HMG Seminar Series, Session 4
December 1, 2021

Cephalopod gastronomy

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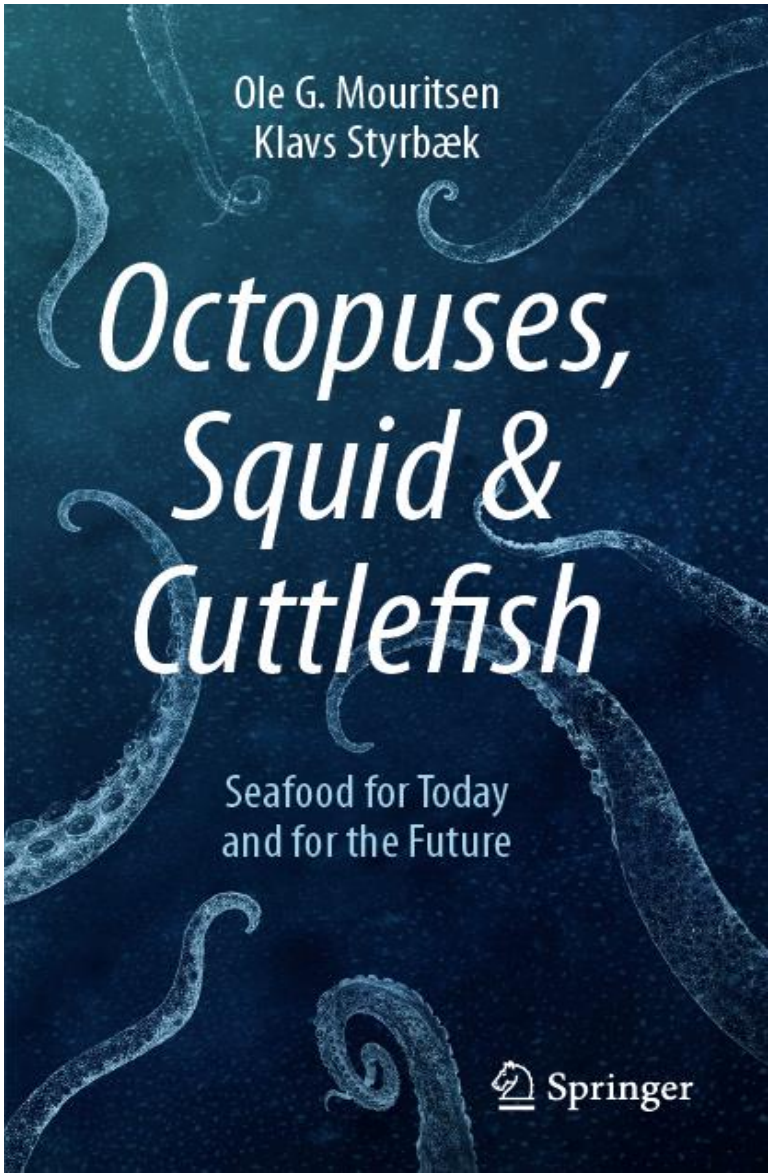
Chef Klavs Styrbæk



Squid: Gastrophysics of squid: from gastronomy to science and back again (O. G. Mouritsen, C. V. Schmidt, P. L. Faxholm, and M. P. Clausen). In *CRC Handbook of Molecular Gastronomy: Scientific Foundations and Culinary Applications* (R. Burke, A. Kelly, C. Lavelle, and H. This, eds.) CRC Press, pp. 541-544 (2021).

Global changes are needed

More than half of the goals are related to food, food systems, and health.

Food in the Anthropocene: the EAT–*Lancet* Commission on healthy diets from sustainable food systems

Walter Willett, Johan Rockström, Brent Loken, Marco Springmann, Tim Lang, Sonja Vermeulen, Tara Garnett, David Tilman, Fabrice DeClerck, Amanda Wood, Malin Jonell, Michael Clark, Line J Gordon, Jessica Fanzo, Corinna Hawkes, Rami Zurayk, Juan A Rivera, Wim De Vries, Lindiwe Majele Sibanda, Ashkan Afshin, Abhishek Chaudhary, Mario Herrero, Rina Agustina, Francesco Branca, Anna Lartey, Shenggen Fan, Beatrice Crona, Elizabeth Fox, Victoria Bignet, Max Troell, Therese Lindahl, Sudhvir Singh, Sarah E Cornell, K Srinath Reddy, Sunita Narain, Sania Nishtar, Christopher J L Murray

Lancet 2019; 393: 447–92

TASTE ?

Food production is the main reason for changes in the Earth's ecosystems (climate, water, use of land, drinking water, biodiversity, P and N cycles)

Proposed solution for a healthy and sustainable diet for an increasing population:

<u>Diet mainly composed of</u>
- Vegetables, fruits, whole grain, legumes, nuts and unsaturated fats
- Moderate amounts of fish and poultry
- Little or no red meat, processed meat, added sugar, refined cereals, and starchy vegetables

<u>Daily recommendations, plant based</u>
- 300g vegetables, 200g fruit
- 230g whole grain (rice, wheat, corn); 60% of caloric intake
- 50g starchy vegetables (e.g., potatoes)

The solution is fragile

Can we eat that much?

