Food and Agriculture Organization of the United Nations

FMM/RAS/298: Strengthening capacities, policies and national action plans on prudent and responsible use of antimicrobials in fisheries Final Workshop in cooperation with AVA Singapore and INFOFISH

12-14 December, Concorde Hotel, Singapore

Fish Waste Management :

Turning fish waste into healthy feed

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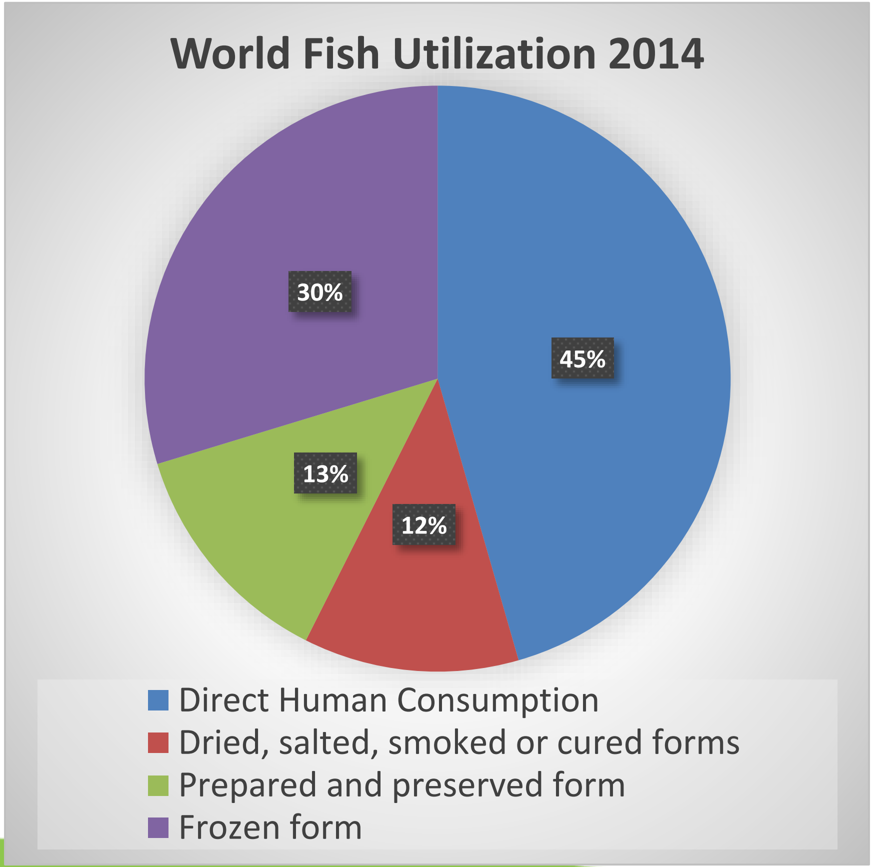
Fish Silage and AMR

- Use of fish silage in treating dead fish to prevent spreading of disease

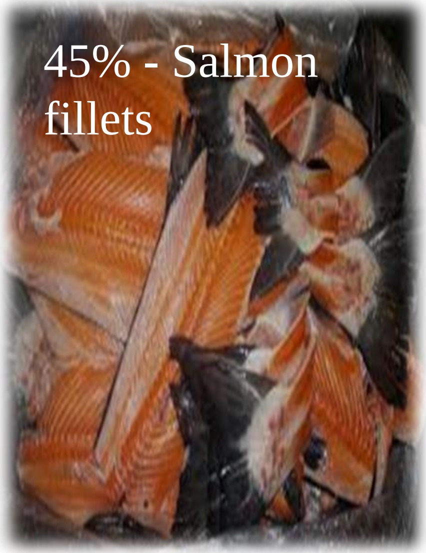
- Fish silage as antimicrobial product to reduce use of antibiotic and to promote healthy immune system of fish

FISH PROCESSING

- 55% is processed
- Most common in industrial fisheries and with larger species
- Less processing in small scale fisheries or with smaller species 20 – 80% waste generated



Fish Processing Byproducts



Fish Processing Byproducts

14% in Atlantic salmon
10% in coho
8% in trout
3 to 5% in carp
9.5% milkfish

10.1% in milkfish
2.0% in Atlantic salmon
1.2% in trout

Fish Processing Byproducts

- Contains:
  - Proteins
  - Ether extract or fat
  - Minerals
  - palmitic acid, stearic acid, oleic acid and DHA

Fish Waste Byproducts Utilization

2025, fish meal produced from fish waste will represent 38% of world fish meal production, compared with 29% for the 2013 to 2015 average level

Fish Oil : 0.856 million tonnes produced on 2015

Raw materials used for production of fishmeal and fish oil in 2015

- Whole fish 13.9Mt
- By-product from wild capture 3.75Mt
- By-product from aquaculture 1.94Mt

Source: Institute of Aquaculture, University of Sterling and IFFO, July 2016.

