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Increasing the value of our fish landings – what´s beyond the fillets?

Thoughts on a (Baltic) fish based biorefinery

Ingrid Undeland and many co-workers
Chalmers University of Technology, Chemical and Biological Engineering –Food Science, Göteborg, Sweden

Foto: Ilar Gunilla Persson

193 000 tons fish produced by Swedish fisheries 201 (BS ~125 000 t)

100 000 tons consum fish (BS ~65 000 t) **93 000 ton stry fish”** (BS ~60 000 t)

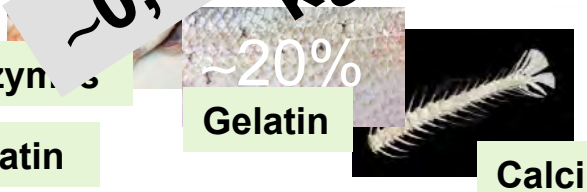
Only ~50 000 tons to food! **~76 00 timally used fish muscle**

~0,1-0,3 Euro/kg

- Fish mince
- Functional proteins
- Functional peptides

~0,1-0,3 Euro/kg

- Residuals → Feed Bioenergy

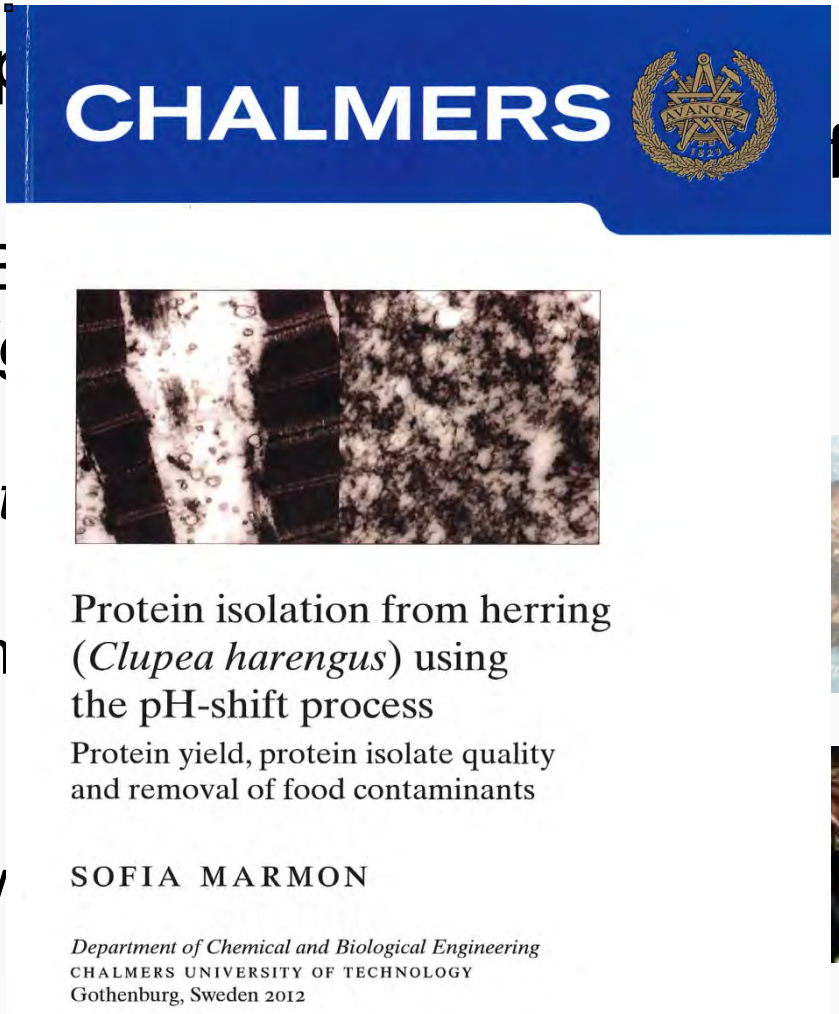


- Enzym s
- Gelatin
- Gelatin
- Calcium concentrate
- Oil
- Phospholipids
- Nucelic acids (e.g. DNA)/nucleotides

