Post mortem changes influencing sensory quality of seafood

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Content

- How fish goes bad
- Factors influencing freshness
- Rigor mortis
- Autolytic changes
- Bacterial changes
- Chemical changes
- Histamine

Learning objectives

After this lecture participants will be familiar with

- Factors that affect fish freshness and fish food quality
- Be able to apply the knowledge gained from this lecture and carry out good manufacturing practices to maintain the best quality of the raw material and minimize spoilage by proper handling of products.

How fish goes bad

- Self digestion by enzymes (autolytic changes)
- Bacteria
- Oxidation & hydrolysis

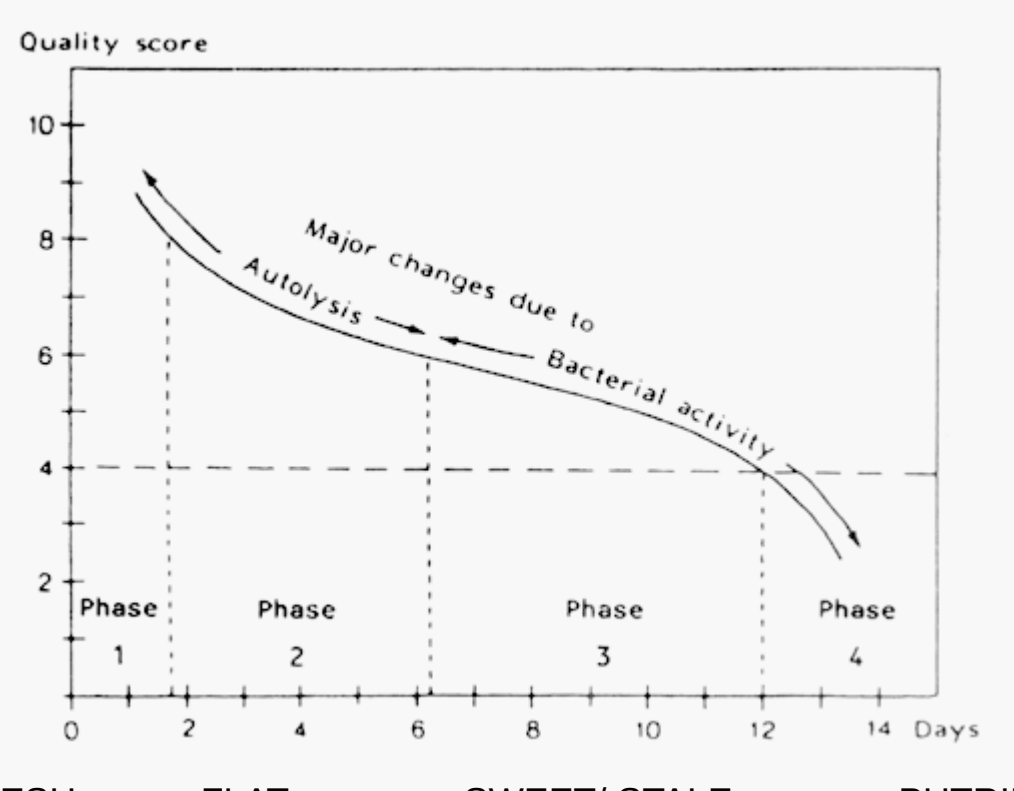
Factors influencing freshness

- ***Sensory changes***
  - ***Smell, taste, texture, appearance, colour***
- Autolytic changes
  - ATP degradation, enzymatic reactions
- Changes by microorganisms
  - TVC, SSO
  - TMAO, TMA, DMA,NH3, TVB,
  - Amino acid degradation
  - Sulphur compounds
    - H2S, CH3SH, DMDS
- Chemical lipid oxidation
  - Lipid oxidation, hydrolysis