Fish Waste Byproducts Utilization

Fish Collagen/Gelatin

Fish Sauce

Fish Leather

Fish Silage

What is fish silage?

- minced fish or parts of fish, added a preservative stabilizing the mixture
- a liquid solution where proteins are pre-digested, but with a nutrient composition similar to fishmeal

Why make fish silage?

- simple
- does not require huge investments
- product can be preserved for longer periods, even years
- waste problem can be converted into profit

Production of Silage

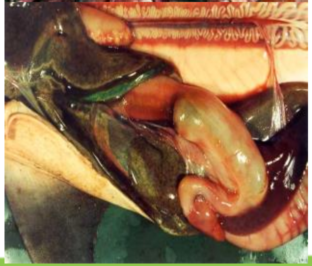
Raw Material

What can be used for fish silage production

- whole fish
- parts of fish
- important to include viscera

Condition of raw material

- Fresh
- Raw



Use of acid

- organic or inorganic
- organic: formic acid, ensure a stable and storable product
- inorganic: lower cost, but will require a lower pH
- lactic acid bacteria fermentation: complicated and requires a closer follow up

Principles

Enzymatic degradation

•digestive system

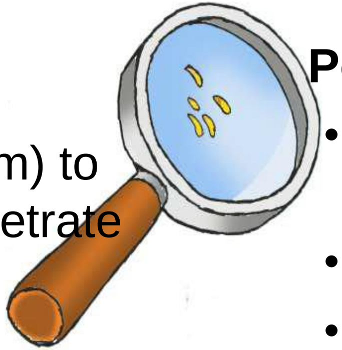
•breaks down the proteins to peptides and amino acids

•pH of 3.5 to 4.0

•temperature 5 to 40°

Particle size

•small enough (max 1mm) to ensure the acid can penetrate all cells



Quality Control

- raw material
- pH
- effect of fish bones
- storage

Potential Problems

- variations in the raw material
- high levels of bones
- undissolved bones

Safety

- handling of any acid
- protective glasses/safety face shield
- acid resistant gloves
- rubber boots
- protective clothing

Equipment

Grinder

- small enough to enable the preservative (acid) to enter into the heart of the particle

Pump

- move silage
- for circulating the product

✓ to ensure all fish particles are exposed to acid and enzymes which transforms the fish into silage

Mixing Tank

- made of an acid resistant material: plastic, fiberglass or stainless steel

Storage Tank

- stable the pH of the product
- resistant to corrosion
- galvanized materials should not be used: lead to the development of some toxic components.

Storage of Silage

Shelf life

- can be stored for years

Quality Assurance

- regular control, maintenance and cleaning of the equipment
- regular stirring of silage
- pH control

Separation of oil

- warmer climates, the fat/oil will float on top of the silage
- decantation
- antioxidant

Separation of bones

- high levels of bones = higher consumption of acid
- removed from the tank on a regular basis

Silage Production Process

Processing → **Waste segregation** → **Grinding** → **Stir** → **Addition of acid** → **Storage**

Utilization of Silage

Directly as feed

- relatively low acidity
- pigs: resulting in higher growth rates, improved health and reduced mortality

Mixed with other feed ingredients

- will not require any further processing
- retain all the nutritional and health benefits

Utilization of Silage

Use in pellet production and extruded feeds

- partially replaces fish meal in feeds (typically 5-15%)
- high level of free amino acids and peptides: improve the growth performance
- stronger and more resistant

Fertilizer

- if it does not meet the quality requirements for feed purposes
- good source of Nitrogen (from the protein)
- source of Phosphorus, Potassium, Calcium, Magnesium (particularly from the bone structure)
- most trace element needed for plants
- part of the irrigation process (adding 5-10 % liquid silage)

Antimicrobial Product

- During storage, endogenous, proteolytic enzymes break down the tissue protein to low molecular weight peptides and amino acids

