TECHNICAL ASSISTANCE TO BUILD FOOD SAFETY CAPACITY

FOR THE FISHERIES SECTOR

Cleaning and Sanitation in Fish Processing

Train-the-Trainer Course for Ocean Delight, Suriname

Prepared by: Megapesca Lda Portugal

Outline

- The importance of effective cleaning and disinfection in fish processing.
- How the composition of fish waste can impact effective cleaning.
- How biofilm formation can affect sanitation processes.
- Specific examples within the food industry.
- The Science behind ATP hygiene monitoring and using verification data to improve sanitation processes.

Poor sanitation and hygiene can have an adverse effect on the safety and quality of the final product that reaches the consumer

Effective cleaning and disinfection reduces the chance of contamination during fish processing

Fish Type	Fat (%)	Ash (%)	Protein (%)	Moisture (%)
Catfish	7.7	0.9	15.4	76.3
Cod	0.1	1.1	18.2	80.8
Flounder	0.7	1.3	14.0	84.6
Mackerel	11.7	1.1	18.8	69.0
Salmon	1.6	1.1	23.5	74.3

Table 11: Composition of the fish fillets determined by standard methods [39].

Nutrient	Fish waste
Crude protein (%)	57.92 ± 5.26
Fat (%)	19.10 ± 6.06
Crude fiber (%)	1.19 ± 1.21
Ash (%)	21.79 ± 3.52
Calcium (%)	5.80 ± 1.35
Phosphorous (%)	2.04 ± 0.64
Potassium (%)	0.68 ± 0.11
Sodium (%)	0.61 ± 0.08
Magnesium (%)	0.17 ± 0.04
Iron (ppm)	100.00 ± 42.00
Zinc (ppm)	62.00 ± 12.00
Manganese (ppm)	6.00 ± 7.00
Copper (ppm)	1.00 ± 1.00

Values in % or mg/kg (ppm) on a dry matter basis.

Table 12: Composition of fish waste [40].

Fish Processing Wastes as a Potential Source of Proteins, Amino Acids and Oils: A Critical Review

Ghaly et al., 2013

Food constituents are markedly different in their solubility characteristics and in their susceptibility to cleaning .

COMPONENT ON SURFACE	SOLUBILITY CHARACTERISTICS	EASE OF REMOVAL	CHANGES INDUCED BY HEATING SOILED SURFACE
Sugar	Water soluble	Easy	Caramelization, more difficult to clean
Fat	Water insoluble, alkali soluble	Difficult	Polymerization
Protein	Water insoluble, alkali soluble, slightly in acid	Very difficult	Denaturation, much more difficult to clean
Salts Monovalent	Water soluble, acid soluble	Easy	None
Polyvalent (i.e CaPO4)	Water insoluble, acid soluble	Difficult	Interactions with other constituents, more

Cleaning and Disinfection

What is cleaning?

The application of energy to a surface to remove dirt and/or grease.

Energy can be:

- Kinetic – physical, mechanical or turbulence
- Thermal – hot water
- Chemical – detergents

REMINDER

The importance water quality in food processing

- The chemistry of the water, the hardness in particular, greatly affects the performance of cleaning chemicals and can be corrosive to materials

- Water can also contain a significant number of microorganisms. Water used for cleaning and sanitizing must be potable and pathogen-free

- When used in food processing it must be free from undesirable color, odor, taste, and impurities that are harmful to consumers and result in low-quality products

- Unsafe water, which results due to direct contamination or improper or inadequate water treatment processes, generally results in a contaminated food product.

Water hardness affects cleaning performance

- Hard water is high in dissolved minerals (particularly calcium and magnesium)
- Presents a major problem for cleaners by reducing their effectiveness and forming surface deposits → forms film, scale or precipitates
- Increases detergent consumption → MORE NEEDED TO GET THINGS CLEAN

The chemicals used as cleaning compounds can be grouped into classes as follows:

CLASS OF COMPOUND	MAJOR FUNCTIONS
Basic Alkalis	Soil displacement/emulsifying, saponifying and Peptizing
Complex phosphates	Soil displacement by emulsifying and peptizing; dispersion of soil; water softening, prevention of soil depositions.
Surfactants	Wetting and penetrating soils; dispersion of Soil and prevention of soil redepositions.
Chelating	Water softening; mineral deposit control; soil displacement by peptizing; prevention of redepositions.
Acids	Mineral deposit control; water softening.

