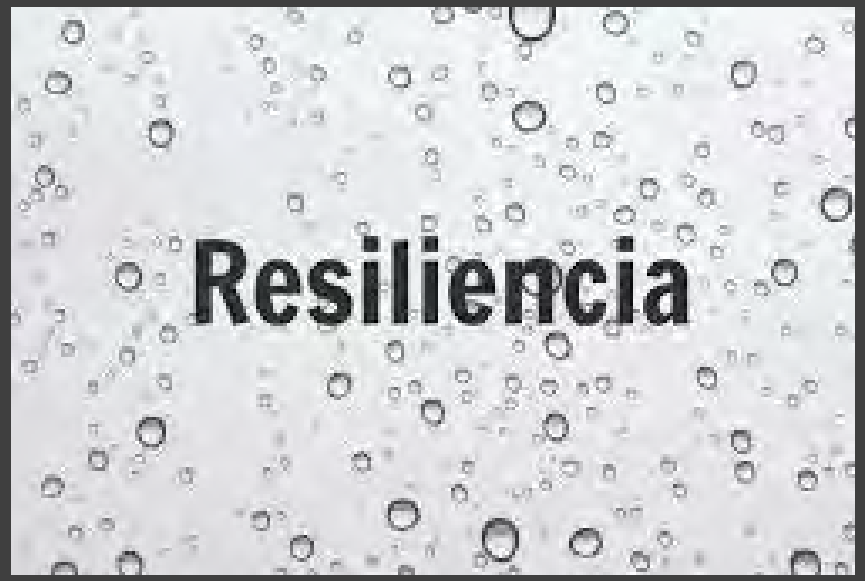
DE LA CIENCIA A LA MESA
ESTRATEGIAS DIETÉTICAS PARA MITIGAR LA EXPOSICIÓN AL MERCURIO

Franklin Chamorro Rivo
Universidad de Vigo

Burela, 2023

Universida de Vigo


Resiliencia

100

PROMOTORES DEL PROYECTO

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ORGANIZACIÓN DE PRODUCTORES DE PESCA DEL PUERTO Y RÍA DE MARÍN / OPP 08

OPP78
ORGANIZACIÓN DE PRODUCTORES PESQUEROS ARTESANALES DEL ESTRECHO

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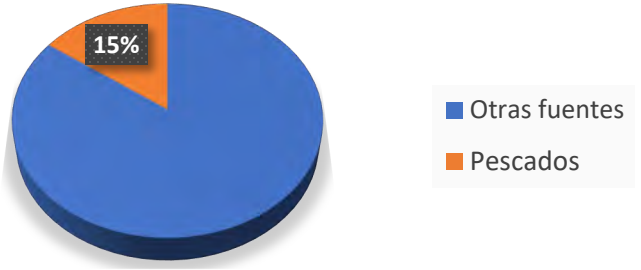
Estrategias Dietéticas

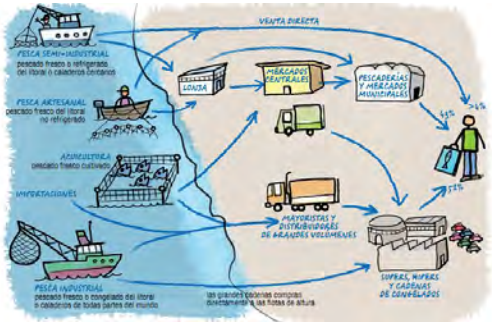
2 Importancia económica

Aporte de Proteinas



(90% de capturas de la flota de la UE)

95 %
Flota UE
(Atlántico, Índico y Océano Pacífico)



(80% de la cadena e suministro de la UE)

3 Composición Nutricional

Proteínas
16 – 21 %

Hidratos
0.5 %

Minerales

Vitaminas

Lípidos
0.5 – 2.3 %

Agua
52 – 82 %

Factores:

- Especie
- Factores ambientales
- Edad
- Comportamiento migratorio
- Fuente de alimentacion

BENEFICIOS NUTRICIONALES

3 Composición Nutricional

Tabla 1. Composición Nutricional de las especies, pez espada, tintorera, atún rojo y recomendaciones de energía y nutrientes