- Peptides have antimicrobial properties

Table 2: Overview of antimicrobial peptides from fish known to date

Fish	Name	Length	Activity
Anguilla japonica	Ajl-2	142	Antibacterial
Ctenopharyngodon idella	LEAP	78	Antimicrobial
Danio rerio	hepcidin 1	20	Antimicrobial
Dicentrarchus labrax	Dicentracin	22	Antimicrobial
Epinephelus coioides	Epinecidin	25	Antimicrobial
	Hepcidin		
Glyptocephalus cynoglossus	Pleurocidin-like peptides	26	Antimicrobial
Grammistes sexlineatus	Grammistins	26	Antibacterial
Hippoglossoides platessoides	Pleurocidin-like peptides	26	Antimicrobial
	Hipposin	51	Antibacterial
Ictalurus punctatus	histone-like protein	20	Antimicrobial
	LEAP	73	Antimicrobial
Lateolabrax japonicus	Hepcidin-like peptide	21	Antimicrobial
Limanda ferruginea	Pleurocidin-like peptides	25	Antimicrobial
Misgurnus anguillicaudatus	Misgurin	21	Antimicrobial
Morone chrysops	Moronecidins	23	Antimicrobial
Morone chrysops x Morone saxatilis	Hepcidin	21	Antibacterial
	Moronecidins	22	Antimicrobia
Morone saxatilis	Moronecidins	23	Antibacterial
Myxine glutinosa	HAP	38	Antimicrobia
Oncorhynchus mykiss	Salmocidins	13	Antibacterial
	Oncorhyncins	69	Antibacterial
	Histone H2A	12	Antimicrobia
	β-defensin 1	60	Antibacterial
	Hepcidin	25	Antibacterial
	LEAP2B	77	Antimicrobial
Pagrus major	Chrysophsins		
	hepcidin	85	Antimicrobial
Pardachirus marmoratus	Pardaxin P	33	Antimicrobial
Pelteobagrus fulvidraco	LEAP	78	Antimicrobial
Petromyzon marinus	CRP	19	Antimicrobial
	Pleurocidin-like peptides	21	Antimicrobial
Salmo salar	SAMPH1	30	Antibacterial
Silurus asotus	Parasin I	19	Antibacterial
Siniperca chuatsi	Moronecidin	22	Antibacterial

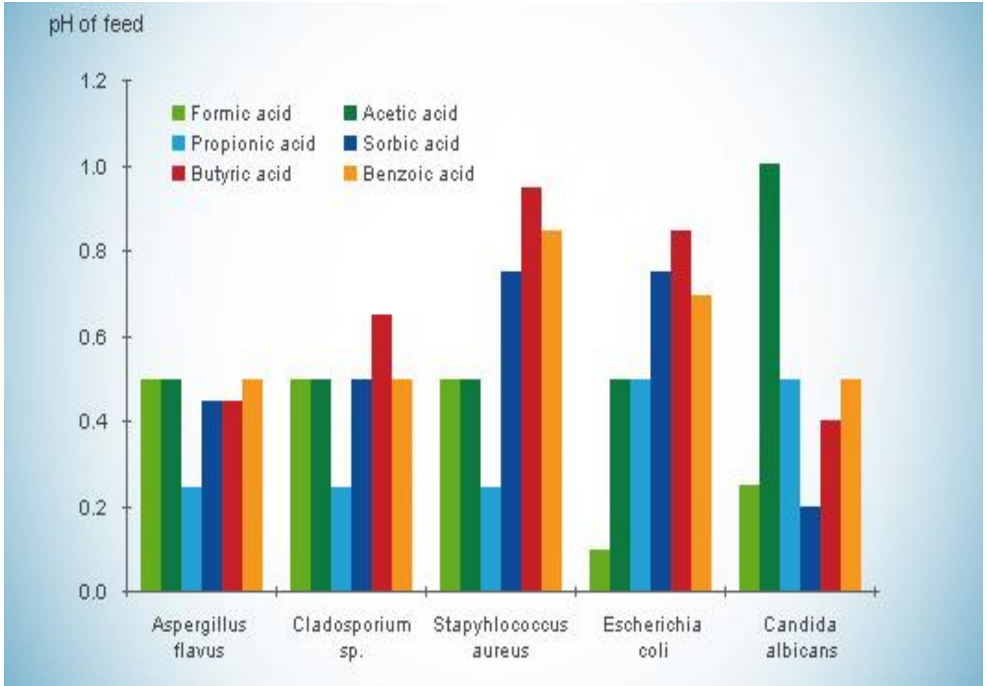
Abbreviations: LEAP: liver-expressed antimicrobial peptide, HAP: hematopoietic antimicrobial peptide, CRP: Corticostatin-related peptide. Antimicrobial differs from Antibacterial by fungal activity.

Desriac F, Jégou C, Brillet B, Le Chevalier P, Fleury Y. Antimicrobial Peptides from Fish. Boca Raton: CRC Press; 2013:106–41

Organic acid

- Use in animal nutrition due to their strong antimicrobial effect
- Antibacterial effects = pathogenic Gram-negative bacteria

Minimum inhibitory concentration (MIC values) of selected organic acids for various microorganisms



http://www.basfanimalnutrition.de/en/news_2013_11_01.php

(Coelho, 1989)

Fish Silage Processing Method (FSPM)

Fish Silage Processing Method (FSPM)

Ensilation :

- pH ≤ 4.0
- Formic acid
- Incubation : ≥ 24 hours
- ≤ 10mm

Heat treatment :