The surface should be considered

- The nature of the surface to be cleaned (stainless steel, aluminum, ceramic, metal) should be considered when selecting cleaning agent
- Compatibility with cleaning agent important
- Eg Acid detergents (pH 1 to 6) can be used for cleaning ceramic surfaces but can corrode metal surfaces

Examples of commonly used sanitizers/disinfectants in the food industry

Halogens	Iodine-containing agents
	Chlorine-containing agents (e.g., sodium hypochlorite), chlorine dioxide
Surface-active agents	Quaternary ammonium compounds (QACs) e.g., benzalkonium chloride (BAC), didecyldimethylammonium chloride (DDAC)
	Amphoterics
	Acid anionics
Peroxy compounds	Hydrogen peroxide
	Peroxyacetic acid

Chemical Sanitizer	Concentration/ Contact Time	Advantages	Disadvantages
Chlorine	50 mg/L in water between 75 °F (24 °C) and 100 °F (38 °C) for 7 seconds	• effective on a wide range of bacteria • not affected by hard water salts • generally inexpensive	• corrosive, irritating to the skin • effectiveness decreases with increasing pH of solution • deteriorates during storage and when exposed to light • dissipates rapidly • loses activity in presence of organic matter
Iodine	Follow manufacturer's use directions; contact time at least 30 seconds	• forms brown color • not affected by hard water salts • less irritating to skin than chlorine • active against a wide range of non-spore-forming bacteria • activity not lost as rapidly as chlorine in presence of organic matter	• bactericidal effectiveness decreases greatly with increase in pH (most active at pH 3.0 and very low acting at pH 7.0) • less effective against bacterial spores and bacteriophages than chlorine • may discolor equipment and surfaces
Quaternary Ammonium Compounds	Follow manufacturer's use directions; contact time at least 30 seconds	• nontoxic, odorless, colorless, noncorrosive, nonirritating • stable in the presence of heat, relatively stable in the presence of organic matter • active over a wide pH range • active against thermoduric organisms	• slow destruction of coliform and psychrophilic organisms • incompatible with anionic detergents and hard-water salts • ineffective against bacteriophages

Table 1. Details for Chemical Sanitizers Commonly Used in Retail/Foodservice Establishments

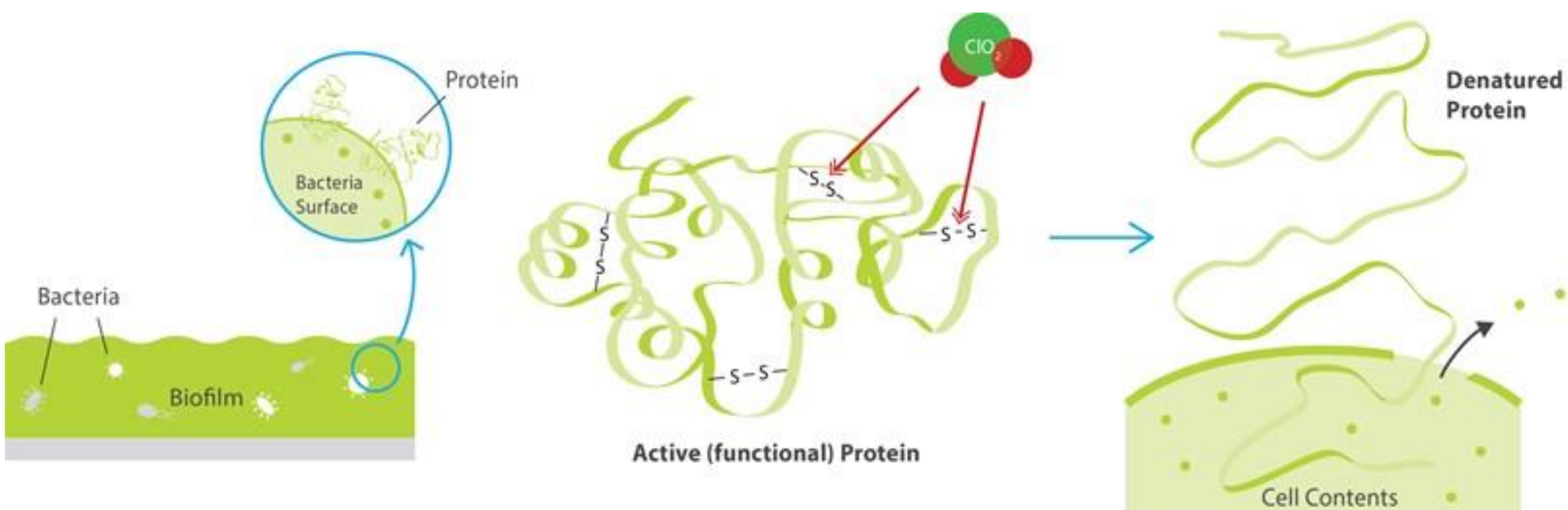
Composition of cleaning/disinfecting products