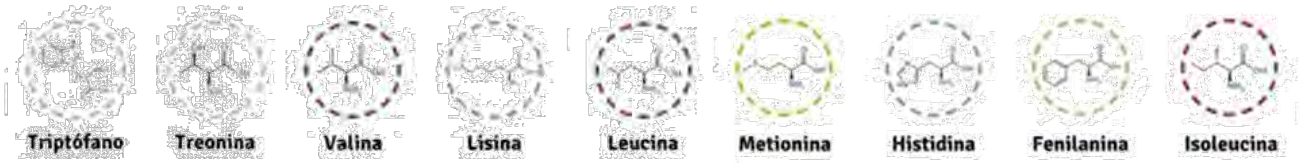
	Pez espada	Tintorera	Atún rojo	Recomendación día-hombres	Recomendación día-mujeres
			g/100 g		
Energía (kcal)	107	82	200	3.000	2300
Proteína (g)	17	18,7	23	54 34 – 42%	41 41 - 56%
Lípidos totales (g)	4,3	4,5	12	100 - 117 ?	77 - 89 ?
Hidratos de carbono (g)	0,20	0,25	0,18	375 - 413	288 - 316

Tablas de Composición de Alimentos. Moreiras y col., 2013. Recomendaciones nutricionales/día. Consenso de la Sociedad Española de Nutrición Comunitaria, 2011 USDA.

Composición Nutricional

Tabla 2. Perfil de aminoácidos, valores de ingesta diaria de referencia presentes en las especies: Pez espada, tintorera y marrajo g/100 g

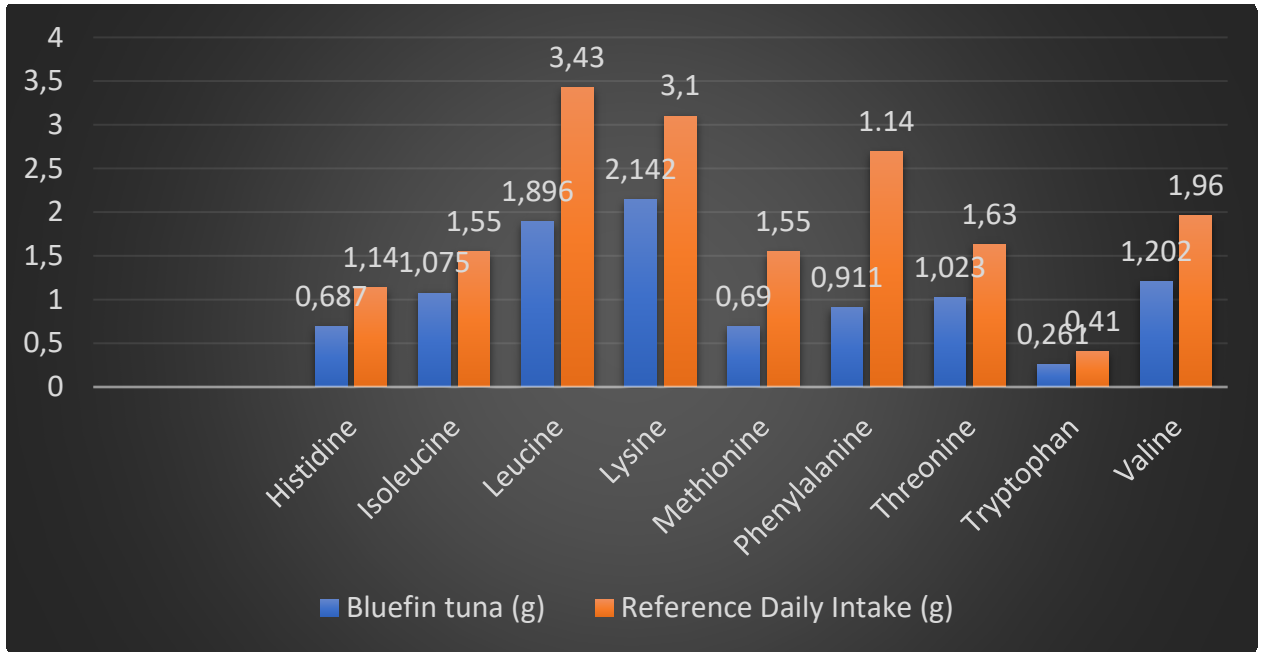
	Pez Espada	Tintorera	Ingesta Diaria de Referencia
Tryptophan	0.222	0.219	0,41 ✓
Threonine	0.868	0.784	1,63 ✓
Isoleucine	0.912	0.898	1,55 ✓
Leucine	1.61	1.099	3,43 ✓
Lysine	1.82	1.545	3,10 ✓
Methionine	0.586	0.756	1,55 ✓
Phenylalanine	0.773	0.565	1,14 ✓
Valine	1.02	0.876	0,41 ✓
Histidine	0.583	0.378	0,70 ✓