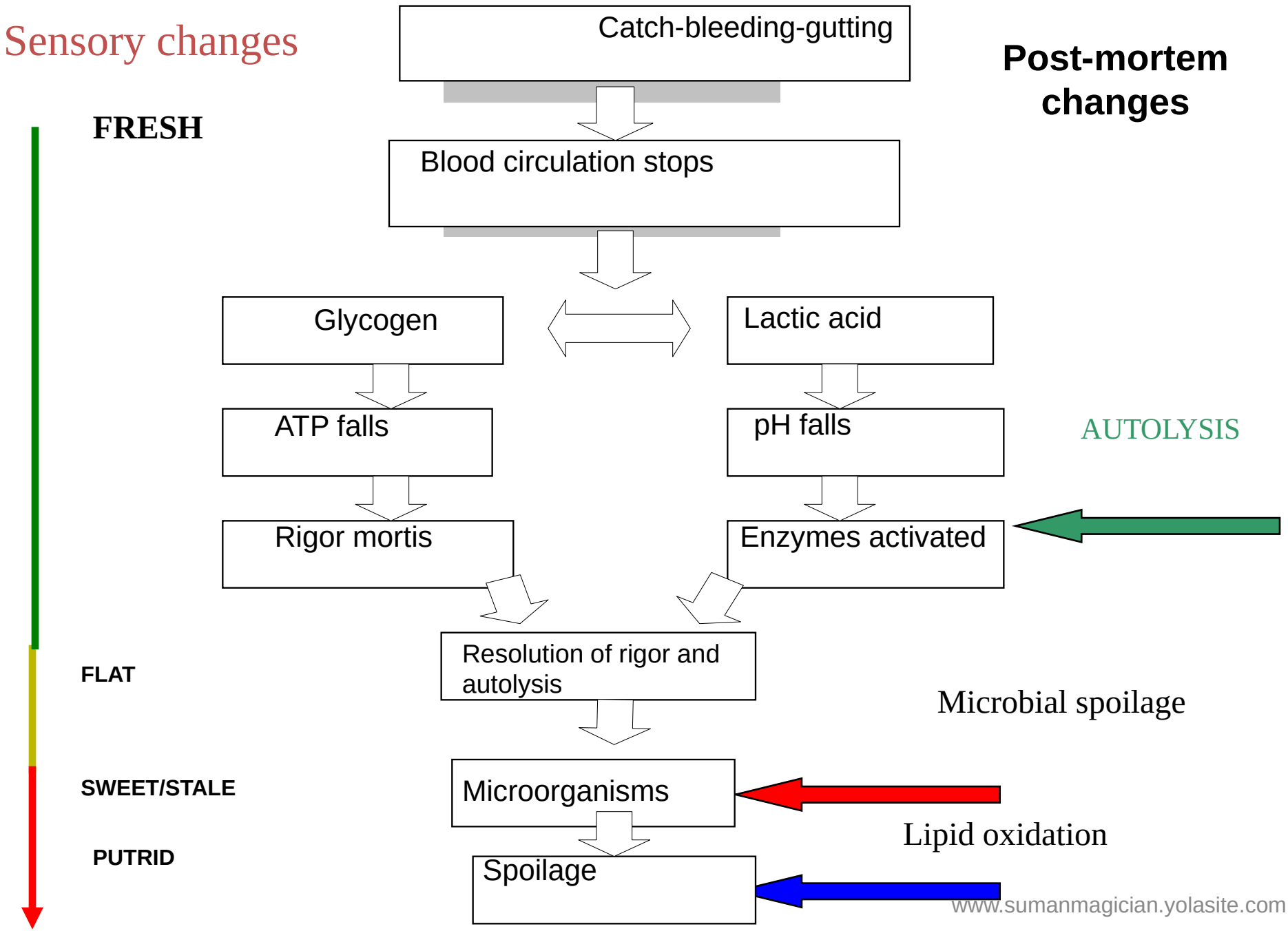
EU limits for TVB-N in fishery products

Species	TVB-N limits
Sebastes sp. *Helicolenus dactylopterus* *Sebastichthys capensis*	25 mg/100 g muscle
Pleuronectidae With the exception of *Hippoglossus* sp.	30 mg/100 g muscle
Salmo salar Merluccidae Gadidae	35 mg/100 g muscle

Changes in eating quality of iced cod (Huss, 1976)