Recipe for making this delicious

➡ *add science*

Focus on

➡ taste

➡texture

(mouthfeel)

Design and 'umamification' of vegetables for sustainable eating (O. G. Mouritsen and K. Styrbæk) *Int. J. Food Design* **5**, 9-42 (2020)

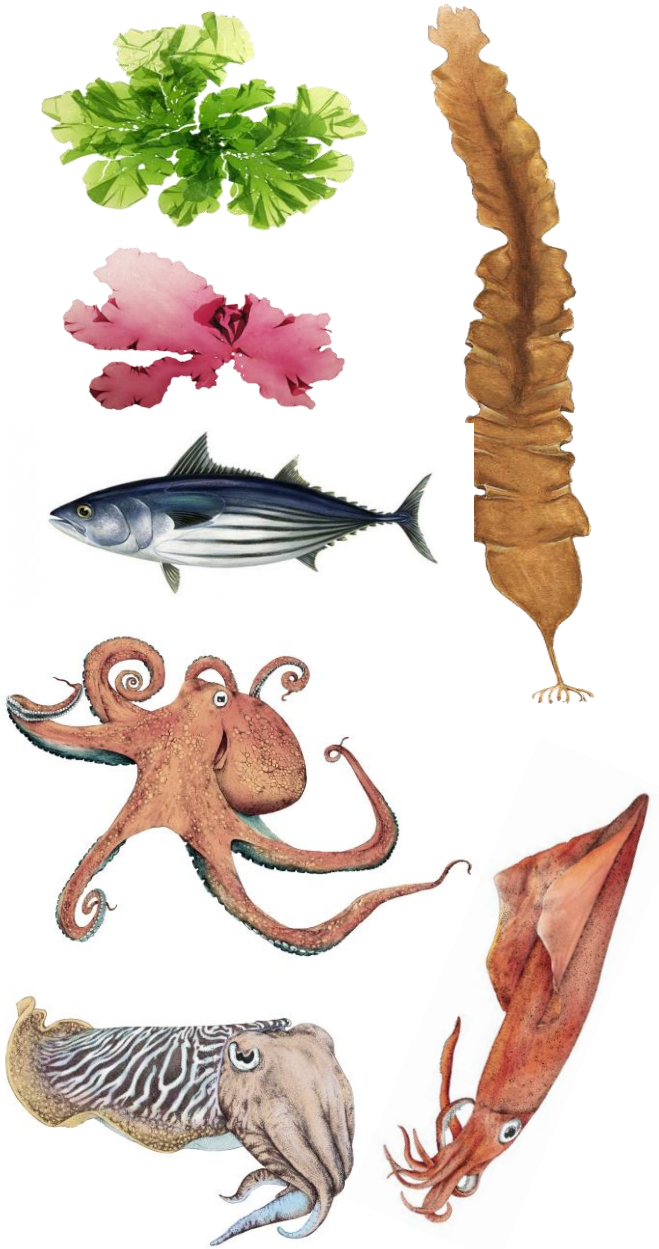
‘Problems’ with vegetables

- Vegetables are not ‘meant’ to be eaten
- Vegetables lack **sweet** and **umami**
- Vegetables can be **bitter**

- *Homo sapiens* craves basic tastes **sweet** and **umami** (by evolution) and stay away from **bitter**

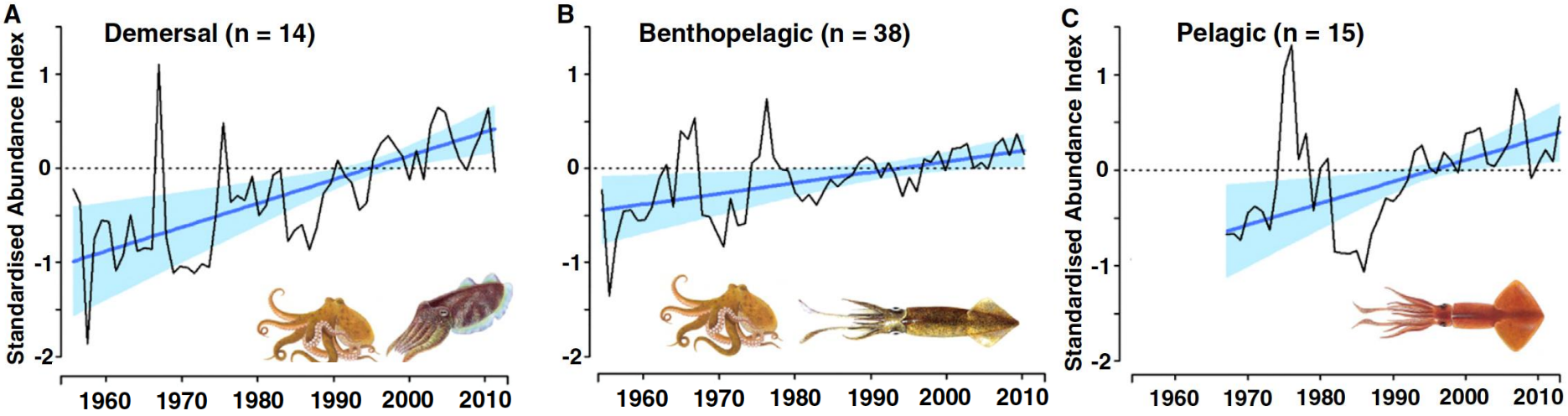
☞ Therefore: there is a need for *culinary sciences* to help promoting the green transition

Some help from the ocean



A role for macroalgae and **cephalopods** in sustainable eating
(O. G. Mouritsen and C. V. Schmidt) *Front. Psychol.* **11**:1402 (2020)

Some data to ponder



Doubleday *et al*., Global proliferation of cephalopods. *Cur. Biol.* **26**, R406-R407, 2016.

" … the first evidence that cephalopod populations have increased globally, indicating that these ecologically and commercially important invertebrates may have benefited from a changing ocean environment."

2016 World Congress on Cephalopods: *Overview on Supplies*. Vigo, Spain

Conclusion: **" … all populations have grown over the past 50 years"**

Cephalopods as food

Global populations of octopus, squid & cuttlefish are increasing

- 800 species in all salty waters. >30 species exploited as human food.
- 5% of total global fisheries and increasing rapidly. Only wild catch.
- Global annual production 4.8 mio. metric tonnes; value ~8 billion $US.

- Highly unexploited seafood.

- Need for **gastronomy** and gastrosciences to enhance broader use in households and food industry as well as to increase market value. Focus on **taste** and **texture**.
- High in protein (16%); future source of **animal protein**.
- High in minerals Ca, Na, Fe and trace elements Cu, Zn, Se, Cr. Octopus high in vit B_{12}.

- Short life cycle (2-3 yr). Rapid reproduction and proliferation.
- Low environmental toxic load
- Quick adaptation to environmental changes. Tipping competition with bonefish?

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Doubleday *et al*., Global proliferation of cephalopods. *Cur. Biol.* **26**, R406-R407 (2016).
Cephalopod gastronomy - a promise for the future (O. G. Mouritsen and K. Styrbæk)
Front. Comm. Sci. Environ. Comm. **3**:38 (2018).