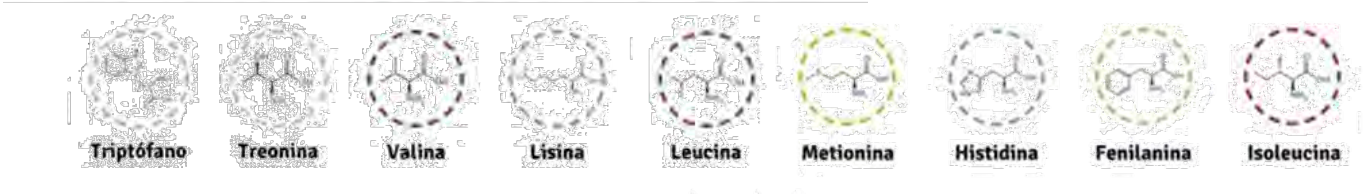


USDA. Recomendaciones nutricionales/día. Consenso de la Sociedad Española de Nutrición Comunitaria, 2011.

Composición Nutricional

Figura 1. Perfil de aminoácidos, valores de ingesta diaria de referencia presentes en el atún rojo





USDA. Recomendaciones nutricionales/día. Consenso de la Sociedad Española de Nutrición Comunitaria, 2011.

Composición Nutricional

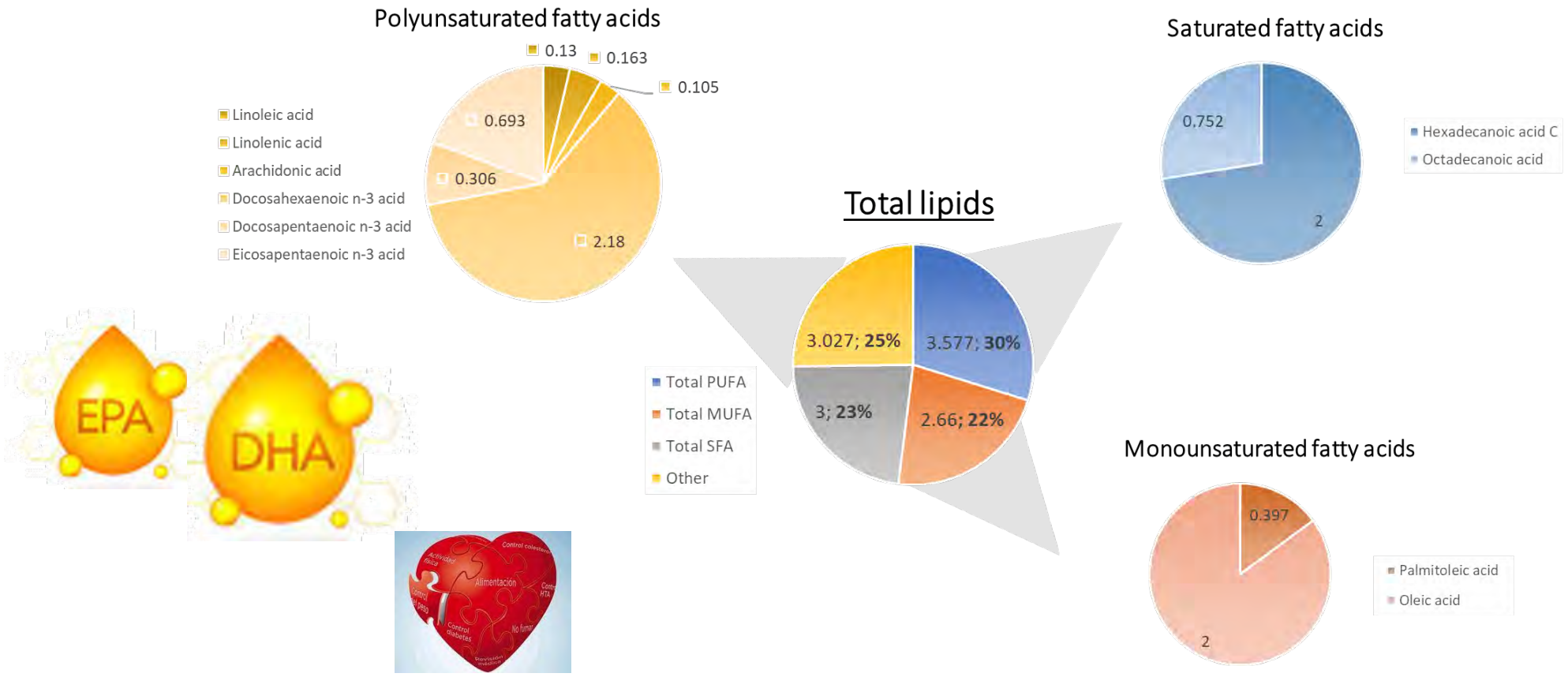
Tabla 3. Perfil lipídico en las especies: Pez espada, tintorera y marrajo g/100g

