

**Off-flavors in RAS:
status on current knowledge on organisms
producing off-flavors and a recent example on
mitigation of off-flavor problems in a recirculated,
experimental system**

Niels O. G. Jørgensen & Raju Podduturi

Department of Plant and Environmental Sciences

Section of Genetics and Microbiology

University of Copenhagen

E-mail: nogj@life.ku.dk



Taste-and-odor (TOC) problems in trout RAS in Denmark:

Resume from study of about 200 rainbow trouts in 2011:

- ***Sensory panels:***

63% of the fish from production basins had detectable content of TOCs


- ***Chemical analysis:***

About 90% of fish from production basins had a TOC level $>0.1 \mu\text{g/kg}$ (human detection limit)

- ***Supermarkets:***

Consumer complaints on TOC-tainted fish



 [ABT on current stock quotes \(click here\)](#)

Products

WHITE CLAM

PANGASIU FISH

Off-flavors
make
consumers
opt out fish
from
freshwater:

In Denmark
Pangasius
fish from
Vietnam
have a low
consumer
acceptance

White Pangasius - Unique Fully Integrated System in VN



1. General information:

- Commercial name: FROZEN PANGASIU HEADLESS & GUTTED
- Latin name: Pangasius Hypophthalmus

2. Product information:

- Headless, gutted, fin off, tail off, skin on cleaned, bone in.
- 5%, 10% or protective glazing depend on clients' order.
- 300-500, 500-700, 700-1000 gram per piece or sizing by customers' order.

4. Ingredient declaration (%): Pangasius 100%

5. Supply stability: Stably for whole year round

6. Raw material: 100% raw fish is from Aquatex Bentre's farms where are all GLOBAL G.A.P certified

6. GM status: Product is free from GMO

7. Organoleptic characteristics:

- Appearance: Frozen
- Colour: Natural colour
- Flavour: No muddy taste
- Smell: No off odour
- Texture: Firm

8. Usage information:

- Storage conditions: < - 18°C
- Life time: 24 months from production date
- Consumption advice: Fully cooked before consumption

9. Packaging information:

- Brand name: By Aquatex Bentre or by client's brand
- Inner packing: + Individually wrap packing, 5 Kg net or with glazing per PE bag/Carton
+ Or individually wrap packing, 10 Kg net or with glazing per PE bag/Carton
Or may be changeable to clients orders.
- Packing material: Inner bag: PE bag and outside: master carton

Known off-flavors compounds in fish:

- **Earthy:** Geosmin
- **Musty:** 2-MIB (methylisoborneol)
- **Rancid:** aldehydes, e.g. 2,4-heptadienal (from oxidation of lipids)
- **Woody:** Terpenes
- **Petroleum:** Environmental pollution

Which organisms produce off-flavors?

- If light, N and P are present:

Cyanobacteria (bluegreen algae) and some **algae**

- If organic matter and oxygen are present:

Streptomyces (bacteria)