Component	Concentration (*w*/*w* %)	Examples of Compounds
Disinfectant (active substance)	0.1–10	Benzalkonium chloride, Sodium hypochlorite
Surfactant	0.1–10	Benzenesulphonic acid, dodecyl-, sodium salt
Base	0.1–25	Sodium hydroxide, Potassium triphosphate
Complexing agent	5.0–30	Pentasodium triphosphate, EDTA
Corrosion inhibitor	1.0–10	Disodium metasilicate
Solvent	0.1–10	2-Propanol
Perfume	0.002–1	Citrus oils, eucalyptus oil
Pigment	0.01–2	
Acid	0.1–35	Phosphoric acid, Citric acid
Diluent	15.0–95	Water

Wolkoff et al., 1998

The mechanisms of action of disinfectants

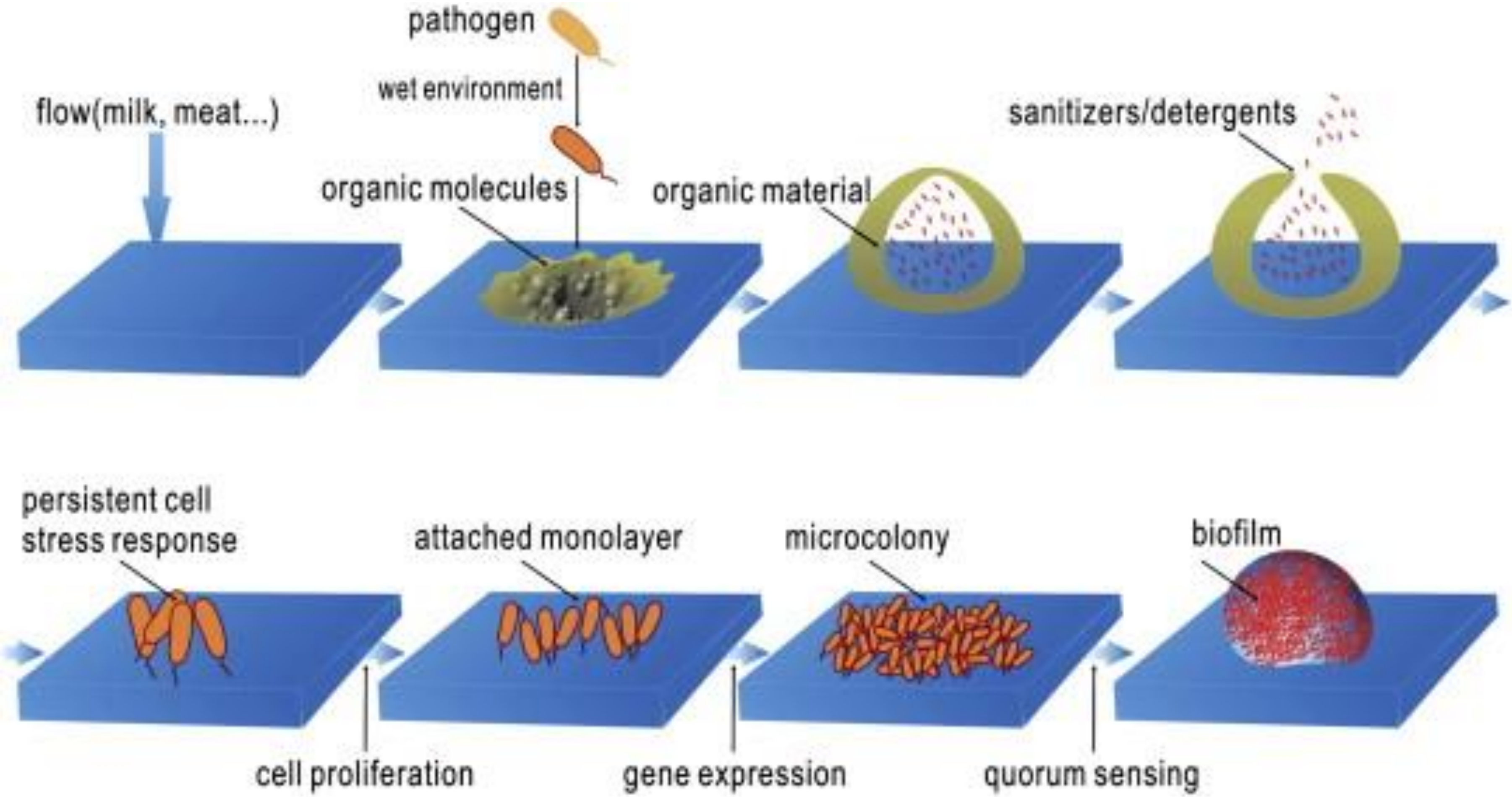
Aldehydes	Mutually bind to proteins, inhibit transport mechanisms
Halogens (hypochlorite, iodophors, ClO_2)	Penetrate the membrane and oxidise proteins, interrupt the cell's oxidative phosphorylation
Peroxides	Penetrate the membrane and oxidise lipids, proteins, and DNA
Phenolics	Poison the protoplasm and damage the cellular membrane
Quaternary ammonium compounds (QUATs)	Damage the cellular membrane and disrupt the membrane, cytoplasmic potential and pH gradient
Biguanides	Damage the cellular membrane and coagulate intracellular constituents



How biofilm formation can affect sanitation processes

What is a biofilm?