	Pez espada	Tintorera
Total lipids (g)	4.3	4.5
FA Saturated (g)	1.15	1.57
FA Monounsaturated	1.43	1.33
FA Polyunsaturated	1.2	1
Omega 3 (g)	0.700	0.600
Omega 6 (g)	0.031	0.01
Cholesterol mg	39	51
Indice AGP/AGS	0.86 ✓	0.6 ✓

Tablas de Composición de Alimentos. Moreiras y col., 2013
USDA.

Composición Nutricional

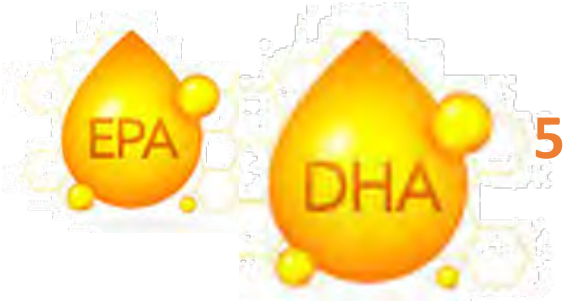
Figura 2. Perfil lipídico en el atún rojo g/100g



Tablas de Composición de Alimentos. Moreiras y col., 2013.
USDA

Lípidos

- Principalmente ácidos grasos saturados, **poliinsaturados** y monoinsaturados.