Sources: FAO, RUBIN, VRF, Sintef, Nofima, Havs och Vattenmyndigheten

The **pH-shift p** 2000, and since then we from work with:

- Herring (partly E
  - *Isolated li*
  - *Fillets*
  - *Whole gu*
  - *Whole*
- Cod heads/fram
- Blue whiting
- Whole vendace
- Mussels (with/w



Most trials dc ng 2010-2011
also **pilot scale trials** carried out

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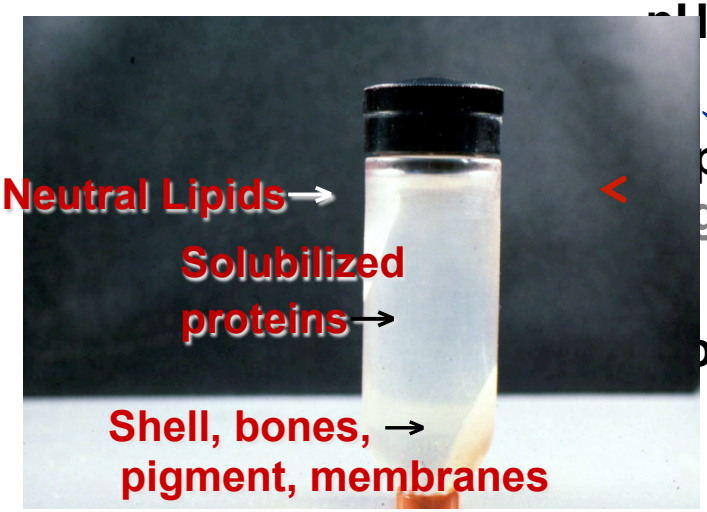
Homogenization
raw material + water (≥1:3)

↓

Protein solubilization
pH → ~3 or 11

↓

Separation
(e.g. ≤10 000g)



↓

Protein precipitation
→ ~5.5

↓

Protein dewatering
(≤10 000g)

↓

Final protein isolate

↓

Gelation
(pH →7.1, 2% salt
20 min 90°C)

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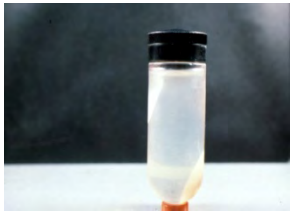
nal protein isolate

- Water consuming



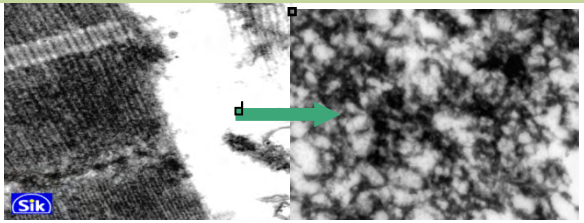
- 50-75% Protein recovery

- Dewatering challening in large scale

- ≤ 70% fat ↓
- ≤ 70-80 % ↓ in dioxins & PCB´s
- ≤ 80 % ↓ DSP-toxins
- ↑ essential amino acids
- Retained protein digestibility

- Requires antioxidants with blood rich materials
- Color could be improved

- Good gelation capacity



Compared to the actual **fishing step**, the pH shift process is not of major importance for neither the climate gas emissions nor the energy consumption coupled to the prot.isolate

Marine protein isolates in foods, and health supplements

- **Surimi:** Its gelation capacity very attractive in all gelled fish products (fish balls, fish cakes, crab sticks..)
- **Powder:** can replace milk-/soyproteins in soups, energy drinks, bakery products
- **Marinades:** injection into fillets for improved water holding/juiciness (replaces phosphates with a natural product)
- **Coating:** on fried products (nutrilean™)
- **Biodegradable films :** with antimicrobial and antioxidative properties
- **In capsules;** Positive effects documented in relation to high blood pressure, diabetes and weight management



In Japan, ~40 000 ton marine proteins and peptides are yearly used as food ingredients…

What could an expected value addition be?