How to proceed:
Add (gastro)science

- Gastrophysics & food science
- Gastronomy
- Culinary food innovation
- Cut food waste

Squids of the North: gastronomy and gastrophysics of Danish squid (P. L. Faxholm, C. V. Schmidt, L. B. Brønnum, Y.-T. Sun, M. P. Clausen, R. Flore, K. Olsen, and O. G. Mouritsen)
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Cephalopod gastronomy

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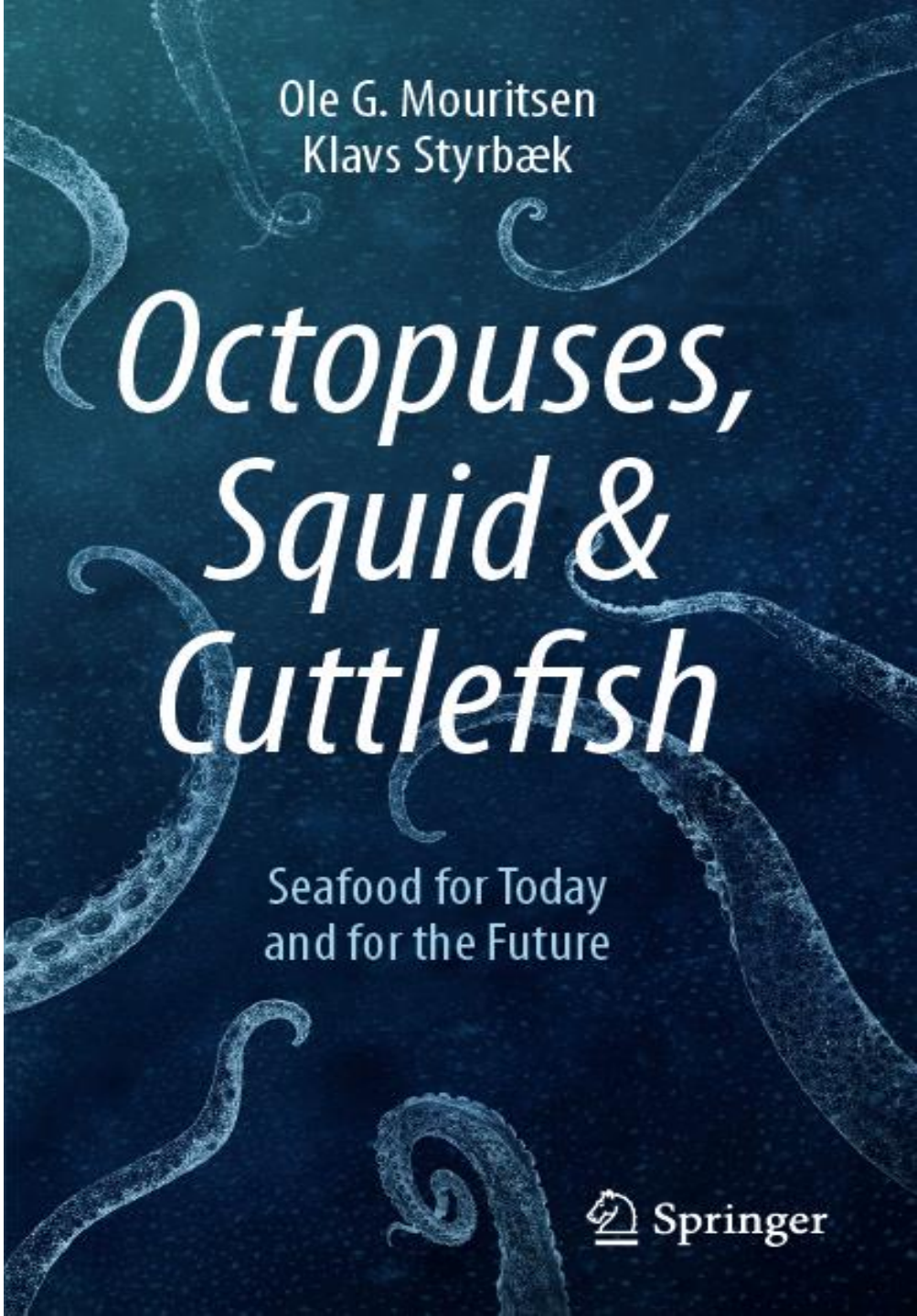
Cephs & Chefs Recipe Book (2021).



How do cephs ‘taste’?

Basic tastes

Umami
Sweet
Salty

} Marine food

Teksture

Tender, chewy, soft, crispy, creamy, rubbery,

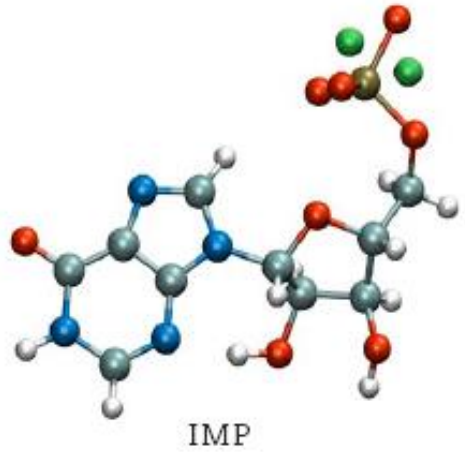
…

Taste: Umami synergy

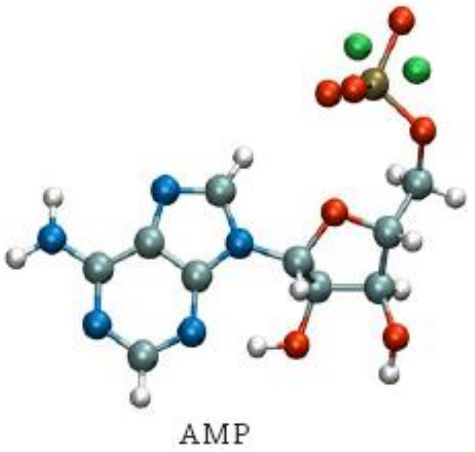
Free amino acid

Glutamate (Glu)