50 – 70 %

Omega 3 : Ω3

Eicosapentaenoico (EPA, 20: 5n-3)
Docosahexaenoico (DHA, 22: 6n-3

Ω3: 0.700 g/100 g

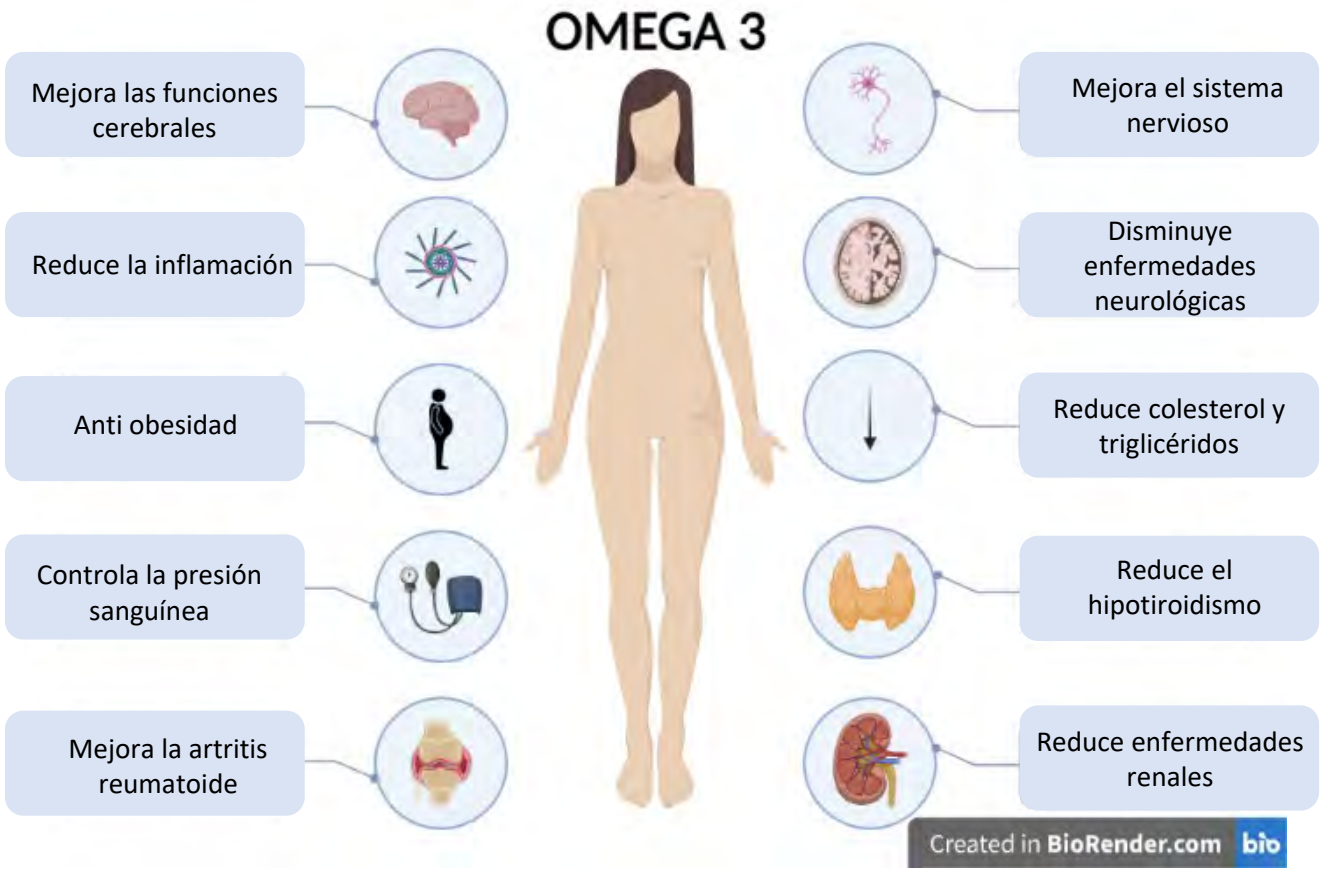
Ω3 :0.600 g/100 g

Ω3:0.695 g/100 g

Ω3: 3.027 g/100 g

EFSA: **250 mg Ω3** (mantener buena **salud cardiovascular**)
La Asociación Americana del Corazón (**AHA**): 1 g de Ω3 (**enfermos cardiacos**)

Lípidos



Weichselbaum, E., Coe, S., Buttriss, J., & Stanner, S. (2013). Fish in the diet: A review. Nutrition Bulletin, 38(2), 128–177

Domingoa, J. L., Bocio, A., Falco, G., & Llobet, J. M. (2007). Benefits and risks of fish consumption Part I. A quantitative analysis of the intake of omega-3 fatty acids and chemical contaminants. Toxicology, 23(1), 236–244.

Composición Nutricional

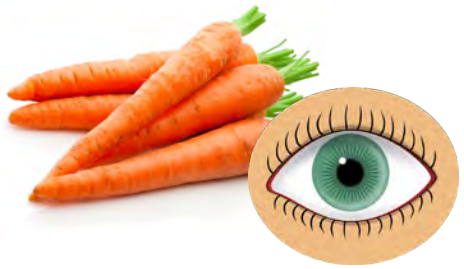
Vitaminas

Son una excelente fuente de vitaminas: Liposolubles (A,D) e Hidrosolubles Complejo B (Niacina B3, Piridoxina B6 Cobalamina B12)

Vit. A

Contribuye:

- Formación y mantenimiento de las mucosas
- Favorece la visión
- Metabolismo normal de el hierro
- Sistema inmunitario y los procesos de diferenciación celular



Vit. D

Contribuye:

- Absorción del calcio
- Juega un rol en su sistema nervioso, muscular e inmunitario

100 g de pez espada, tintorera o marrajo pueden aportar el **50 %** de los **requerimientos** diarios de **vitamina D** Y el **atún rojo el 150 %**

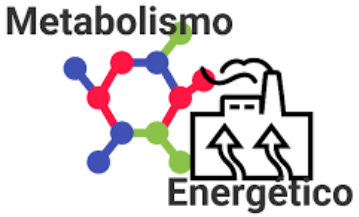
100 g de pez espada puede aportar el **50 %** de **requerimientos** diarios de **vitamina A**

Vitaminas

Vit. B3

Contribuye:

- Metabolismo energético normal
- Sistema nervioso
- El mantenimiento de las mucosas y piel en condiciones normales
- Disminuye la fatiga y el cansancio