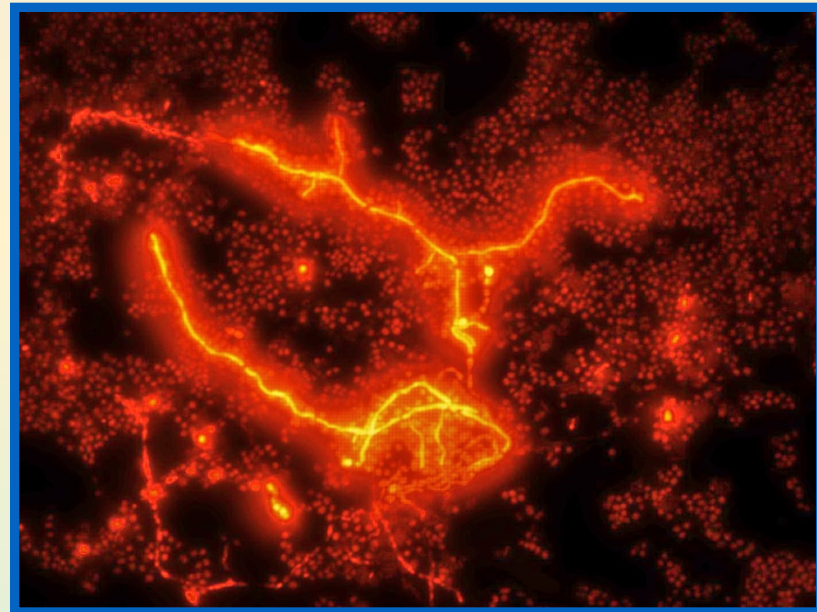
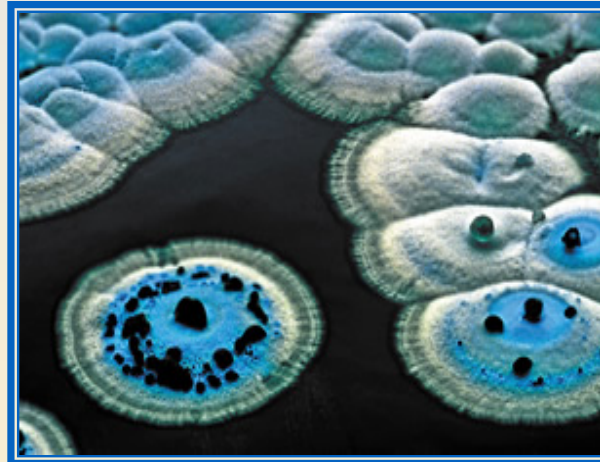
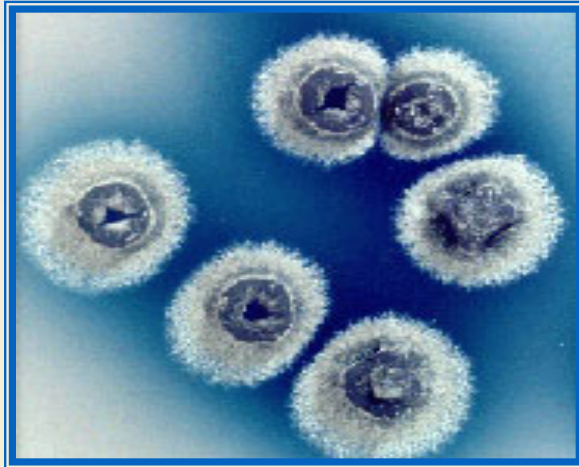
Myxobacteria (slime or gliding bacteria)



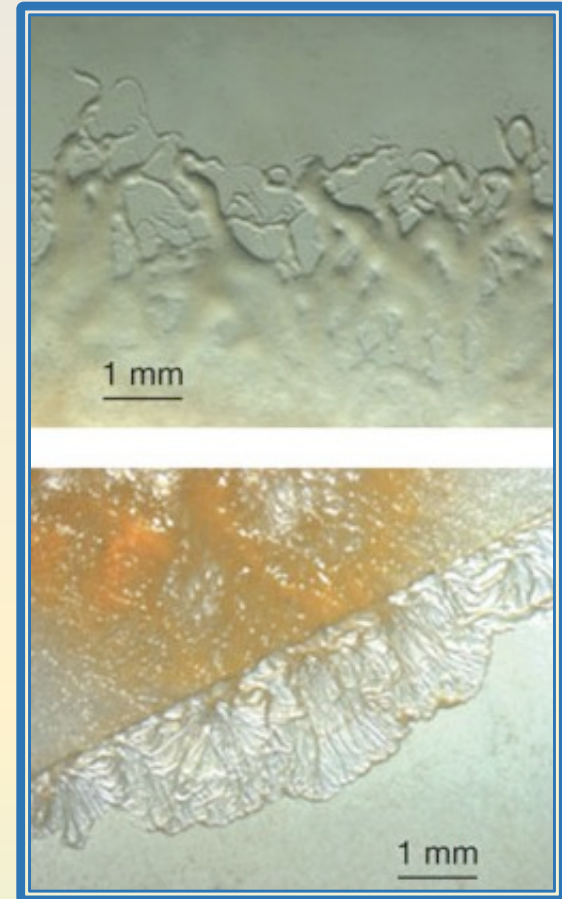
Cyanobacteria: free cells or filaments



Streptomyces: Gram-positive, filamentous bacteria



Myxobacteria (*Sorangium* and *Nannocystis*): Gram-negative, slime- and spore-forming bacteria



Molecular method indicate capacity to produce geosmin (presence of the gene encoding the geosmin synthase enzyme)*