Free nucleotides



Inosinate (IMP)

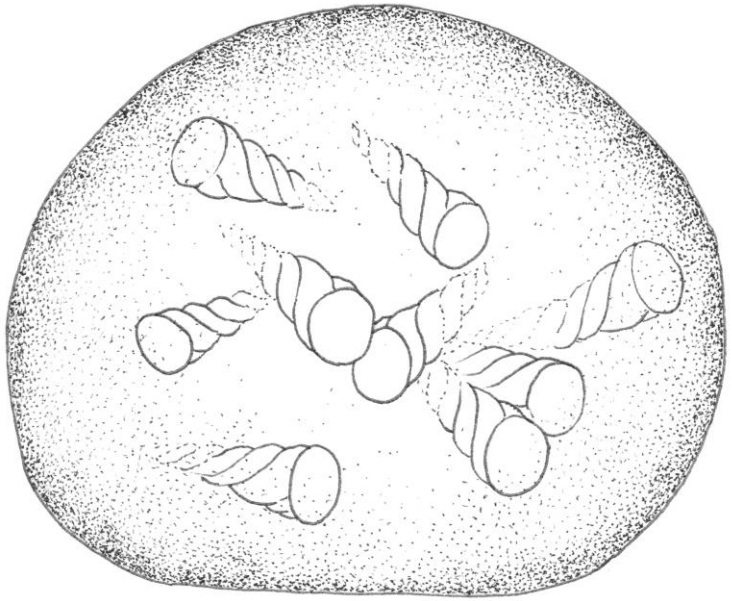


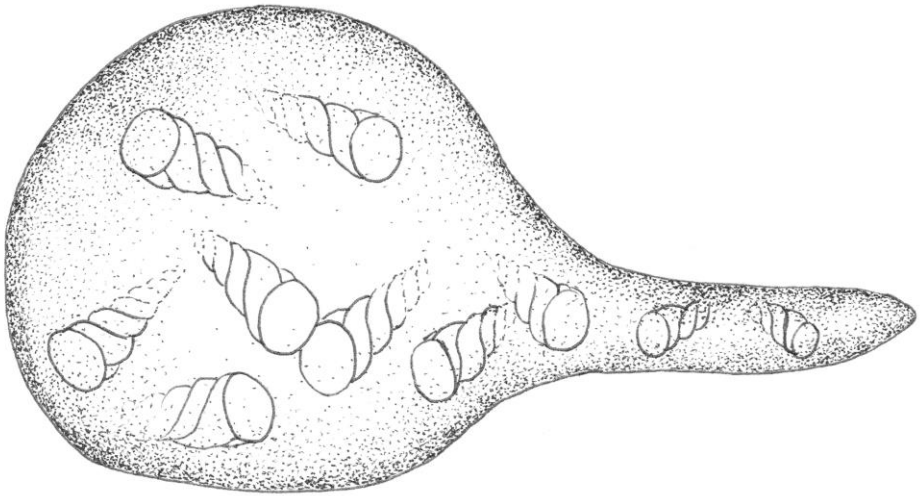
Adenylate (AMP)

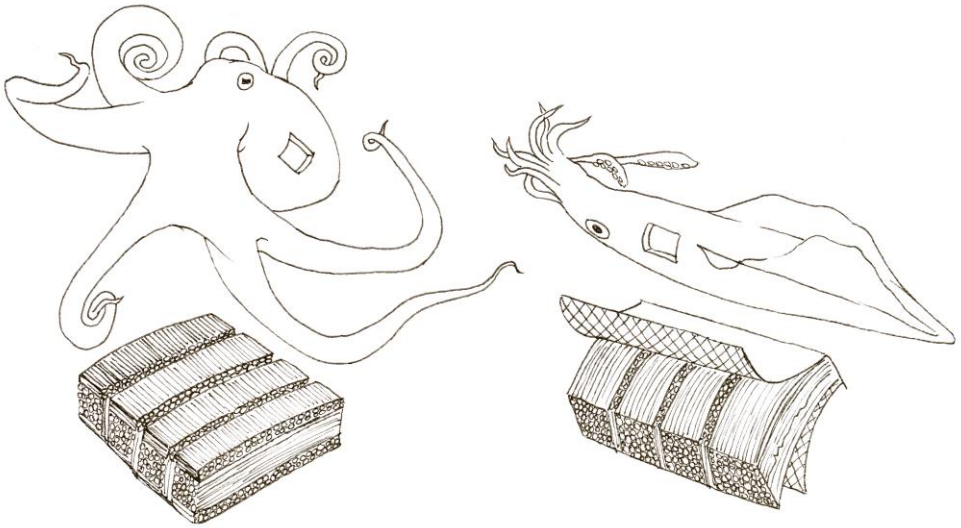
$$EUC = \Sigma_i u_i + (\Sigma_i u_i) \times \Sigma_i \Sigma_N \gamma(N) v_{i,N}$$