FRESH → FLAT → SWEET/ STALE → PUTRID


Sensory changes
Post-mortem changes
FRESH
FLAT
SWEET/STALE
PUTRID
Catch-bleeding-gutting
Blood circulation stops
Glycogen
Lactic acid
ATP falls
pH falls
AUTOLYSIS
Rigor mortis
Enzymes activated
Resolution of rigor and autolysis
Microbial spoilage
Microorganisms
Lipid oxidation
Spoilage
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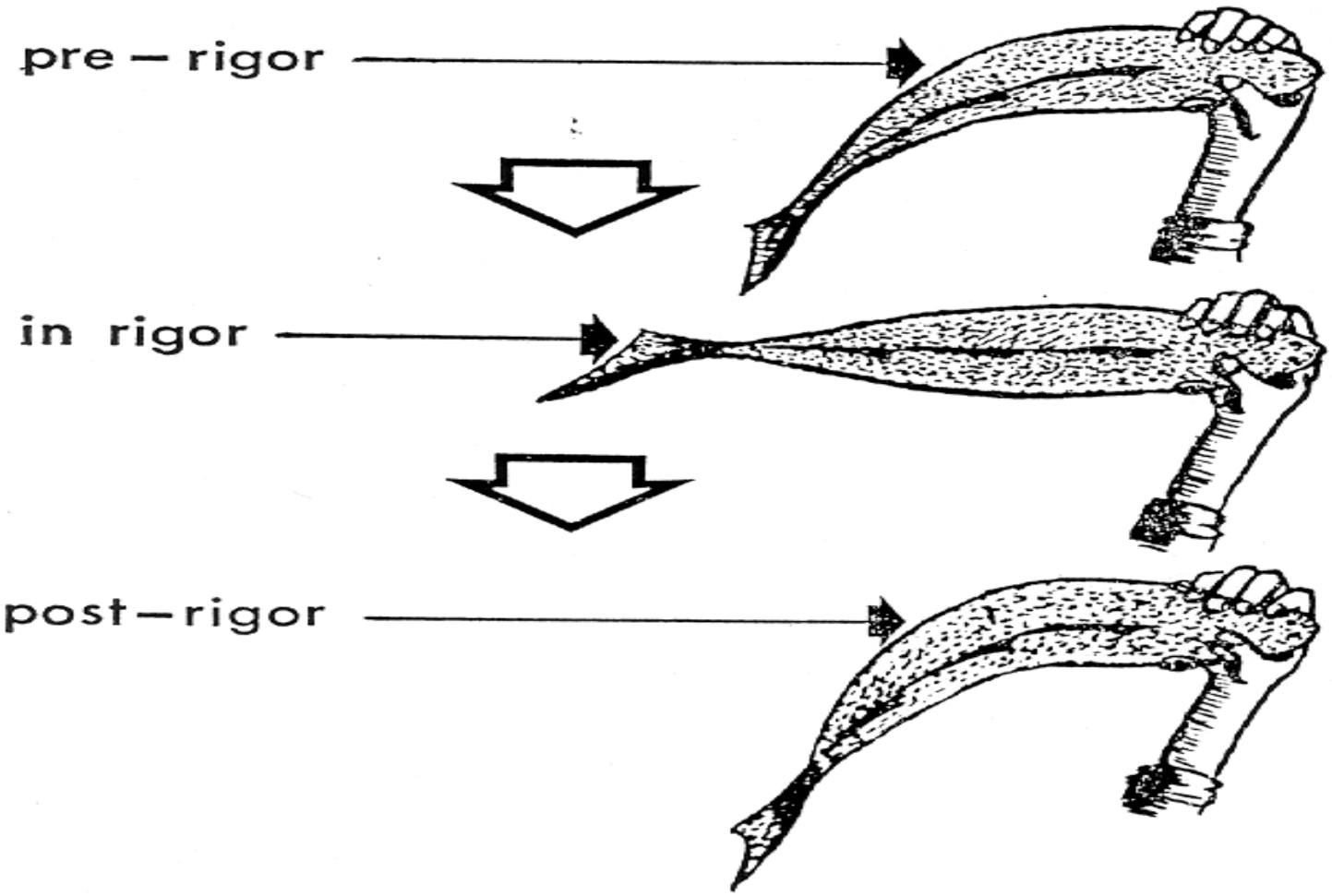
Rigor mortis

Rigor mortis

- Immediately after death the muscle is totally relaxed and the limp elastic texture usually persists for some hours