Vit. B6

Contribuye:

- Metabolismo energético normal
- Regulación hormonal
- El metabolismo normal de la homocisteína, de las proteínas y del glucógeno
- Formación de los glóbulos rojos

Vit. B12

Contribuye:

- Formación glóbulos rojos
- Metabolismo celular
- Función nerviosa
- Producción de ADN

Minerales

Cobre (Cu)

Contribuye:

- Cofactor catalítico en numerosas reacciones enzimáticas críticas en el metabolismo
- Funcionamiento normal del sistema nervioso

Manganeso (Mn)

Contribuye:

- Cofactor de una amplia variedad de enzimas importantes
- Deficiencia da como resultado un rendimiento reproductivo deficiente, retraso del crecimiento, malformaciones congénitas en la descendencia y función anormal de los huesos y cartílagos

Composición Nutricional

Minerales

Selenio (Se)

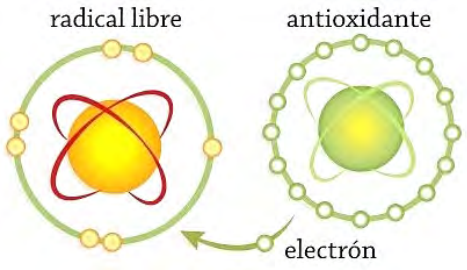
Contribuye:

- Componente crítico de numerosas selenoproteina, que son componentes importantes de los sistemas antioxidantes
- Protege contra el daño de los radicales libres y las especies reactivas del oxígeno, otorgando un efecto proteger contra el cáncer o las enfermedades cardiovasculares

Zinc (Zn)

Contribuye:

- Cofactor de más de 300 enzimas involucradas en funciones importantes como el metabolismo del ARN y el ADN
- Juega un papel importante en la estabilización de la estructura de una gran cantidad de proteínas



Ratio Se:Hg

Algunos componentes de la dieta pudieran modular el efecto tóxico del mercurio

Se:Hg 1

Puede indicar si el producto presenta un mayor o **menor riesgo toxicológico**, diversos autores señalan que esta ratio puede ser una forma de evaluación del **riesgo beneficio en el consumo de pescados**

Ratio Se:Hg

Biol Trace Elem Res (2007) 119:255–268
DOI 10.1007/s12011-007-8005-7

Importance of Molar Ratios in Selenium-Dependent Protection Against Methylmercury Toxicity

Nicholas V. C. Ralston · J. Lloyd Blackwell III · Laura J. Raymond

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Abstract The influence of dietary selenium (Se) on mercury (Hg) toxicity was studied in weanling male Long Evans rats. Rats were fed AIN-93G-based low-Se torula yeast diets or diets augmented with sodium selenite to attain adequate- or rich-Se levels (0.1, 1.0 or 15 µmol/kg, respectively) These diets were prepared with no added methylmercury (MeHg) or with moderate- or high-MeHg (0.2, 10 or 60 µmol/kg, respectively). Health and weights were monitored weekly. By the end of the 9-week study, MeHg toxicity had impaired growth of rats fed high-MeHg, low-Se diets by approximately 24% ($p<0.05$) compared to the controls. Growth of rats fed high-MeHg, adequate-Se diets was impaired by approximately 8% ($p<0.05$) relative to their control group, but rats fed high-MeHg, rich-Se diets did not show any growth impairment. Low-MeHg exposure did not affect rat growth at any dietary Se level. Concentrations of Hg in hair and blood reflected dietary MeHg exposure, but Hg toxicity was more directly related to the Hg to Se ratios. Results support the hypothesis that Hg-dependent sequestration of Se is a primary mechanism of Hg toxicity. Therefore, Hg to Se molar ratios provide a more reliable and comprehensive criteria for evaluating risks associated with MeHg exposure.