- **Basically anything exceeding the value of fish meal, which is currently 1,2 Euro/kg[1]**

- **Difficult, however, to find relevant price information on novel products where a market is not yet developed..**

***Casein/caseinates; 9,5 Euro/kg [2]**
***Soy protein: 4-14 Euro/kg[2],[5]**
***Surimi, i.e. washed fish mince: 5,5 and 28 Euro/kg on a wet and dry weight basis, respectively[3]**
***Fish protein based seafood marinades; 13-38 Euro/kg**
***Fish skin gelatin; 10-19 Euro/kg[4,5]**
***Fish collagen peptides; 10-150 Euro/kg[4]**
***DNA salts: 10-160 Euro/kg[5]**

1. http://www.indexmundi.com/commodities/?commodity=fish-meal&currency=sek
2. U.S. Protein Ingredients Markets, Frost & Sullivan research service (http://www.frost.com/prod/servlet/ report-brochure.pag?id =N415-01-00-00-00
3. http://www.seafoodsource.com/newsarticledetail.aspx?id =4294999004
4. http://www.alibaba.com/showroom
5. RUBIN report nr. 4613/111

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Residuals
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Feed
Bioenergy

Enzymes

Gelatin

Gelatin

Calcium concentrate

Oil

Phospholipids

Nucelic acids (e.g. DNA)/nucleotides

Sources: *FAO, RUBIN, VRF, Sintef, Nofima, Havs och Vattenmyndigheten*

THANK´s

The marine research group at Food Science

Manat Chaijan (visiting professor)
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Lillie Cavonius (PhD student)
Karin Larsson (PhD student)
Sofia Marmon (Previous PhD-student/Post Doc)
Linnea Eriksson (PhD-student, not in picture)

External collaborators

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Maud Langton (prev SIK)
Annika Krona (SIK)
Per Liljelind (Umeå Universitet)
Herbert Hultin & Steve Kelleher (prev Umass Marine Station)

Our main Financers

Jordbruks verket
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The Swedish Research Council Formas
Committed to excellence in research for sustainable development
norden
Nordic Innovation

pH-shift processing of mussels

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	Protein yield
Acid process, isolated mussel meat	43%
Alkaline process, isolated mussel meat	58%
Acid process, whole mussels	31%
Alkaline process, whole mussels	48%

Changes in dioxins/dioxin-like PCB´s during pH-shift processing of Baltic herring

	Herring mince	Protein isolate
Fat % (On 80% water basis)	7.1	2.1
Dioxins TEQ (pg/g, on 80% water basis)	5.7	2.0
Dioxin-like PCB´s TEQ (pg/g, on 80% water basis)	3.3	1.0

* Average value based on isolates from acid and alkaline processing

EU limits: 4/8 pg/g

This herring: 5.7/9 pg/g → 2/3 pg/g

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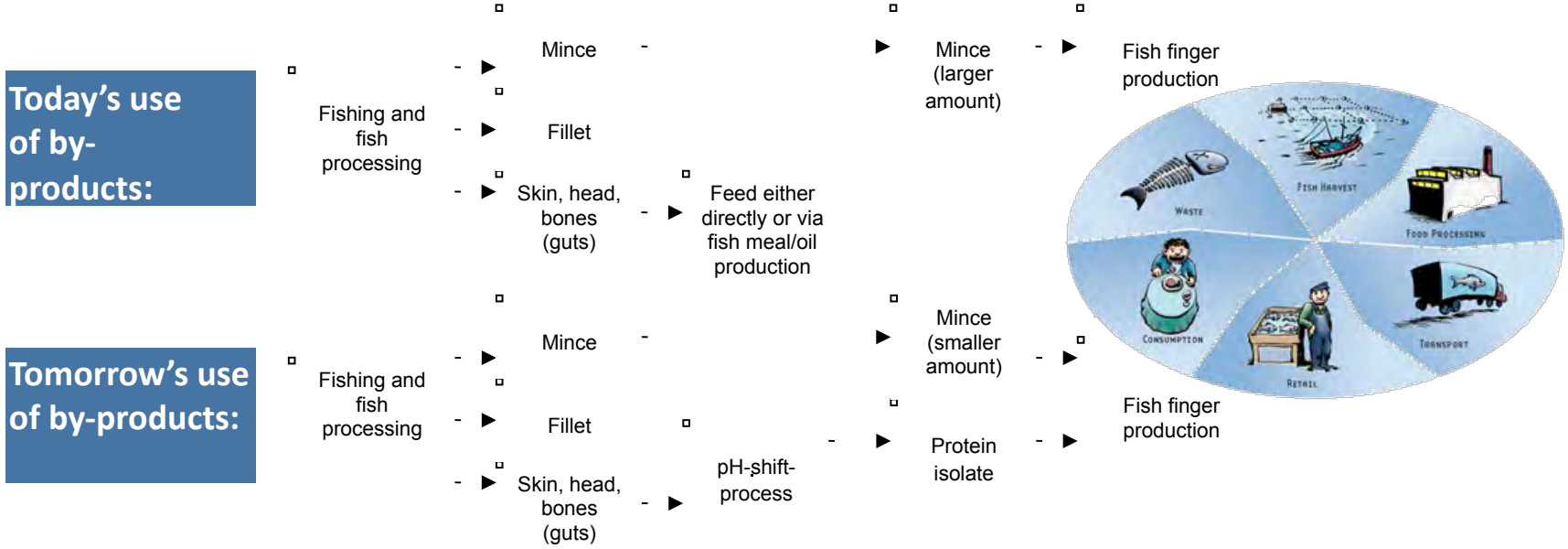
Life Cycle Assessment (LCA) of protein isolation with the pH-shift process