*Auffret et al. (2013). Impact of water quality on the bacterial populations and off-flavours in recirculating aquaculture systems. FEMS Microbiology Ecology 84, 235-247



Pangasius and tilapia from ponds in Bangladesh: **Unpleasant taste and flavor in fish but not caused by geosmin nor MIB**

- 20 **terpenes** found in the fish
- 11 of the 20 compounds have **woody** odor

Bangladeshi fish:

- **β -caryophyllene** [clove and hops],
- **α -pinene** [rosemary and pine],
- **β -ionone** [rose and violet], and
- **α -humulene** [hops]

were well above the threshold for human detection.
Source(s) of the off-flavors unknown.



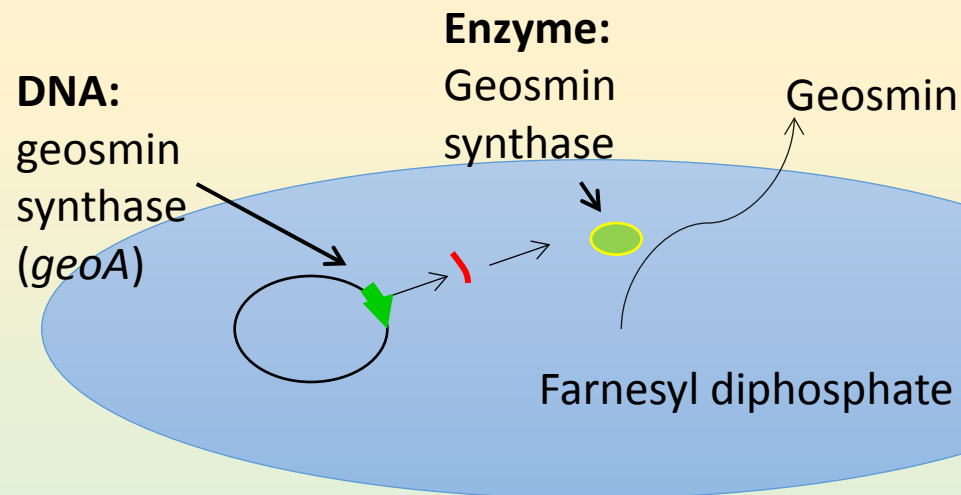
Terpenes, geosmin and MIB have same precursor:

Monoterpenes are synthesized from geranyl diphosphate and sesquiterpenes from farnesyl diphosphate by enzymes