- *A biofilm forms when a community of microorganisms irreversibly adheres to a surface in a moist environment and reproduces.*
- The microorganisms form an attachment to the surface by secreting a slimy, glue-like substance.
- In fish processing, it is possible that biofilms that form may contain pathogenic microorganisms, such *Listeria monocytogenes*, *Salmonella* spp., *Vibrio* spp., *Bacillus* spp., *Aeromonas* and *Pseudomonas* spp.



Biofilms in fish processing. Rajkowski (2009).

Biofilm formation can affect fish quality

- Formation of a microbial biofilm on the surface of fish processing equipment increases the threat of cross contamination of final product.
- Can influence quality and safety of final product, especially if specific spoilage organisms (SSO) or pathogenic bacteria become dominant population in biofilm.

Bacterial resistance

- Biofilm cells are more resistant to cleaning and disinfection processes in the food industry.
- It has been found that some bacteria (e.g. *Pseudomonas* spp.) may have resistance mechanisms against antibacterial components commonly used in disinfectants such as quaternary ammonium compounds

Decontamination Efficiency of Fish Bacterial Flora from Processing Surfaces

Eyjólfur Reynisson[1,3]*, *Birna Guðbjörnsdóttir*[2], *Viggó Þór Marteinsson*[1] and *Guðmundur Óli Hreggviðsson*[1,3]

[1]Matis, Gylfaflöt 5, IS-112 Reykjavík, Iceland

[2]Icelandic Fisheries Laboratories, Skúlagata 4, IS-101 Reykjavík, Iceland

[3]The University of Iceland, Sæmundargötu 2, IS-101 Reykjavík, Iceland

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Summary

There are numerous parameters that can influence bacterial decontamination during washing of machinery and equipment in a food processing establishment. Incomplete decontamination of bacteria will increase the risk of biofilm formation and consequently increase the risk of pathogen contamination or prevalence of other undesirable microorganisms such as spoilage bacteria in the processing line. The efficiency of a typical washing protocol has been determined by testing three critical parameters and their effects on bacterial decontamination. Two surface materials (plastic and stainless steel), water temperatures (7 and 25 °C) and detergent concentrations (2 and 4 %) were used for this purpose in combination with two types of detergents. Biofilm was prepared on the surfaces with undefined bacterial flora obtained from minced cod fillets. The bacterial flora of the biofilm was characterised by cultivation and molecular analysis of 16S rRNA genes. All different combinations of washing protocols tested were able to remove more than 99.9 % of the bacteria in the biofilm and reduce the cell number from 7 to 0 or 2 log units of bacteria/cm^2. The results show that it is possible to use less diluted detergents than recommended with comparable success, and it is easier to clean surface material made of stainless steel compared to polyethylene plastic.

Specific cleaning and sanitation examples

Prevalence of enteric isolates associated with food handlers and surfaces of a food manufacturing plant in Pakistan

Table 1. Swabs samples collection frequency from food handlers and surfaces.

Categories	Variables	Collected swabs (n = 3499)
Plan surfaces	Floors, doors and walls	1175
Personals care/PPEs	Uniforms, hairnets, hands, papers and shoe covers	566
Machines/ Equipments	Ball mills, grinders, holding tanks, hoppers, weighing scales, Air conditions, products lining/ pipes	957
Product Carriers	RM (raw material) buckets, bags, cups, trolleys, packaging cartons and wrappers	801

Table 2. Prevalence of *Enteric* isolates (*Enterobacteriaceae, Coliforms* and *E. coli*) associated with food handlers and surfaces of food industry.