by In an up-scaling project coordinated by Chalmers (and funded EU-structural funds – project 31-652-08), SIK has evaluated the environmental burden coupled to the protein isolate production using Life Cycle Assessment (LCA). LCA is a method for accounting the environmental performance of a product through the whole chain from cradle to grave, or certain steps in the product's life cycle, regarding the impact categories chosen. In this study greenhouse gas emissions (GHG) as well as energy use was assessed. In addition a Life Cycle Costing (LCC) analysis was performed, where the price of producing the protein isolate was calculated, and economic hotspots were identified. The raw material used for processing was cod back bones.

Results showed, not surprisingly, that the main environmental burden lies in the fishing phase where diesel is used as fuel and refrigerants are used to preserve the fish. Hence the contribution from the process for extracting the protein is not of major importance for neither the climate gas emissions nor the energy consumption coupled to the protein isolate.

Sund, V. Ziegler, F. Stark, M. Undeland, I 2011

Sik

Changes in DTX-1 during pH-shift processing of mussels

::

	DTX-1 µg/kg (80% moisture basis)
Mussel mince	800
Protein isolate (acid process)	65
Protein isolate (alkaline process)	135

EU limit 160µg/kg mussel meat

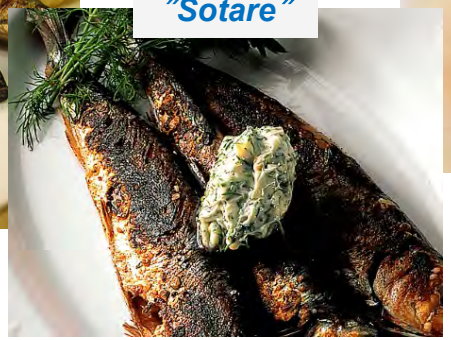
Major value increases and environmental gains to expect if moving further than fillets, fish meal and biogas!

Consumer attitudes, terminology, techniques and entrepreneurship/courage will be decisive!

Vi måste se bortom lax- och torskfilén….

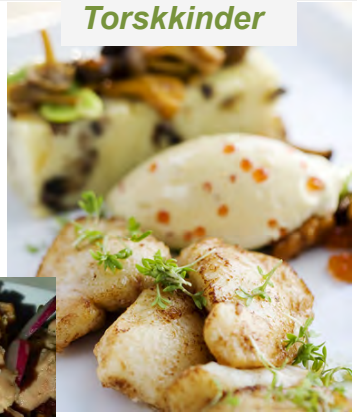
Grillade sardiner

”Sotare”