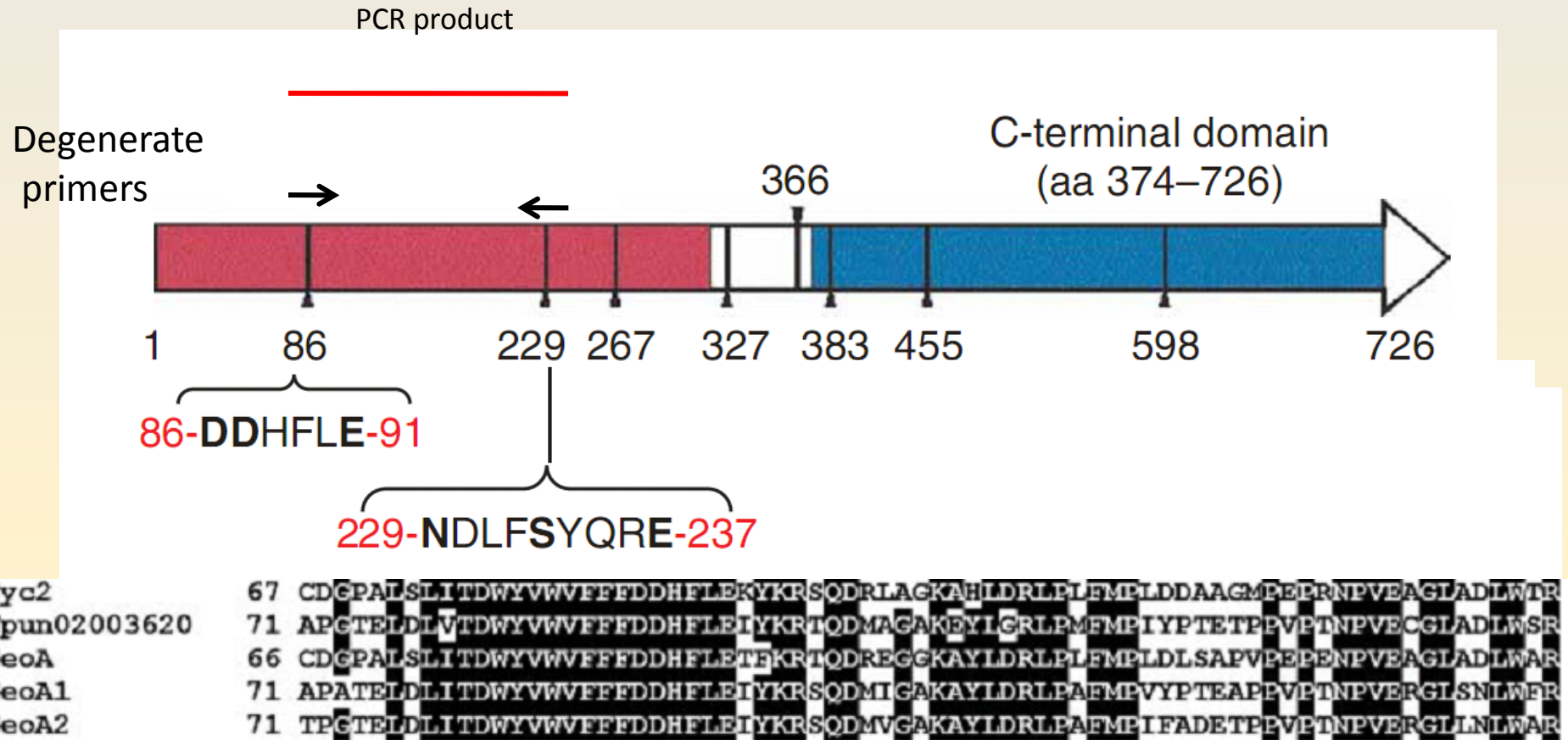
Example:

Geranyl diphosphate → 2-MIB [and other monoterpenes]

Farnesyl diphosphate → Geosmin [and other sesquiterpenes]



Molecular detection of off-flavor production: *geoA* gene



Do algae produce off-flavors?

Water reservoir in China:

Unpleasant **fishy** odor was caused by dense growth of certain algae (chrysophyte [golden algae] *Dinobryon*: diatoms *Melosira* and *Cyclotella*)

Odor compounds: **aldehydes** (*n*-hexanal, *n*-heptanal, 2,4-decadienal, 2,4-heptadienal)*

*Zhao et al. (2013). Journal of Environmental Sciences 25:2361–2366



CONTROL OF GEOSMIN AND MIB (1)

PHYSICAL AND CHEMICAL METHODS

Particulate activated carbon (PAC), e.g. for drinking water

Advanced oxidation procedure (AOP): UV light + ozone

BIOLOGICAL METHODS

Australia (drinking water): Bioreactor (sand column) with bacteria isolated from sewage treatment plant: 70% degradation of geosmin at 100 ng/l. Slow process, long contact time (5 ml/min in reactor).

China (RAS): Enrichment of bioflocs with *Bacillus* bacteria: 99% reduction of geosmin at 100 ng/l in 10 l biofloc reactor after 2 days.

Challenge: Geosmin removal from water in tanks



CONTROL OF GEOSMIN AND MIB (2)

BIOLOGICAL METHOD: SNAILS GRAZING ON BIOFILM



Can snails reduce TOC in RAS?

Davidson and coworkers at Freshwater Institute, Shepherdstown:
500 l experimental tanks with 30 rainbow trouts (111 g)

