An overview of the risk-benefit assessment associated to contaminants and nutrients intake through seafood consumption: case studies

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How to assess the risks and benefits arising from the Seafood consumption?

- Identify main hazards and benefits worthy of study
- Apply a probabilistic approach
- Quantify probability of exceeding thresholds
- Compare and balance probabilities of exposure to hazards and attainment of benefits
Methylmercury Risks and EPA + DHA Benefits Associated with Seafood Consumption in Europe

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STATISTICAL-PROBABILISTIC ANALYSIS (Cardoso et al., 2010)

1. Collect nutritional, toxicological & medical data

2. Adjust distributions to the nutrients & contaminants contents & consumption levels

3. Combine contents with consumption data
   (consumption frequency, scenarios or surveys)

1. Compare nutrients and contaminants intake distributions with thresholds

2. Calculate risk and benefit probabilities
Benefit/risk characterization

Calculation of the probability of exceeding the thresholds (i.e DRI for nutrients and the TWI for contaminants).

Software @ RISK and assumed a meal of $X$ g and a human body weight of $Y$ kg as described Cardoso et al (2010).

In the case of MeHg risk is always analysed with Se (Protective effect against the MeHg toxicity):

The Se-Health Beneficial Values (Se-HBV) were calculated as described by Ralston and Raymond (2014).

$$
\text{Se-HBV} = \frac{[\text{Se}]-[\text{MeHg}]}{[\text{Se}]} \times ([\text{Se}]+[\text{MeHg}])
$$

[...] Molar concentrations
Influence of culinary treatment and bioaccessibility on the Risk-Benefit evaluation

Mixing, heating, pasteurizing, extruding, etc

Fresh Foods
- Nutrients
- Antinutrients
- Contaminants

Processed Foods
- Nutrients
- Antinutrients
- Contaminants
- Processing formed products

Cooked Foods
- Nutrients
- Antinutrients
- Contaminants
- Processing formed products
- Cooking formed products

Culinary treatments

Gastrointestinal digestion
- Intestinal absorption & Presystemic metabolism (depending on definition)

Digested Foods

Bioaccessible Constituents

Nutrients and/or scenarios

Bioaccessibility Assessment

Risk-Benefit Analysis

Overestimated Probability

Total Contents

Consumption data and/or scenarios

Bioavailability Assessment

More Accurate Probability

Refined Risk-Benefit Analysis

Introduction
Health and nutrition are intimately linked. Food provides nutrients, but also antinutritional compounds and contaminants. This raises the issue of quantifying and balancing the risks and benefits associated with a given food. Such an analysis requires knowledge of the consumption frequency levels in a population or subgroups of it, because, as Paracelsus once stated, “it is only the dose which makes a thing poison.” Scenarios can also be constructed on the basis of hypothetical consumption frequencies. A reliable and in-depth quantitative evaluation of the risk–benefit balance is a fundamental requirement. Moreover, such evaluation must take into account that foods are typically subjected to further culinary treatment before ingestion (Cardoso et al., 2019). Besides, the level of a nutrient or contaminant in a portion of food that is eaten may be quite different from the bioaccessible level, i.e., the component concentration that is released from the food matrix into the intestinal lumen after digestion, and, according to some other definitions, after absorption across the intestinal wall and the presystemic metabolism. This content may also differ from the...
Bioaccessibility of a compound is the amount available for intestinal absorption and therefore reachable for the systemic circulation (bioavailable)

- *In vitro* simulation the human digestion (mouth, stomach, & small intestine) with proteases, lipases, & other enzymes
- Determination of compounds in the bioaccessible fraction

More realistic assessment of the nutritional value of seafood, thus adding knowledge & value
So, for Risk-Benefit assessment:

- Evaluate the effect of culinary treatments
- Determine compounds bioaccessibility/bioavailability
- Assess the risk/benefit binomial on the basis of bioaccessibility/bioavailability and cooking practices

Formulation of consumption recommendations for Seafood
**Benefits**

- **EPA+DHA n-3 PUFA**
  DRI 250 mg/day (EFSA)
  
  - Beneficial effects on cognitive and visual development;
  - lowering the risk of coronary heart disease and stroke;
  - Prevention/reduce multiple other adverse health outcomes.