Mouthfeel: here is the trouble

The science behind: the muscular hydrostate

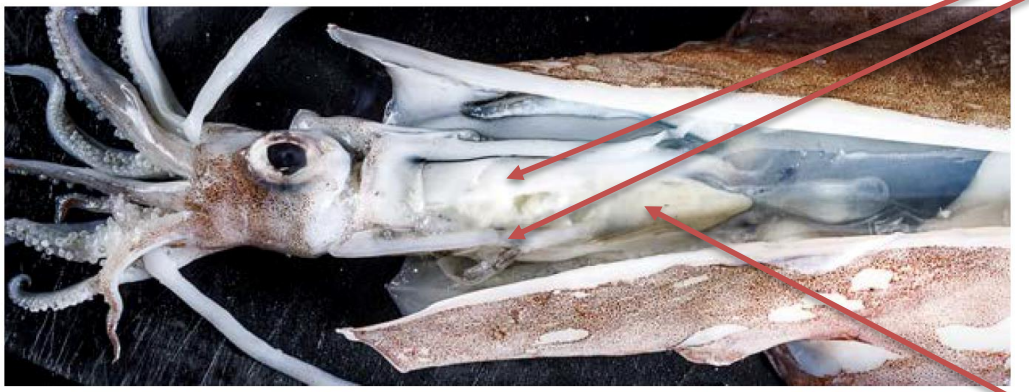


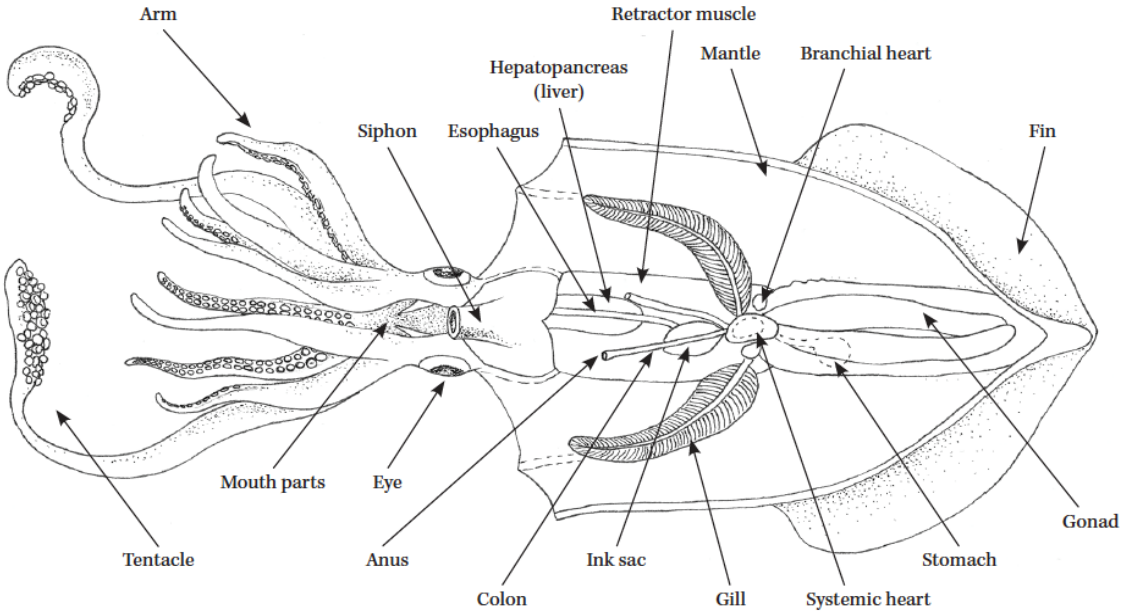




Loligo: anatomy

Loligo forbesii





Gastrophysics of *Loligo forbesii*

- Thermal analysis/thermodynamics: calorimetry
- Analytical chemistry: component analysis
- Mechanics/materials properties: texture analysis
- Structure: fluorescense-microskopi
- Structure: small-angle X-ray scattering (SAXS)
- Sensory science, comsumers' preference
- Gastronomic innovation

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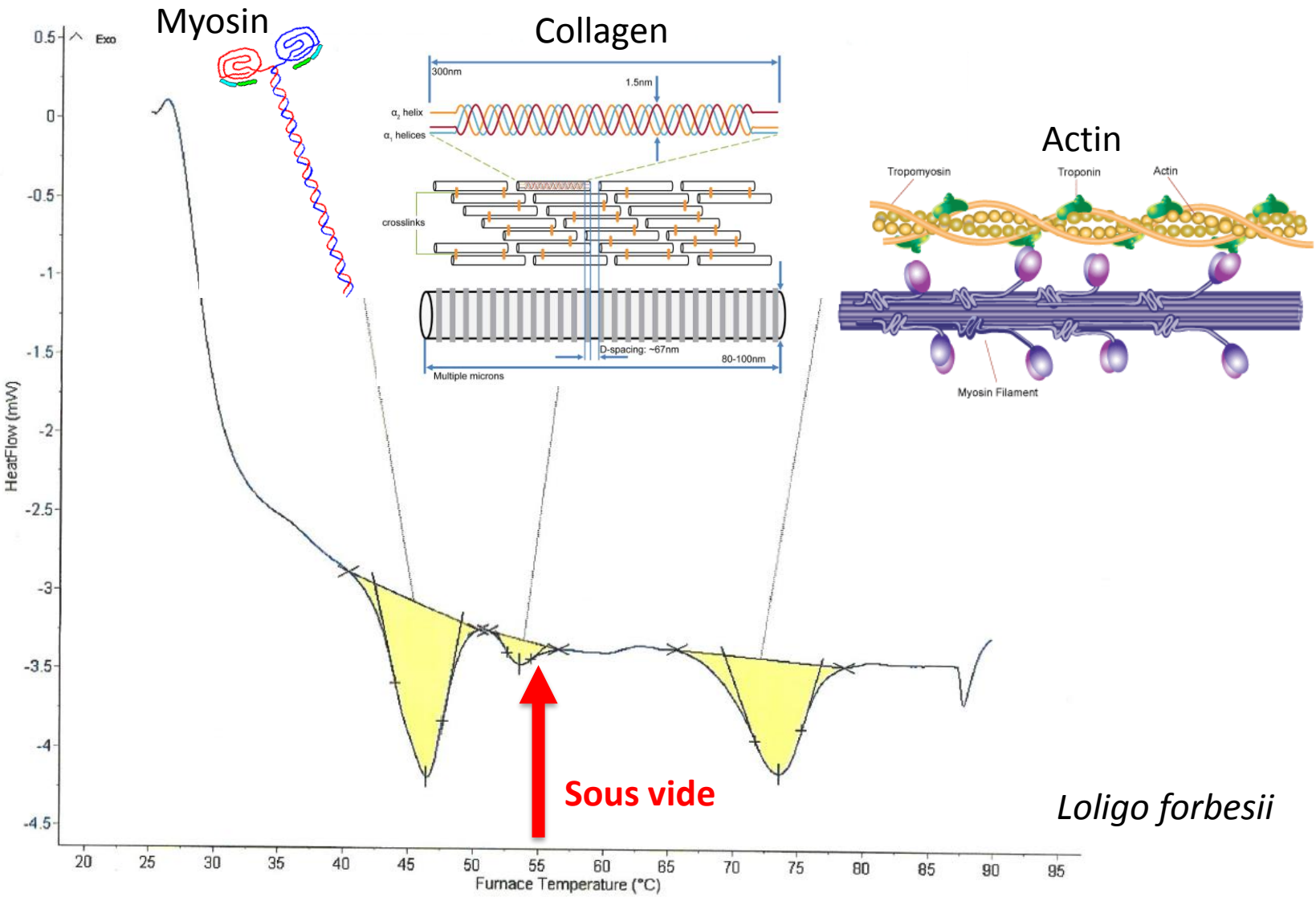
Umami potential of Nordic squid (*Loligo forbesii*) (C. V. Schmidt, M. M. Poojary, O. G. Mouritsen, and K. Olsen) *Int. J. Gastronomy. Food Sci. Int. J. Gast. Food Sci*. **22**, 100275 (2020)