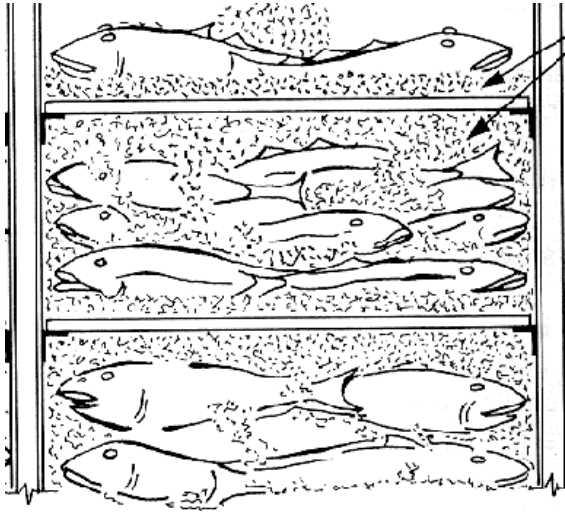
- Afterwards the muscle will contract. When it becomes hard and stiff the whole body becomes inflexible and the fish is in rigor mortis

General effect of rigor



Influences of rigor mortis on fish

General influence of rigor on fish is that it makes the fish stiffen



Rigor mortis does not affect whole fish that is iced on board and during transportation to the factory.

This is because rigor mortis has passed during holding in ice on board and transportation to the factory.

Factors affecting Rigor Mortis

Method used for stunning and killing

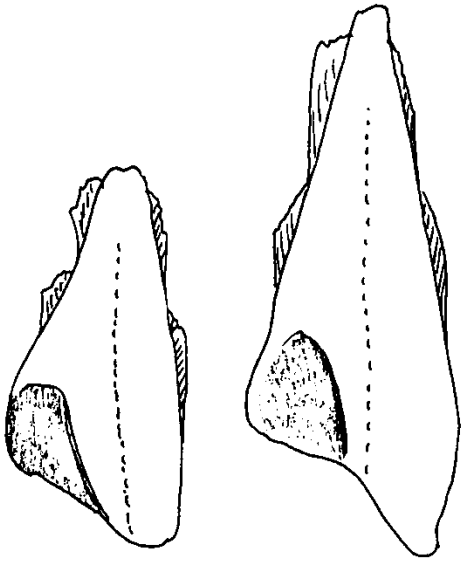
Temperature

Shrinkage of the fillets

The shape of the fillets becomes distorted and the surface of the flesh takes on a corrupted appearance

a-The fillet is cut off before rigor mortis => the length is reduced 24 %

b-The fillet is cut off after rigor mortis => the length is reduced a little bit



a **b**

Onset and duration of rigor mortis in various fish species

Species	Condition	Temperature °C	Time from death to onset of *rigor* (hours)	Time from death to end of *rigor* (hours)
Cod *(Gadus morhua)*	**Stressed**	**0**	**2-8**	**20-65**
	Stressed	10-12	1	20-30
	Stressed	30	0.5	1-2
	Unstressed	**0**	**14-15**	**72-96**
Grouper *(Epinephelus malabaricus)*	Unstressed	2	2	18
Blue Tilapia *(Areochromis aureus)*	**Stressed**	**0**	**1**	
	Unstressed	**0**	**6**	
Grenadier *(Macrourus whitson)*	Stressed	**0**	**<1**	**35-55**
Anchovy *(Engraulis anchoita)*	Stressed	**0**	**20-30**	**18**
Redfish *(Sebastes* spp.)	Stressed	0	22	120
Carp *(Cyprinus carpio)*	**Stressed**	**0**	**1**	
	Unstressed	**0**	**6**	

HUSS (1995)

Autolytic changes

Self-digestion controlled by enzymes

Autolytic changes during frozen storage

- Reduction of trimethylamine oxide (TMAO), an osmoregulatory compound in many marine teleost fish, is usually due to bacterial action

- In some species, an enzyme is present in the muscle tissue which is able to break down TMAO into dimethylamine (DMA) and formaldehyde (FA):

$$(CH_3)_3\,NO \rightarrow (CH_3)_2NH + HCHO$$

- Formaldehyde : Greater commercial significance

- Formaldehyde induces cross- linking of the muscle proteins making the muscle tough and readily lose its water holding capacity.

Bacterial changes

Bacterial flora on newly-caught fish depends on the environment in which it is caught rather than on the fish species

Fish caught in very cold waters carry lower counts whereas fish caught in warm waters have slightly higher counts.