- **Selenium- Essential elements**
  
  RDA 30 μg/day (IOM) – children (3 and 6 years old)
  High Bioavailability (> 85%)

  - Antioxidant properties, etc
  - Protective effect against the MeHg toxicity

**Risks**

- **MeHg -Environmental contaminant**

  MeHg in fish muscle ≈ 80-90% total Hg
  Biomagnification
  Bioavailability > 80%

  - crosses the **placental and blood-brain barrier - Neurotoxicity**

  - PTWI 1.6 μg/kg body weight (JECFA)
  TWI 1.3 μg/kg body weight (EFSA)
Case studies:

• Fish species were selected on the basis of guidelines of the Education Ministry for school meals (DGE, 2013) and fish consumption surveys.

• On the basis of dietary advice (Cordeiro, 2011), for children between 3-6 years (average weight of 17 kg) it was assumed a 25 g fish serving.

• Databases with EPA, DHA, Se, and MeHg contents both before and after digestion (bioaccessible) and bioavailable (in raw and cooked fish) were mined, including IPMA data, scientific papers, and official entities documents (i.e. FAO/WHO).

• Probabilities of exceeding recommended intakes and thresholds were estimated through the combined application of the Monte Carlo algorithm and the Extreme Value Theory (Cardoso et al., 2010) to hypothetical scenarios (1 meal/day EPA+DHA and Se, 1/2/3 meal/week MeHg).

• Selenium Health benefit value (Se-HBV), Se and MeHg molar ratio and Estimation of children IQ changes due to maternal fish consumption (FAO/WHO, 2010)
Assessment of the risk-benefit binomial

Probability (%) of exceeding the EPA+DHA DRI (250 mg/day)

Salmon presented the highest probability not only considering the total levels (prior to digestion) but also bioaccessible levels (after digestion)
Assessment of the risk-benefit binomial

Probability (%) of exceeding the Se RDA (30 µg/day)

- Bioavailability > 80%

The results shown that tuna conveys a big benefit.
The results showed that there are large differences between species and culinary treatments, being higher risk found with blue shark.
Assessment of the risk-benefit binomial

**Tuna & other fish species**

- **Se-HBV positive**
  - Se:MeHg $> 1$
  - Protection against MeHg toxicity

**Blue shark**

- **Se-HBV negative**
  - Se:MeHg $< 1$
  - No protection against MeHg toxicity

This suggests that the consumption of blue shark can be a risk to health, once Se cannot offset the negative effects of MeHg.
### Assessment of the risk-benefit binomial

#### Global evaluation of risk-benefit consumption recommendations:

<table>
<thead>
<tr>
<th>BENEFITS</th>
<th>RISKS</th>
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<tbody>
<tr>
<td><strong>EPA+DHA</strong></td>
<td><strong>MeHg</strong></td>
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<tr>
<td>Salmon</td>
<td>Blue shark</td>
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<tr>
<td>Mackerel</td>
<td>Black scabbard fish</td>
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<td>Sardine</td>
<td>Swordfish</td>
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<td>Sea bream</td>
<td>Black scabbard fish</td>
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Workshop on risk-benefit assessment of foods 21st May 2018, Portugal
Green seaweeds are a good source of I.

- *R. riparium* had the highest levels of Mn, Sr, Cd, Sn, & I.
- *U. lactuca* had the highest Ni and Cu concentrations.

### Iodine (ppm dw)

- *R. riparium*: 282
- *C. linum*: 93
- *U. lactuca*: 114
- *U. prolifera*: 120
- *U. intestinalis*: 45

### I bioaccessibility: 14 – 31%

![Graph showing bioaccessibility of I in different seaweeds](image-url)
So, to estimate the dietary intakes of a given element it is important to take into account bioaccessibility results.

Iodine in *R. riparium* as an example:

**Before digestion**

0.5 g of dried *R. riparium* covers the I DRI and attending to UL exceeding a daily consumption of 4 g of this dried seaweed may warrant a note of caution.

**After digestion**

2 g of dried *R. riparium* covers the I DRI and a risk of surpassing its UL would arise with 13 g of dried *R. riparium*.

The bioaccessibility results lead to the calculation of larger amounts of dried seaweed for reaching the dietary recommendations and thresholds.
Risk-benefit assessment associated to through seafood consumption: case studies

Seafood potential applications

Other applications

Supplements

Feed

Nutraceuticals

Food

QUALITY and SAFETY

Health

Consumer

Well-being

Risk

Benefit

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Final remarks

✓ Culinary treatment and Bioaccessibility/bioavailability are important in the risk-benefit assessment

✓ Risk-benefit assessment helps to better define the nutritional value of any given seafood

Contribute to formulation of recommendations of cooking practices and seafood choices in diet

Promotion of human health and well-being
Thank you very much for your attention!

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