Physicochemical characterisation of sous vide cooked squid (*Loligo forbesii* and *Loligo vulgaris*) and the relationship to selected sensory properties and hedonic response (C. V. Schmidt, L. Plankensteiner, P. L. Faxholm, K. Olsen, O. G. Mouritsen, and M. B. Frøst) *Int. J. Gast. Food Sci.* **23**, 100298 (2021)

Gastrophysical and chemical characterization of structural changes in cooked squid mantle (*Loligo forbesii and L. vulgaris*) (C. V. Schmidt, L. Plankensteiner, M. P. Clausen, A. R. Walhter, J. J. K. Kirkensgaard, K. Olsen, and O. G. Mouritsen) *J. Food. Sci. New Horizons in Food Research* **86**, 4811-4827 (2021)

Calorimetry



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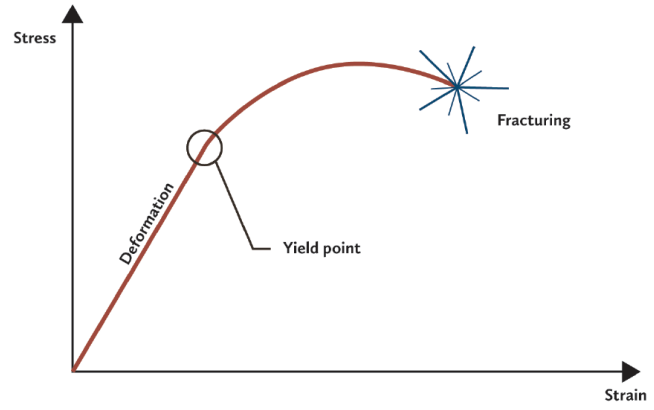
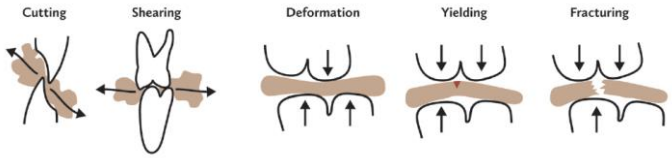
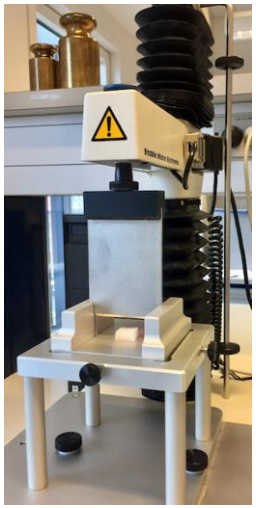
Texture analysis