Bacteria varies with

Raw material

skin, gills, gut

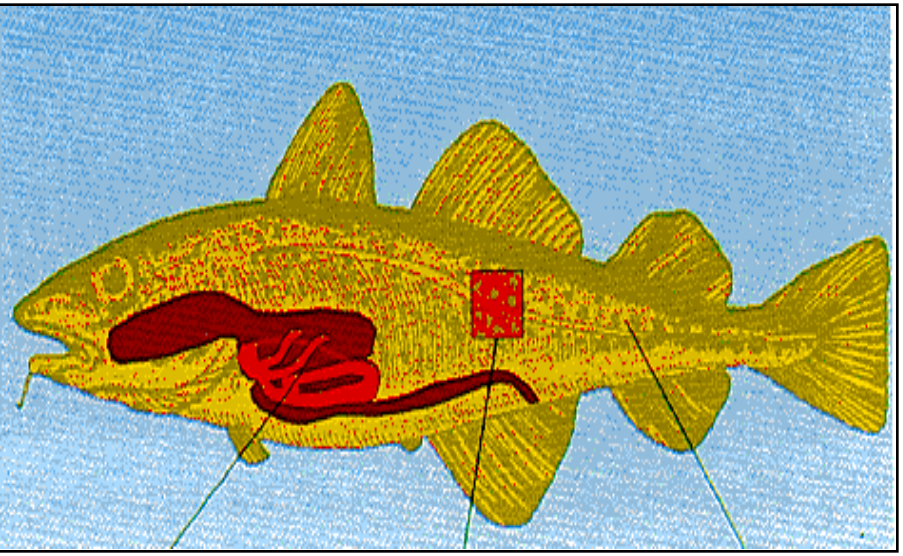
Contamination by

Environment, air, soil, water

Process

Equipment, staff, pests

Origin of bacteria in fish



	Bacterial Number/Square cm
Before decay	
Skin	100 – 10,000
Gill	1,000 – 1,000,000
Digestive tract	1,000 – 100,000,000
After decay	
Skin	1,000,000 – 100,000,000

Generally, the most important factor affecting microbial growth is temperature.

Types of bacteria present in the environment

- not all bacterial population initially found on the fish will cause spoilage
- produce metabolites which cause quality changes in the fish

  =>

  these changes are important and can cause the product to be rejected

Lipid oxidation & hydrolysis

Reactions that give rise to a variety of chemical and physical changes in lipids

- Oxidation
  - enzymic oxidation (lipoxygenase)
    - generation of characteristic fresh fish odour
  - autoxidation
    - oxygen reacts with double bonds of unsaturated fatty acids
    - affects nutritional value, taste, odour, colour and texture

- hydrolysis
  - formation of free fatty acids
  - normally this does not cause problems in fish but causes an off-flavour in oils (soapy)

Histamine poisoning

- Allergy-like poisoning
- Consuming scombroid and scombroid-like marine fish with high levels of histamine
- Usually occurs if levels of histamine exceeds 200 ppm.
- Severity depends on the individual and the presence of other amines or diamines

How and where can it happen?

- Produced by bacterial decarboxylation of histidine mainly in fish belonging to the sub-order Scombroidei
- High levels of histamine indicates decomposition has occurred even before a fish smells bad/looks-like good fish
- Usually in fresh fish, but can happen in frozen, cooked, cured or canned fish products