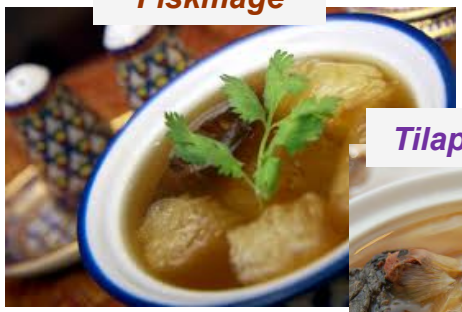
Torsknacke

Torskkinder



Torsklever

Fiskmage



Tilapiafenor

Fiskgelatin

Fiskprotein

DNA-salter

Fiskmølje

Fiskpeptider

The problem: *The fishing industry yields large amounts of poorly utilized fish proteins → low income & not sustainable*

Total consum fish landed in Sweden 2011*:

100 000 tonnes

Total ”fodder fish” landed by Swedish boats 2011:

93 000 tonnes

Fillet: ~56% w/w

Guts: ~12%

Frame: ~21

~1-2.20 SEK/kg!

Muscle: 45-50%

~ ~~15 500 tonnes muscle~~

Protein: ~18%

~~~3000 tonnes proteins~~

~2.8 million tonnes proteins

~ ~~24 000~~ tonnes proteins

~ 2.8 million tonnes proteins

**Incl aquaculture*

Sources: *FAO, RUBIN, VRF, Sintef, Nofima, Havs och Vattenmyndigheten*

Some conclusions

• The pH-shift process very promising for complex bone/shell structures-”2nd generation use”

