ii) a dried MARIPET BARF product

DISCUSSION ACTIVITY

BARF processing (link to the case Pdf file)

CASE STUDY ACTIVITY – CASE 2

Part 5 - Packaging and distribution of BARF

- User-friendly packaging and distribution concepts
- Active packaging solutions

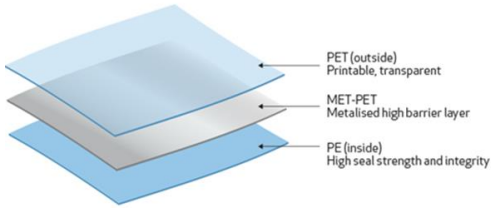
User-friendly packaging concepts

Distribution of frozen BARF products increase the product flexibility and shelf life

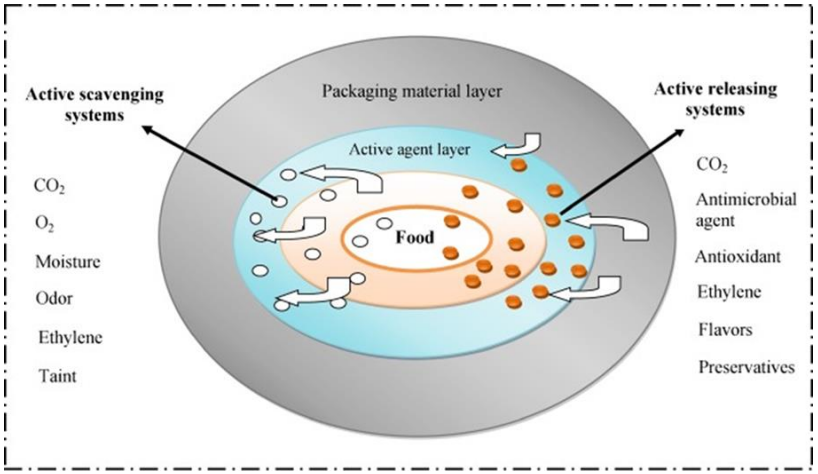
- The BARF must be portion-sized to meet user requirements and reduce BARF loss (vested BARF)
- Packaging materials with excellent barrier properties related to gas and water diffusion and sealing properties must be selected. Typical materials are;
  - Polyamide (PA)
  - Polyethylene (PE)
  - Polyethylene terephthalate (PET)
  - Ethylene vinyl alcohol (EVOH)
  - Polyvinylidene chloride (PVdC)
  - Metalized materials (e.g., MET-PET)

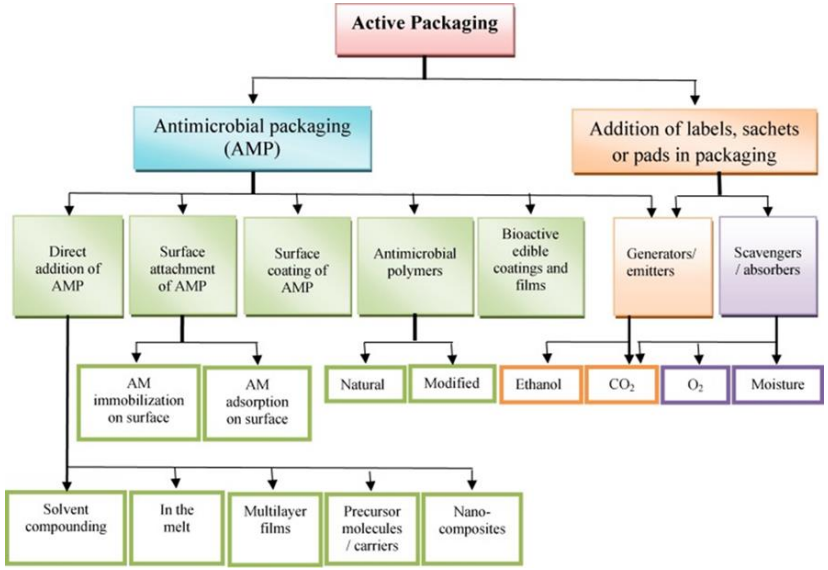
Good barriers can be achieved by using multilayer packaging materials, such as:

- PP/EVOH/PP
- PA/PE/EVOH/PE
- PE/EVOH/PE
- PP/EVOH/PE
- PET/MET-PET/PE



Active packaging solutions





https://www.sciencedirect.com/science/article/pii/S0956713517303006#fig1v

Active packaging can extend the shelf life and improve product quality by influencing processes such as the oxidation of fish, oils, and fats and microbiological spoilage due to bacteria, fungi, and yeast. It employs technology that intentionally releases or absorbs compounds from the food or the headspace of food packaging, which extends the shelf life of products by stalling the degradative reactions of lipid oxidation, microbial growth, and moisture loss and gains better than traditional food packaging. The use of an active packaging concept can reduce the risk of foodborne pathogens and improve the quality and safety of food products in general.

Questions to Part 5:

- Discuss briefly potential packaging solutions for the MARIPET BARF products
- How can active packaging solutions improve the sustainability of the packaging concept?

DISCUSSION ACTIVITY