Categories	**Variables**	**No. of examinations**	**No. of detected isolates/ Percent**	**No. of individual detected isolates/ Percent**		
				Enterobacteriaceae	*Coliforms*	*E. coli*
Plan surfaces	Floors	1350	398/ 29.5	195/ 49.0	123/ 30.9	80/ 20.1
	Doors	1275	252/ 19.8	132/ 52.4	74/ 29.4	46/ 18.3
	Walls	900	105/ 11.7	51/ 48.6	31/ 29.5	23/ 21.9

Categories	Variables	No. of examinations	No. of detected isolates/ Percent	No. of individual detected isolates/ Percent		
				Enterobacteriaceae	*Coliforms*	*E. coli*
Machines/ Equipments	Ball mill machines	675	13/ 1.9	6/ 46.2	4/ 30.8	3/ 23.1
	Grinder machines	450	22/ 4.9	9/ 40.9	7/ 31.8	6/ 27.3
	Holding tanks	300	4/ 1.3	2/ 50.0	1/ 25.0	1/ 25.0
	Machines hoppers	450	6/ 1.3	3/ 50.0	2/ 33.3	1/ 16.7
	Utensils	280	4/ 1.4	2/ 50.0	1/ 25.0	1/ 25.0
	Weighing scale	140	4/ 2.9	2/ 50.0	1/ 25.0	1/ 25.0
	Split ACs	152	0/ 0.0	0/ 0.0	0/ 0.0	0/ 0.0
	Pipe lines	425	1/ 0.2	1/ 100.0	0/ 0.0	0/ 0.0
Product Carriers	RM Buckets	460	80/ 17.4	36/ 45.0	25/ 31.3	19/ 23.8
	RM Bags	880	198/ 22.5	82/ 41.4	64/ 32.3	52/ 26.3
	Oil buckets	155	6/ 3.9	3/ 50.0	2/ 33.3	1/ 16.7

Categories	Variables	No. of examinations	No. of detected isolates/ Percent	No. of individual detected isolates/ Percent		
				Enterobacteriaceae	*Coliforms*	*E. coli*
	Oil cups	78	4/ 5.1	2/ 50.0	1/ 25.0	1/ 25.0
	Trolleys	375	45/ 12.0	22/ 48.9	14/ 31.1	9/ 20.0
	Packaging carton	225	1/ 0.4	1/ 100.0	0/ 0.0	0/ 0.0
	Packaging wrapper	230	0/ 0.0	0/ 0.0	0/ 0.0	0/ 0.0
Sum		10495	1277/ 12.2	604/ 47.3	393/ 30.8	280/ 21.9

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Evaluation of Surface Contamination and the Presence of *Listeria monocytogenes* in Fish Processing Factories

HANNA MIETTINEN,* KAARINA AARNISALO, SATU SALO, AND ANNA-MAIJA SJÖBERG†

VTT Biotechnology, P.O. Box 1500, FIN-02044 VTT, Finland

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ABSTRACT

The main objective of this study was to determine the level of surface contamination in fish processing factories and the presence of *Listeria* in the factory environment and products. Another objective was evaluation of the different hygiene-monitoring methods. Total aerobic heterotrophic and enterobacteria, yeast and mold samples were collected and ATP levels measured in 28 factories. The number of well or adequately washed and disinfected factories was small (2 of 28), in terms of total aerobic heterotrophic bacterial counts on the surfaces. Most surfaces contaminated with bacteria were heavily contaminated. Results of the ATP and the total bacteria contact agar slide methods were poorly correlated ($r = 0.21$) although 68% of the samples were categorized as good to moderate or unacceptable with both methods. The *Listeria*-positive surface samples usually contained increased numbers of total bacteria (70.9%). The contamination of products and raw fish together with *Listeria* spp. was 45% and with *Listeria monocytogenes* 12%. Cold smoked fish was the most contaminated, with 75% *Listeria* spp. and cold salted fish with 20% *L. monocytogenes*. *Listeria innocua* was found in the samples more than twice as often as *L. monocytogenes*.

TABLE 1. *Surface hygiene guidelines for total aerobic heterotrophic bacteria, enterobacteria, yeasts, and molds on food processing surfaces (CFU/cm^2) investigated using contact agar slides*

Microbial group	Good	Moderate	Unacceptable
Total aerobic heterotrophic bacteria	1.8	1.8–5	>5
Yeasts	<1	1–5	>5
Molds	<0.6	0.6–1.6	>1.6
Enterobacteria	<0.1	0.1–1.0	>1