Fish species that can cause scombroid poisoning

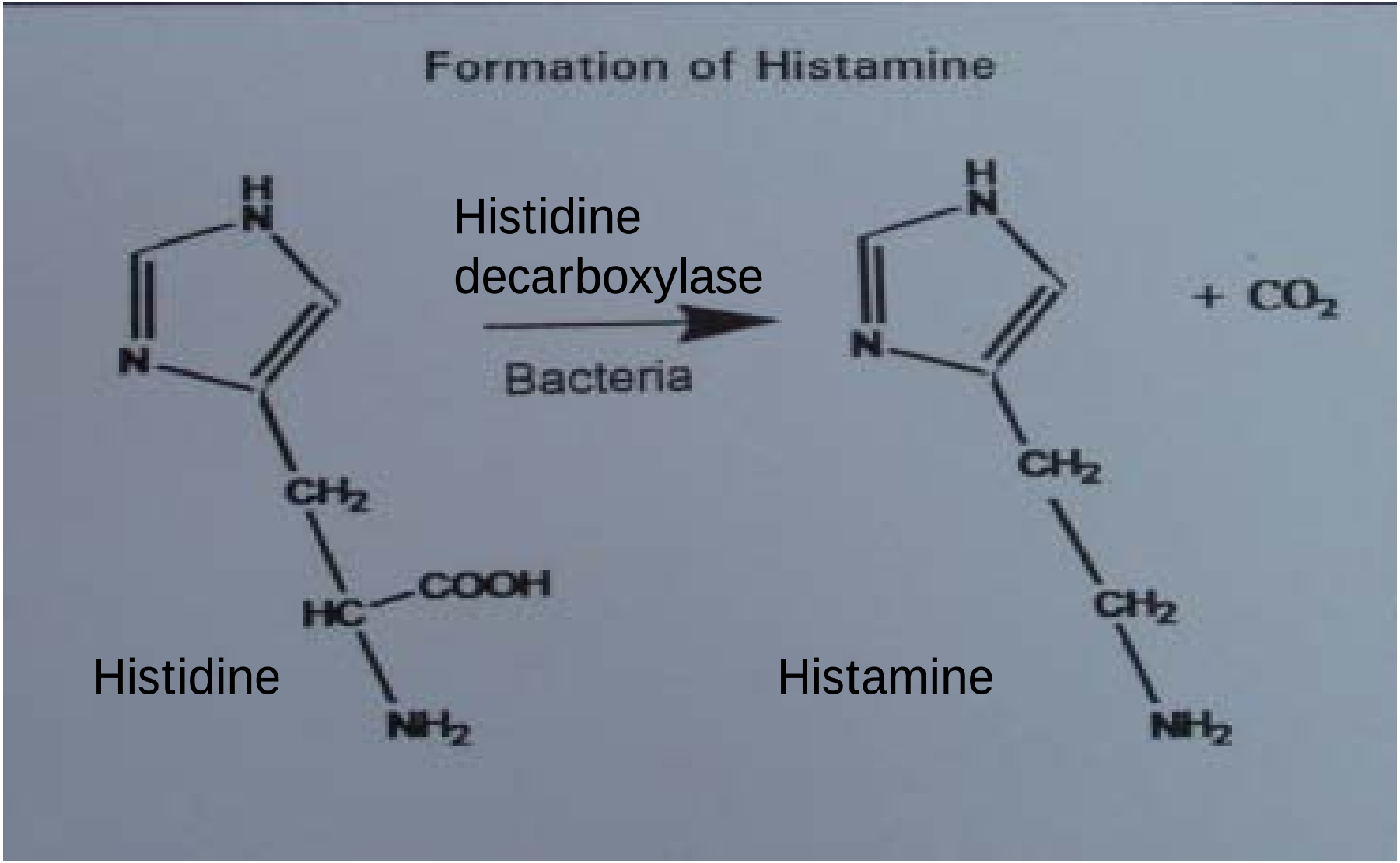
- Scombridae and Scomberesocidae families- scombroid fish- (tuna, bonito and mackerel)
  - Have large amounts of free histidine which may be converted to histamine during improper storage

- Clupeidae (herring, sardines)
- Coryphaenidae (mahi-mahi)

Example of tuna and mackerel

Indian Mackerel

Formation of histamine



Symptoms of scombroid poisoning

- Symptoms can occur immediately to several hours after eating fish with histamine
- Symptoms more severe if ingested with alcohol
- Usually recovers within half a day.

The symptoms are:

- Cutaneous (rash, urticaria or itching, oedema, localized inflammation)
- Gastrointestinal (nausea, vomiting, diarrhea)
- Neurological (headache, palpitations, perspiration and sensations such as tingling, burning, blistering, flushing and itching).

Potential of histamine toxicity

- Early studies showed that histamine was not the sole source of scombroid toxicity
- Putrescine and cadaverine increase the absorption of histamine in the intestine
  - are decarboxylation products of ornithine and lysine (amino acids)
  - are perhaps better spoilage indicators than histamine in scombroid fish
  - histamine toxicity increased 10x when putrescine was administered 40 min before histamine