Streptomyces bacteria found in biofilm on walls in **aeration sump**

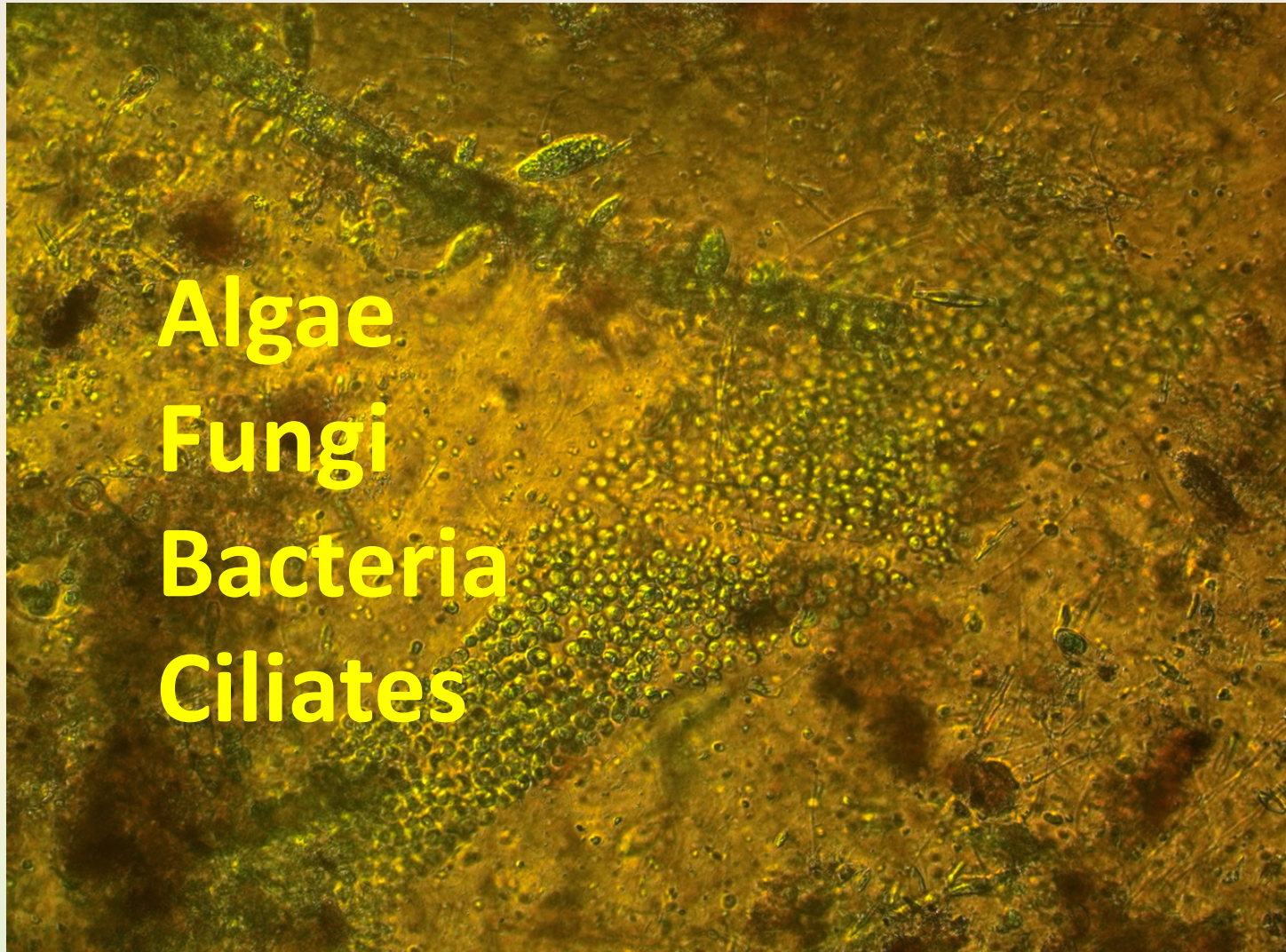
Freshwater snail *Physa gyrina* living in aeration sump removed biofilm.

Snails reduced density of streptomyces bacteria by 3-fold in the biofilm*. Few streptomyces in the water.

*from 150,000 to 50,000 streptomyces per 100 ml biosolids



Biofilm in RAS in Denmark: probably excellent food for snails



INITIATIVE TO REDUCE OFF-FLAVOR IN FISH FROM RAS IN DENMARK 2012:

Recommended treatments:

- Purging of fish for up to 6 days in water with <10 ng geosmin/l
- 6 annual analyses of geosmin in the water

Testing for TOC in fish

Selected fish from each party (loading) are cooked and tasted

Chemical quantification of TOC in fish

No commercial facilities for the analysis are yet available



Fish production in Denmark in 2003:



Comments, questions?
Contact Niels Jørgensen
nogj@plen.ku.dk