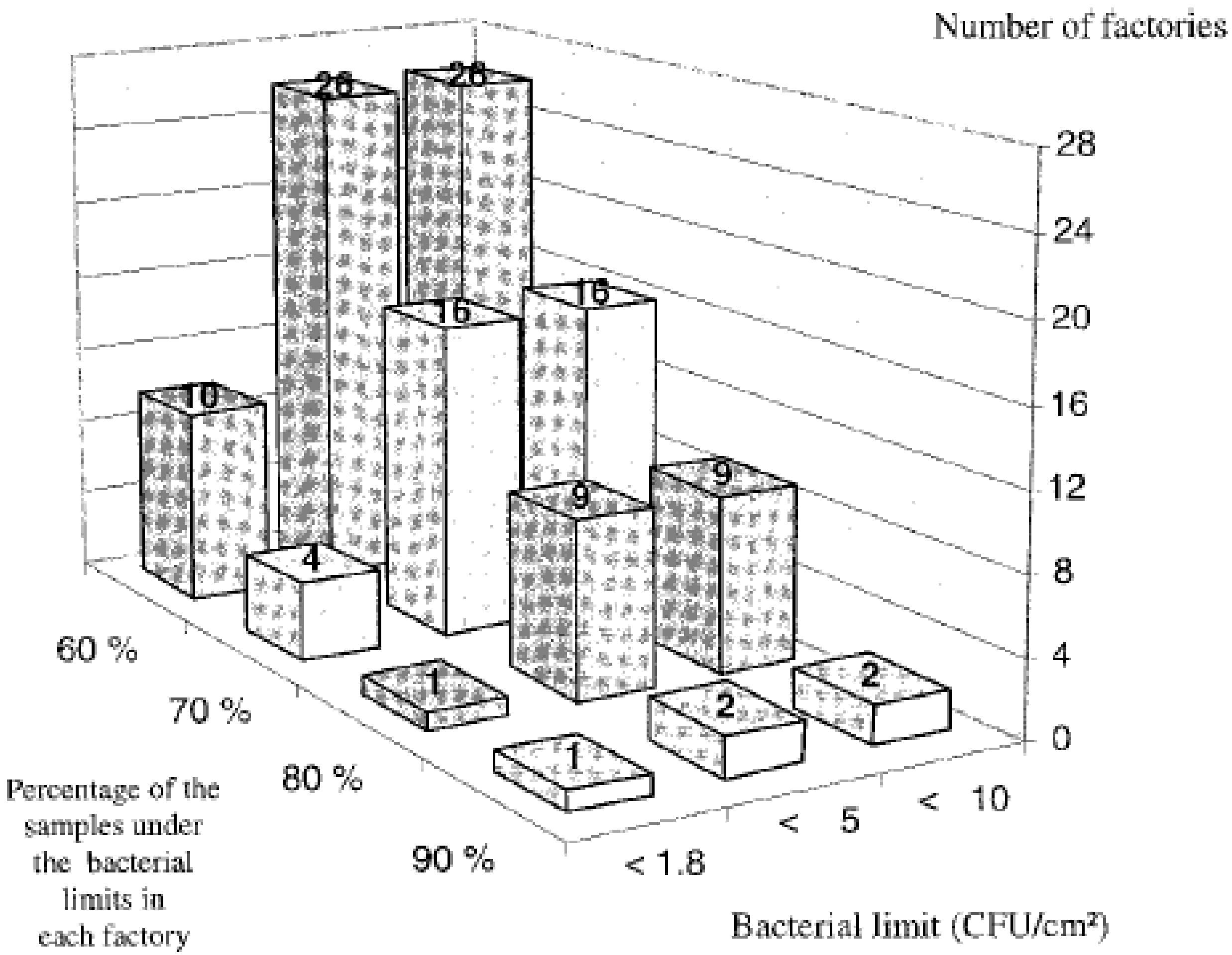


FIGURE 1. *Number of factories (total 28) at which total aerobic heterotropic bacteria results from surfaces were below the bacterial contamination limits (1.8 to 10 CFU/cm^2) in at least 60 to 90% of the samples in each factory (<1.8 CFU/cm^2 = good; 1.8 to 5 CFU/cm^2 = moderate; >5 CFU/cm^2 = unacceptable).*

In only one factory was over 90% of samples clean (<1.8 CFU/cm^2).

TABLE 2. *Mean total aerobic heterotrophic bacteria, enterobacteria, mold, and yeast counts and ATP results from the fish factory surfaces analyzed with contact agar slides and ATP method from fish factory surfaces*