- ≥ 85˚C
- ≥ 25 minutes

- Processed into fish oil, protein water and protein concentrate
- Agricultural fertilizers
- Biofuels
- Feed for fur, zoo, pet, circus animals

Fish Silage Processing Method (FSPM)
Prevent spreading of disease

Effective against:

- Non-spore forming bacteria
- Clostridium perfringens
- Moulds
- Saprolegnia (cotton moulds)
- Parasites
- Viruses

Non-spore forming bacteria

Salmonella

- 85˚C for 1 minute
- Formic acid, pH 4.0-4.1, 24 hours = 4 log reduction

Enterobacteriaceae

- 80-85ºC for 30 minutes

- *Listeria monocytogenes*
- *Mycobacterium*
- *Vibrio*
- *Lactococcus garvieae*
- *Aeromonas*
- *Francisella*

Spore forming bacteria

- *Clostridium botulinum*
  - Inactivation of toxin:
    - heat treatment at 79˚C for 20minutes
    - 85˚C at 5 minutes
- *Clostridium perfringens*
  - 85˚C, pH ≤ 4.0, 25 minutes

Viruses

- Infectious pancreatic necrosis – a viral disease usually associated with salmonids
- IPNV - among the most resistance virus
- **99.999% inactivation after 30 minutes at 60˚C, pH 3.0**

Moulds

- Saprophyte or pathogen
- Fish fungal pathogens:
  - *Aphanomyces invadans*
  - *Aphanomyces astaci*
  - *Icthyophonus hoferi*

Aphanomyces invadans

Icthyophonus hoferi “spores” in hearts

soft abdominal cuticle caused by *Aphanomyces astaci* infection

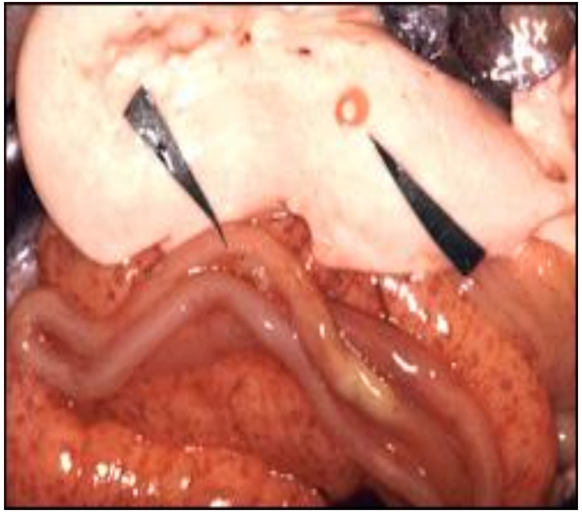
Moulds

- Fungi affecting fish are strictly aquatic
- Cannot survive outside an aqueous environment
- Negligible levels at > 40˚C

FSPM method will inactivate fungi and Saprolegna

Parasites

- 85˚C will kill any parasites possibly found in farmed or wild living fish
- 60 to 77˚C – sufficient to destroy any known parasites



Anisakis larvae

FSPM method will inactivate all known types of parasites

Mycotoxins

- Heat stable
- Knowledge on toxicokinetics of mycotoxins in fish is scarce
- No knowledge of potential effect of mycotoxins from fish on animal or human health
- No evidence that mycotoxins are more associated with waste of fish origin than healthy fish slaughtered for human consumption

FSPM method will not inactivate mycotoxins, however it has not been shown that mycotoxins from fish may pose a hazard to animal or human health

Prions

- Transmissible Spongiform encephalopathy (TSE)
- Proteinous particles able to give infection in mammals, including human.
- Maintain infectivity after heat treatment, irradiation and exposure towards disincentive agents

FSPM method will not inactivate potential prions in by products from fish, however it is not likely that prions from fish may pose a hazard to animal or human health

Antibiotic Resistance Genes

- DNA fragments degradation in acidified and heat treated foods
- Experiment (Bauer et al., 2003) pH 4.3, 65C = 99% degradation observed within 90 minutes
  - Main factor = low pH

Free DNA will most probably not retain its functionality after FSPM method, such DNA would not be able to transfer antibiotic resistance

AMR and Fish Silage Management

- Workshop and Training on Fish Silage Production (July 2017 in Manila Philippines)
- On-going feasibility study on the potential production and utilization of fish silage
- Fish Silage Manual (for publication)

Prospect and Future Actions

- Creation of web-based platform for exchange of ideas and information on fish waste utilization
- More capacity building and training on fish silage technology
- Scaling up and commercialization/ potential markets







nicht blutend
pH 0 - 14
MERCK
0 1 2 3 4 5 6 7

FAO Project "Strengthening capacities, policies and national action plans on prudent and responsible use of antimicrobials in fisheries"

03-07 July 2017 Manila, Philippines

Thank you

Contact us
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