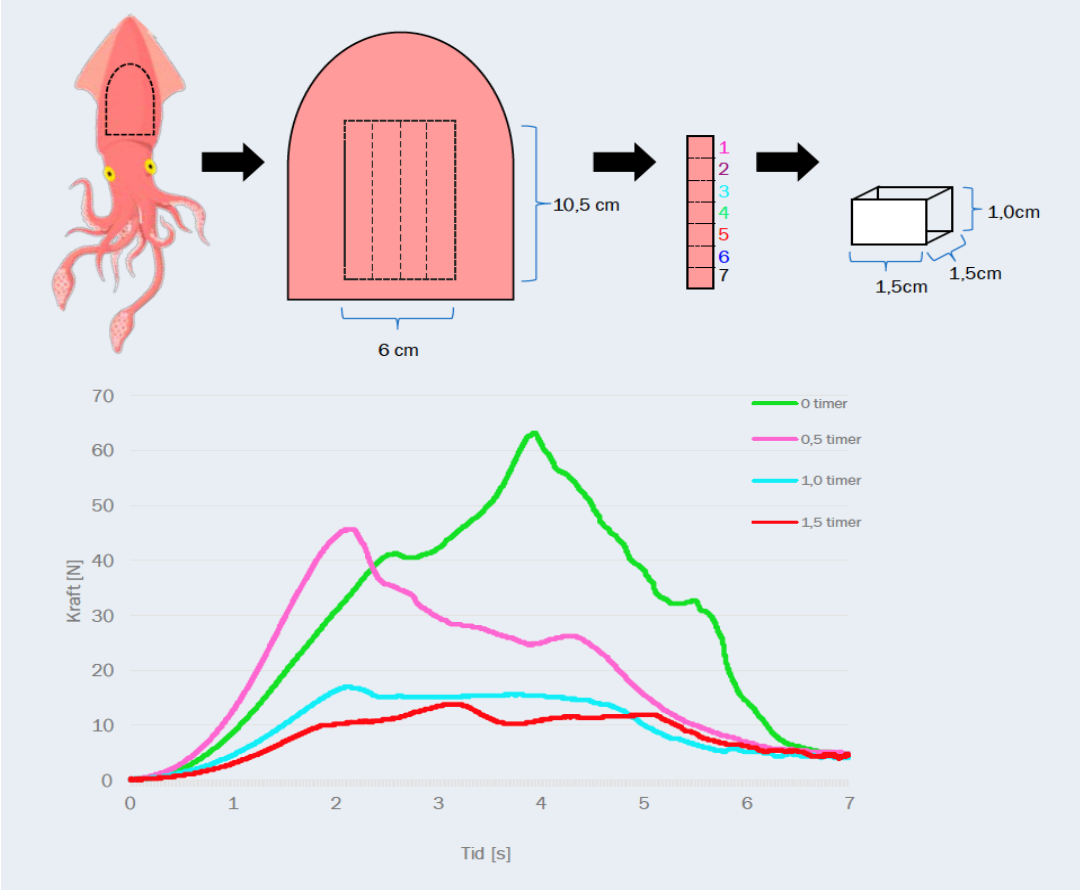




TA parameters

- **Hardness**
- **Chewiness**
- Cohesiveness
- Springiness
- Resilience





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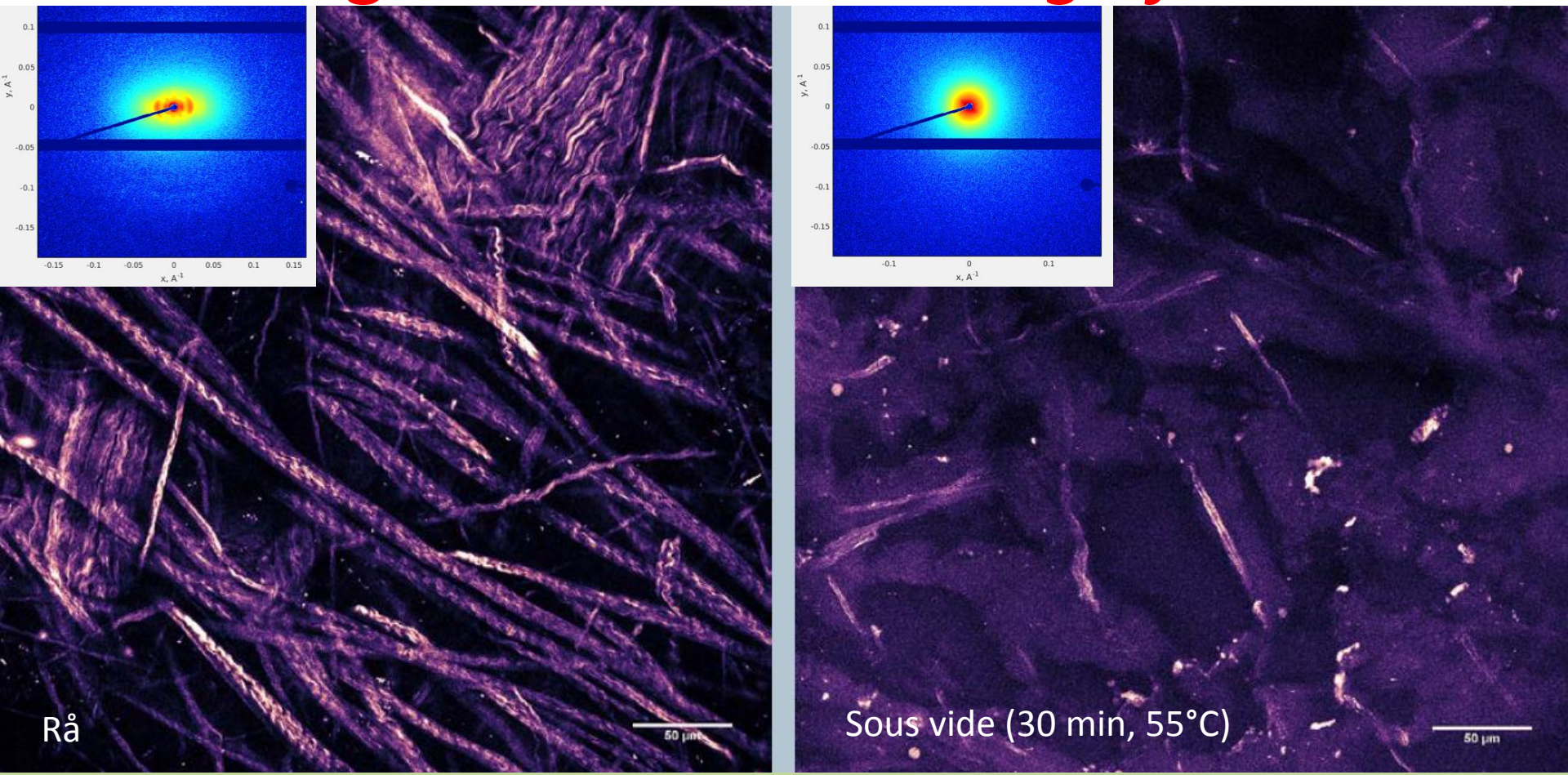
Second-harmonic microscopy & SAXS

Collagen structure af *Loligo forbesii*



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Some compounds in Loligo forbesii

Heavy metals (Hg, Pb, Cd < ppb)

Umami taste compounds (synergy)

Raw [mg/100g]	Glu	IMP	AMP
Loligo forbesii			
Mantle	109	5.3	48
Arms	101	5.4	15
Fins	72	6.2	38
Liver	462	10.3	5.3
Ostrea edulis	257	30	94
Crassostrea gigas	160	15	89
Scallop	140	n.d.	172
Chicken	22	202	13

Umami potential of Nordic squid (*Loligo forbesii*) (C. V. Schmidt, M. M. Poojary, O. G. Mouritsen, and K. Olsen) *Int. J. Gastronomy. Food Sci. Int. J. Gast. Food Sci*. **22**, 100275 (2020)
Umami synergy as the scientific principle behind taste-pairing champagne and oysters C. Vinther Schmidt, K. Olsen, and O. G. Mouritsen) *Nature Sci. Rep*. **10**, 20077 (2020)