	Mean ± SD					
Surface	ATP (RLU/100 cm^2)	Total bacteria (CFU/cm^2)	Enterobacteria (CFU/cm^2)	Molds (CFU/cm^2)	Yeasts (CFU/cm^2)	Number of factories
Scale	10.0 ± 18.1	42.9 ± 36.0	0.9 ± 1.5	0.9 ± 0.7	2.6 ± 5.2	19–21
Brine basin	30.7 ± 53.9	33.7 ± 41.7	1.1 ± 2.1	0.5 ± 0.7	5.9 ± 12.5	12–13
Chopping board	3.4 ± 8.0	31.0 ± 37.8	2.5 ± 6.3	0.5 ± 0.6	6.7 ± 16.5	21–23
Shovel	2.3 ± 2.9	30.6 ± 39.7	0.9 ± 1.7	0.5 ± 0.6	6.8 ± 11.3	7–8
Packaging table	9.4 ± 23.4	23.8 ± 34.3	0.4 ± 1.4	1.0 ± 0.9	0.9 ± 1.4	10–12
Grindstone	5.2 ± 6.2	22.8 ± 38.7	0.2 ± 0.5	0.8 ± 0.7	1.8 ± 1.4	9–11
Knives	1.9 ± 4.0	17.2 ± 33.7	0.5 ± 1.2	0.3 ± 0.5	2.8 ± 6.4	15–19
Door and/or door handle	13.0 ± 23.7	15.0 ± 20.3	0.2 ± 0.6	0.3 ± 0.5	0.6 ± 1.1	22–24
Apron	10.1 ± 19.7	14.3 ± 20.6	0.2 ± 0.3	0.6 ± 0.5	5.3 ± 17.8	17–20
Faucet	7.8 ± 12.7	13.7 ± 16.0	0.0 ± 0.0	0.4 ± 0.7	0.3 ± 0.4	10–11
Vacuum packaging machine	4.3 ± 8.3	9.1 ± 21.4	0.0 ± 0.1	0.4 ± 0.6	3.4 ± 14.3	17–19
Ice basin/shovel	4.2 ± 6.5	7.7 ± 10.0	0.1 ± 0.2	0.7 ± 0.7	5.0 ± 10.1	11–13
Light/electric switch	0.9 ± 1.0	6.3 ± 9.5	0.0 ± 0.0	0.4 ± 0.3	0.2 ± 0.3	7–9