• Protein yields from herring, cod frames/heads and mussels; 50-70%

• Excellent removal of ash, good removal of lipids, toxins & pigments

• Decent protein functionality of gels produced

• The acid process often gives better recoveries while the alkaline process often perform better in other aspects

• Each new raw material is a new case

• The factor determining success depend on your application

• Among furture challenges are process simplifications and colour/ stability improvements

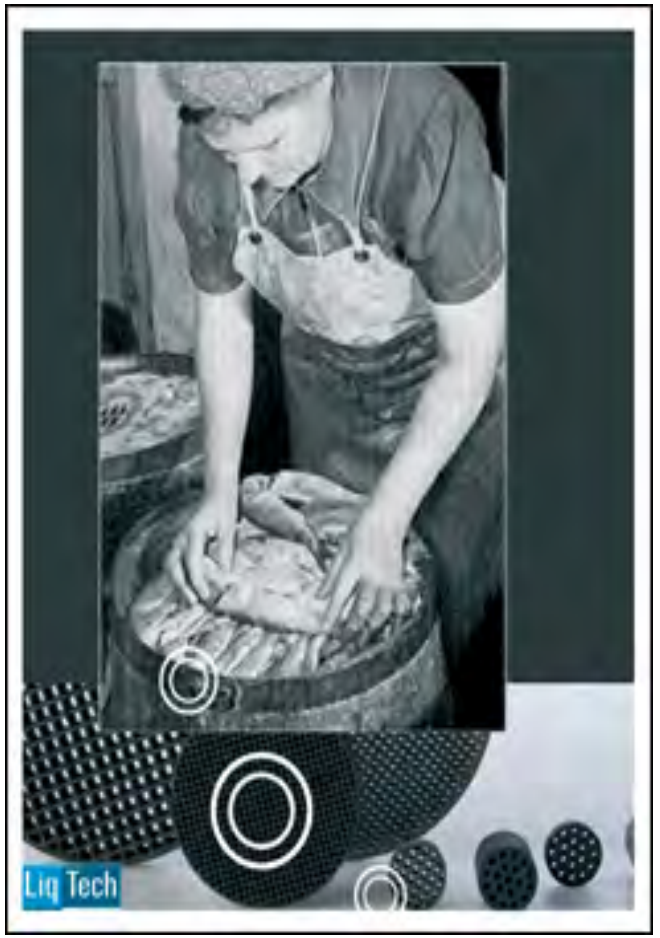
Maximera nyttjandet av vätskeströmmar från fiskindustrin

PIPE projektet

➢ **P**elagic **I**ndustry **P**rocessing **E**ffluents:
Innovative and sustainable solutions

Partners:

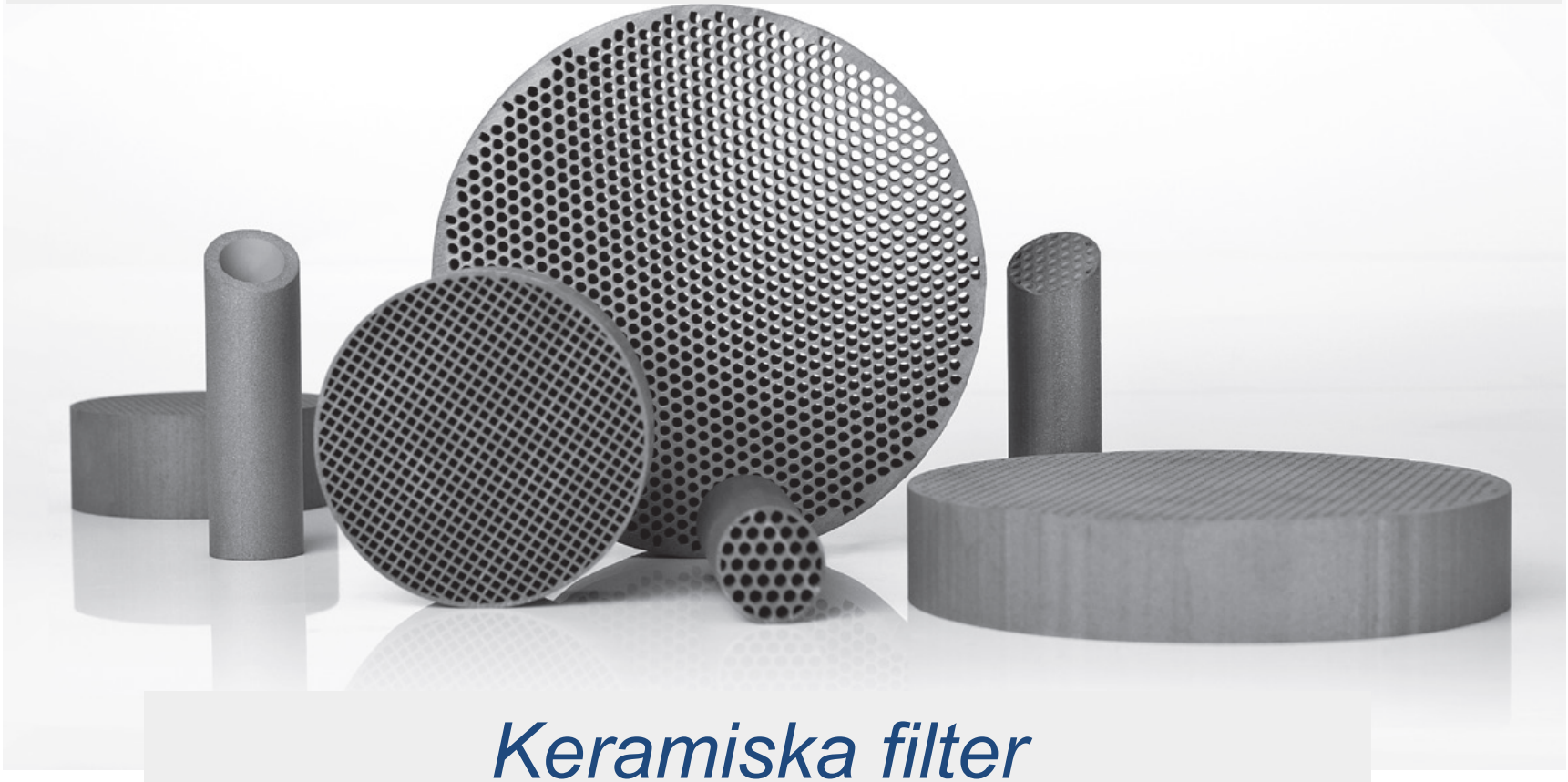
- *Chalmers, Sverige.*
- *DTU, Danmark*
- *Fish and Food Expert (FFE), Danmark.*