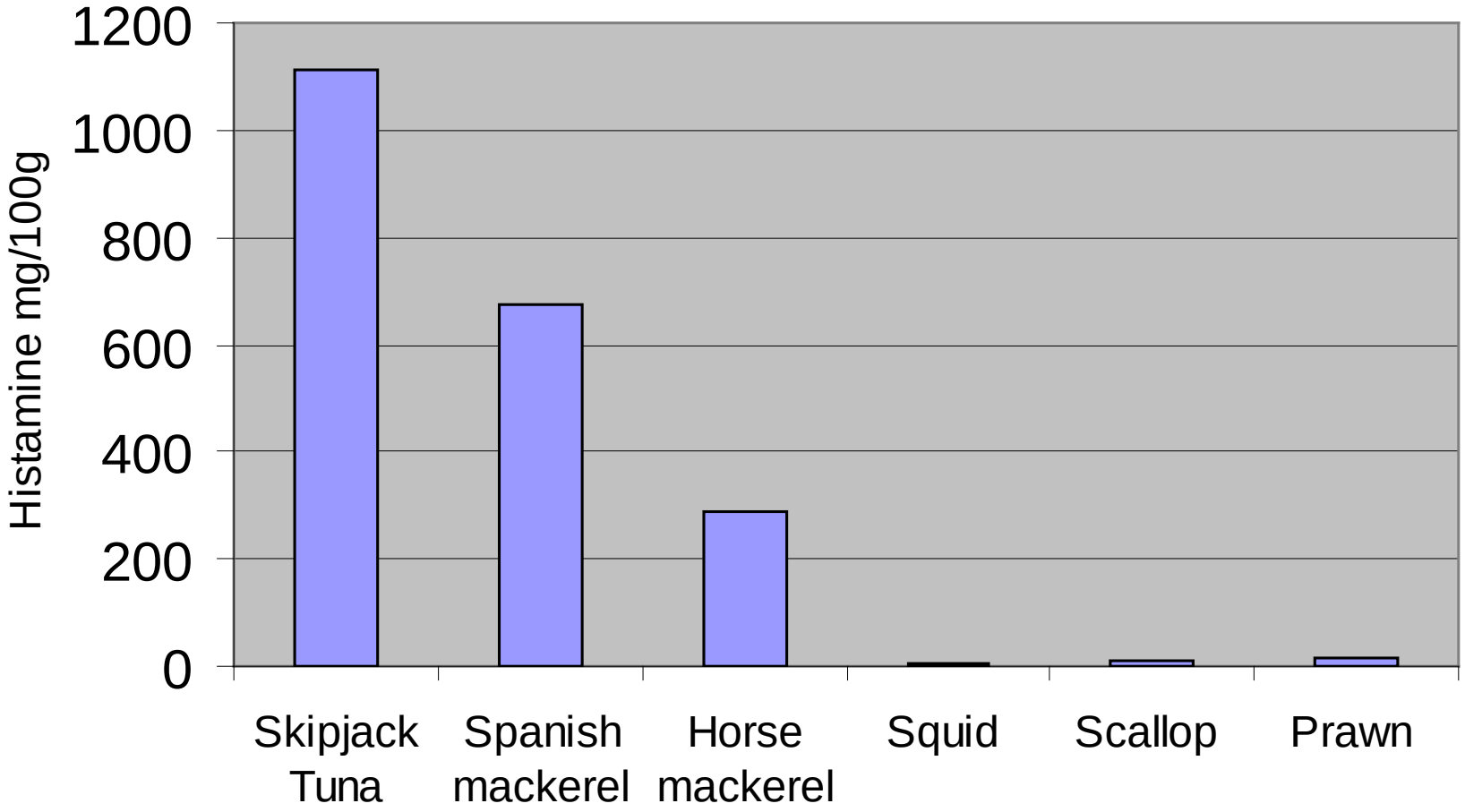
Histamine decarboxylase producing bacteria

1. *Escherichia coli*
2. *Closrtridium perfringens*
3. *Enterobacter aerogenes*
4. *Klebsiella pneumonias*
5. *Hafnia alvei*
6. *Shigella spp*
7. *Salmonella spp*
8. *Citrobacter freundii*
9. *Lactoacillus spp*
10. *Morganella morganii*

Histamine decarboxylase producing bacteria (cont.)

- *Morganella morganii* produces highest level of enzymes per unit time. 10% of fresh fish are contaminated with this bacteria
- Most of the histamine producing bacteria are mesophilic and grow well at 20°C
- A psychrotolerant species of *Morganella* and *Photobacterium phosphoreum* have been responsible for histamine formation in different chilled seafood's at 0-5°C.