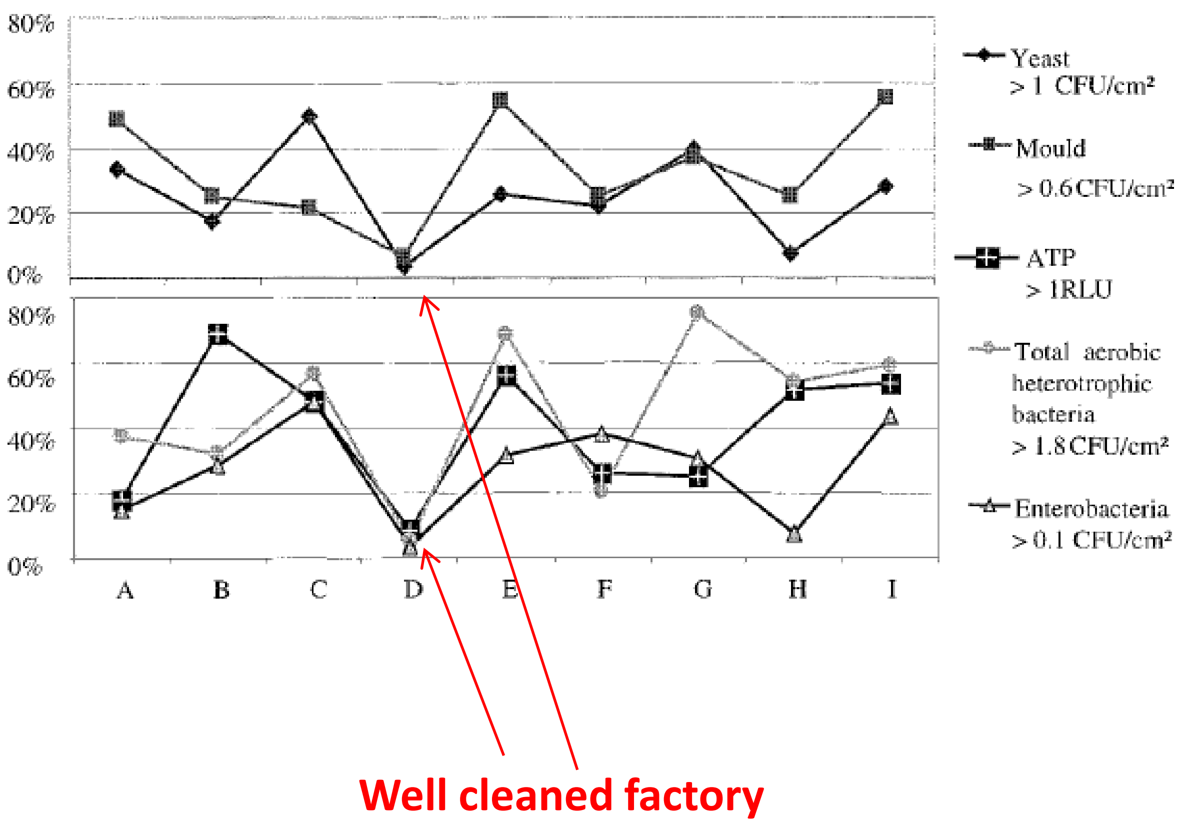
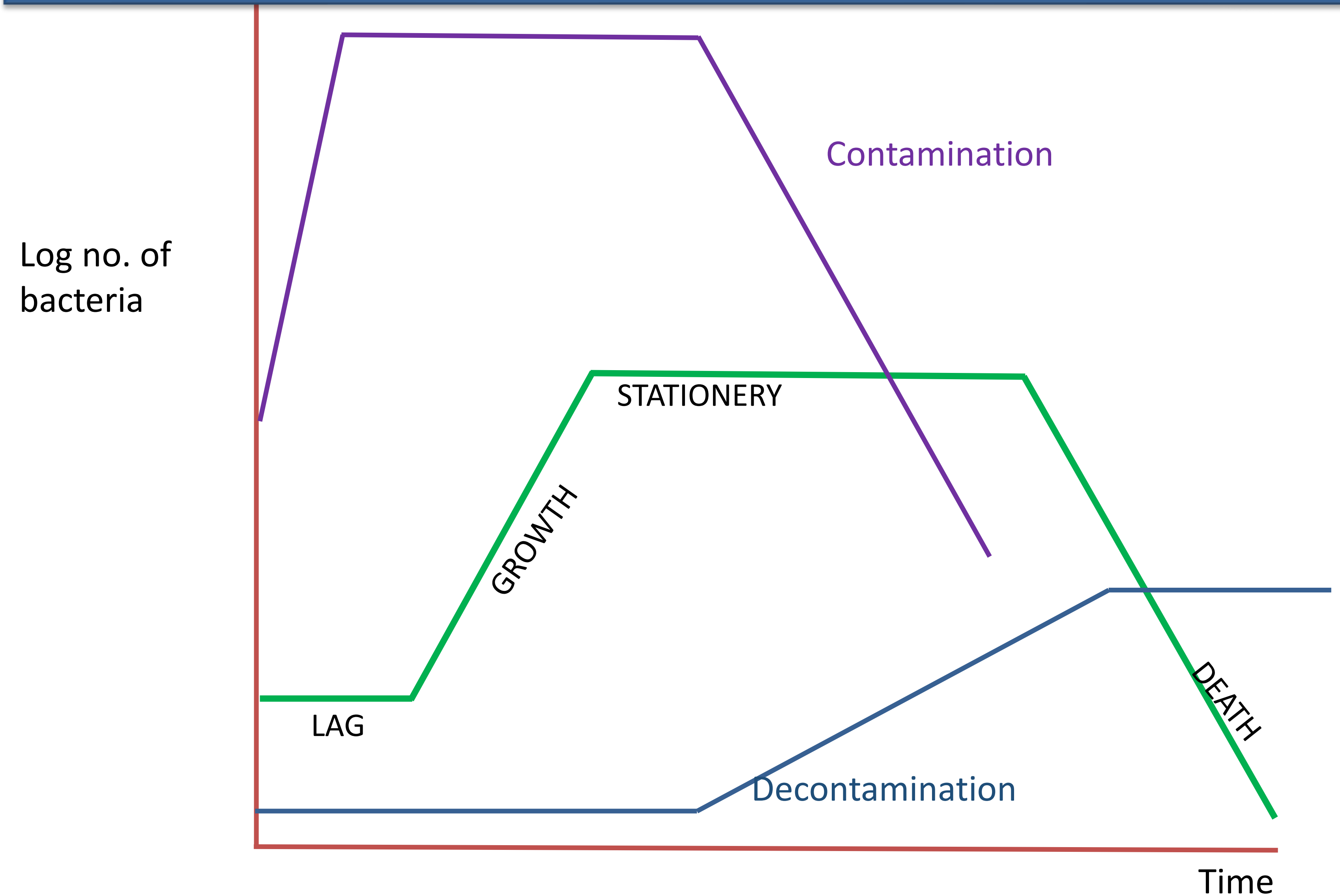


FIGURE 2. *Comparison of main hygiene problems and contamination levels caused by differenct microorganisms or ATP in different fish factories. Results of surface hygiene-monitoring methods from nine factories (A through I). Percentages of the samples that exceeded the microbiological limit of each method.*

Effect of contamination/decontamination on microbial growth
The bacterial growth curve



Not as clean as it looks…

- Visual inspection of cleanliness is not usually sufficient in the food industry.
- Microbiological sampling and bioluminescence have proven that visually clean surfaces do not always meet acceptable limits.

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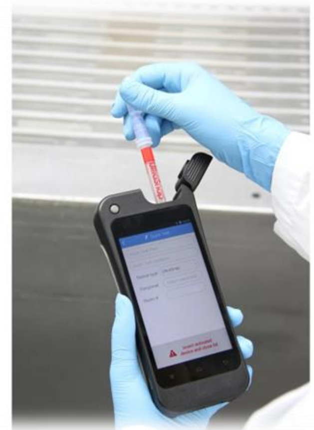

Use verification data to improve sanitation processes

Any questions?