- *Paul Mattsson AB, Sverige: Sillprocessare.*
- *Lykkebergy A/S, Danmark: Sillprocessare*
- *Cometas A/S, Danmark: Keramiska filter*
- *A-factory A/S, Danmark: Elektrokemi*



Fiskindustrin, speciellt sillindustrin, konsumerar mycket vatten….

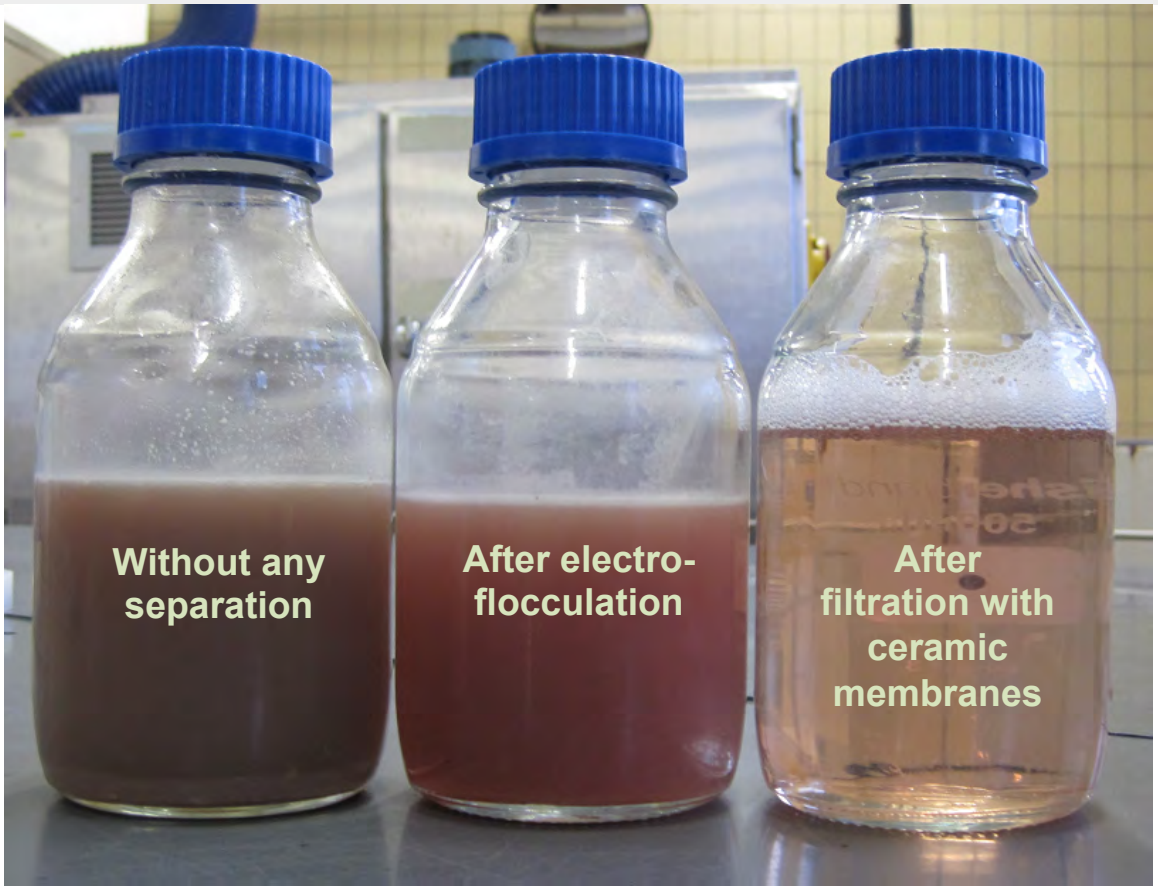
….och genererar spännande sidoströmmar med upp till 7% protein och 2,5% fett!

Utmaning: bra tekniker och processkunskap krävs för att ta tillvara på dessa ämnen!



Keramiska filter

*Pilottest för att koncentrera värdefulla ämnen från sill_*



How to isolate *intact* muscle proteins from complex structures rich in bones and skin

- **Pressing/squeezing** with e.g. a belt drum
- Acid or alkaline solubilization followed by isoelectric precipitation, so called **pH-shift processing**

http://www.diytrade.com/china/pd/9745556/fish_meat_bone_separator_CR_200.html