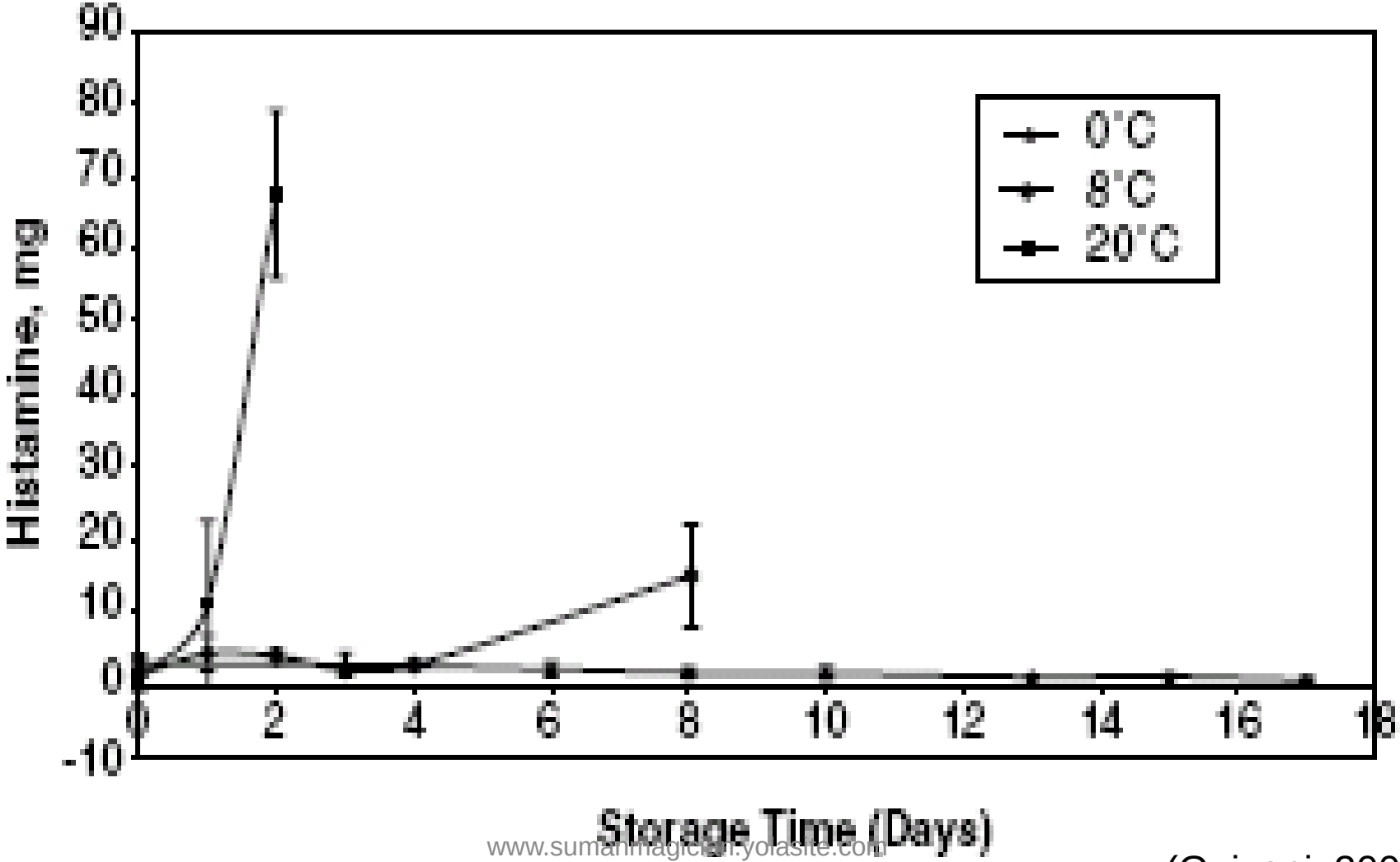
Histamine in some seafoods



Legislation on Histamine

- A level less than 5mg/100g (50ppm) is safe for consumption
- Maximum level of histamine have set at 10-20mg/100g in many countries
- Levels above 50mg/100g is a hazard action level, unsafe for consumption
- Different countries have set different levels as regulatory limits

Changes in content of histamine in yellowfin tuna during storage



(Guizani, 2005)

Control measures and safe shelf-life

- Rapid chilling of fish immediately after death is the most important element for preventing the formation of scombrotoxin
- The internal temperature of the fish should be brought to 10°C or less within 6 hrs of death
- The fish should be chilled to 0°C within 10 hr.

References

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- Huss, H.H. Quality and quality changes in fresh fish. FAO 348, 1995