Umami synergy

EUC: equivalent umami concentration

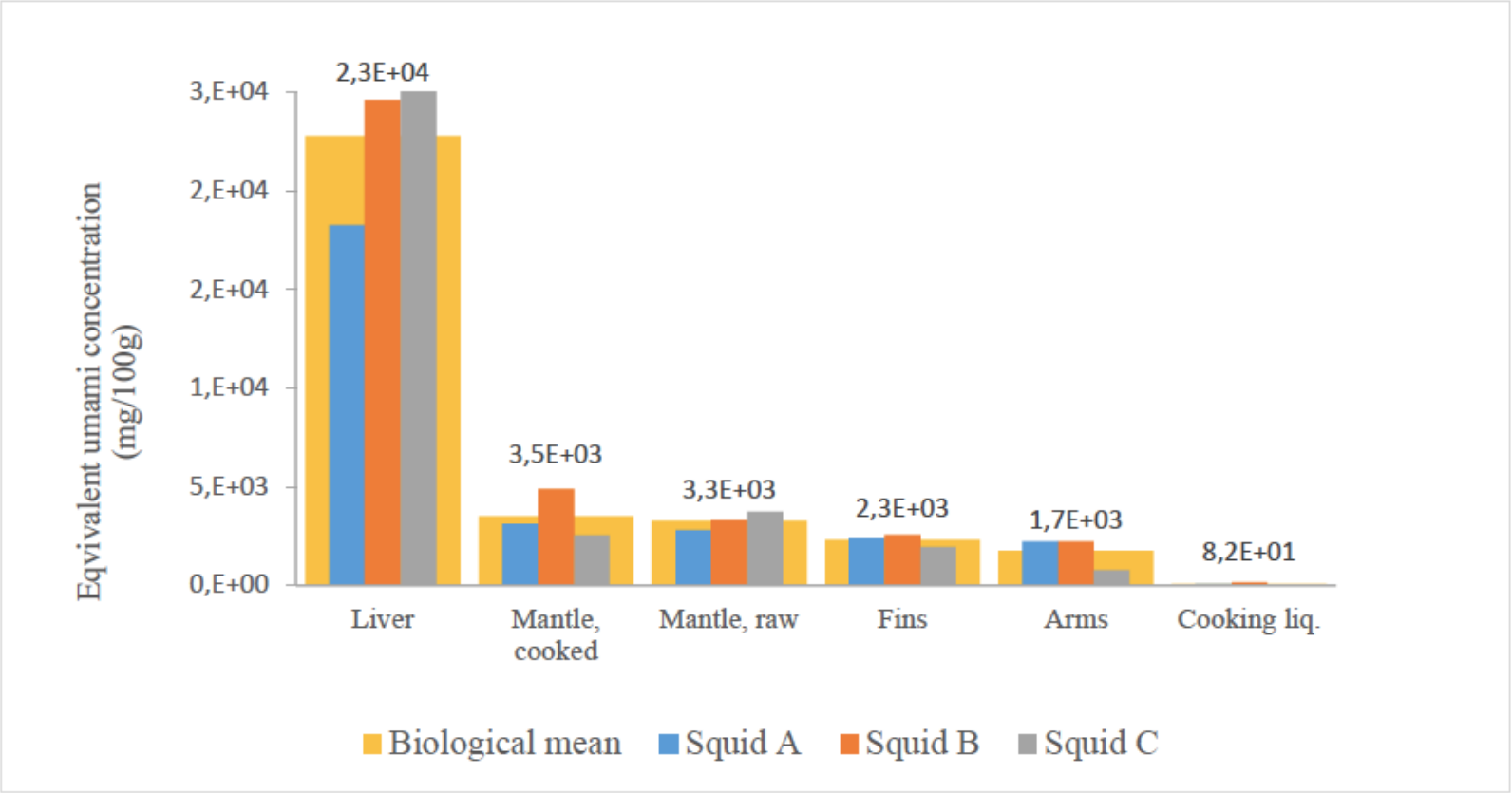

Figure 1. Calculated umami potential of squid. Bar-plot of EUC values calculated from Yamaguchi *et al.* (1971) displaying the synergistic umami taste potential of squid cuts and derivatives (liver, mantle, cooked, mantle, raw, fins, arms, cooking liquid) for each biological specimen (squid A, squid B, squid C) and the biological mean. Values on the top of the bars denotes the biological mean value.

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Consumers' preference

n= 141

- Liking of squid was found independent of gender and familiarity with eating squid, but some dependence of age was identified where the "younger" half of the consumers (<50 years) rated the squid higher in hedonic response.

- Sous vide cooking temperature of 55°C seems to be an acceptable compromise to obtain both a well-liked texture and sufficient juiciness. **Must not be <u>too</u> soft.**

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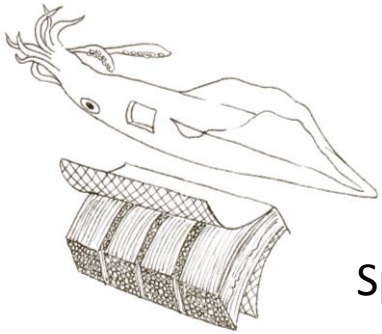
Outreach to children

Todarodes sagittatus

Squid *gyutako*

Culinary food innovation

Curly squid confit



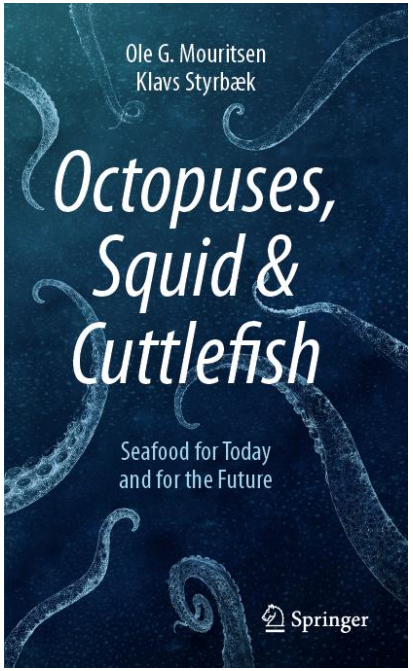
Spontaneous curvature

Peter Lionet Faxholm

Sardinian *pane carasau* with frozen squid paste

Chef Roberto Flore

Thank you for your attention!



(Almost) raw

Ika no shiokara

Ceviche

Squid ‘fettucine’ with lobster

Semi-dried squid

Ika no ichiya-boshi

Grilled squid

Grilled, filled squid

Izaac Walton, 1653

Smoked squid

Steamed squid

Deep fried squid