Keywords Selenium · Mercury · Methylmercury · Toxicity · Brain · Blood

Introduction

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IMPACTS IN ENVIRONMENTAL TRENDS, HEALTH AND WELL BEING: A GLOBAL POLLUTION PROBLEM

Mercury interactions with selenium and sulfur and the relevance of the Se:Hg molar ratio to fish consumption advice

Michael Gochfeld[1,2] · Joanna Burger[2,3]

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Abstract
Eating fish is often recommended as part of a healthful diet. However, fish, particularly large predatory fish, can contain significant levels of the highly toxic methylmercury (MeHg). Ocean fish in general also contain high levels of selenium (Se), which is reported to confer protection against toxicity of various metals including mercury (Hg). Se and Hg have a high mutual binding affinity, and each can reduce the toxicity of the other. This is an evolving area of extensive research and controversy with variable results in the animal and epidemiologic literature. MeHg is toxic to many organ systems through high affinity for –SH (thiol) ligands on enzymes and microtubules. Hg toxicity also causes oxidative damage particularly to neurons in the brain. Hg is a potent and apparently irreversible inhibitor of the selenoenzymes, glutathione peroxidases (GPX), and thioredoxin reductases (TXNRD) that are important antioxidants, each with a selenocysteine (SeCys) at the active site. Hg binding to the SeCys inhibits these enzymes, accounting in part for the oxidative damage that is an important manifestation of Hg toxicity, particularly if there is not a pool of excess Se to synthesize new enzymes. A molar excess of Se reflected in an Se:Hg molar ratio > 1 is often invoked as evidence that the Hg content can be discounted. Some recent papers now suggest that if the Se:Hg molar ratio exceeds 1:1, the fish is safe and the mercury concentration can be ignored. Such papers suggested that the molar ratio rather than the Hg concentration should be emphasized in fish advisories. This paper examines some of the limitations of current understanding

Highlights
1. Fish have high nutritional value, but some also have high levels of methylmercury.
2. Mercury exerts toxic effects by binding to sulfhydryl (–SH) groups which are its most abundant ligand in the fish and in the human.
3. Mercury inhibits many enzymes by reacting with thiols and also selenols.
4. Mercury inhibits microtubule formation essential for cell structure, cellular transport, and cell division, by binding to –SH sites on the tubulin protein to prevent assembly.
5. Mercury has high affinity for selenium and causes oxidative damage by

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Selenium intake from tuna in Galicia (Spain): Health risk assessment and protective role against exposure to mercury and inorganic arsenic

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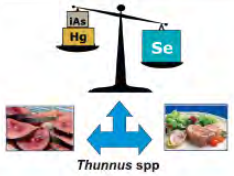
HIGHLIGHTS
- High selenium content makes tuna a great source of Se in the Spanish diet.
- The order of Se levels in the canned preparations was: oil > natural > pickled sauce.
- Traditional risk assessments advise to moderate tuna consumption in children.
- Intake of selenium from tuna prevents the adverse effects of Hg and iAs.
- Application of a new criterion of health risk assessment

GRAPHICAL ABSTRACT



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ABSTRACT

This study aims to quantify the selenium contribution from tuna to the Spanish diet and evidence the Se protective role against mercury and inorganic arsenic toxicity. Selenium concentrations in tuna were determined by ICP-MS spectrometry (expressed as mg kg^{-1}), and the risk assessment was evaluated joined to Hg and iAs contrasting criteria of regulatory agencies with those that consider the Se protective role. Differences between Se average concentrations in fresh (1.24) and preserved (1.17) tuna were not statistically significant. In canned tuna species, Se presented higher mean levels in *Thunnus albacares* (1.28) than *Thunnus alalunga* (1.01) with statistically significant differences ($p = 0.002$), and among canned preparations a decreasing sequence was observed in different preparation-packaging media: oil (1.42) > natural (1.01) > pickled (0.92). Statistical study showed Hg-iAs as the only pair significantly correlated in all samples. The HI (sum of individual target hazard quotients -THQs-) on the consumption of tuna in Spain, due to exposure to Se, Hg and iAs, revealed the possibility of risk of adverse chronic effects in the six-year-old children group (1.09). According to the maximum allowable tuna consumption rate in meals/week (CR_{MW}) and the THQs obtained, tuna intake, especially in children, should be moderated. The health benefit values (HBV_{Se}) were positive in all samples, 14.53 and 15.65 in fresh and preserved tuna, respectively, which allows tuna to be considered safe. The benefit-risk value (BRV) evidenced the Se molar excess with respect to Hg that reached a surplus of 14.32% on Se AI in adults. Since iAs reduces the Se bioavailability, applying a new BRV criterion, the aforementioned percentage decreased to 13.48% of Se AI. In conclusion, tuna offers high levels of selenium to counteract

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Ratio Se:Hg

Tabla 4. Contenido de Hg y Se en las especies en estudio diferentes áreas geográficas

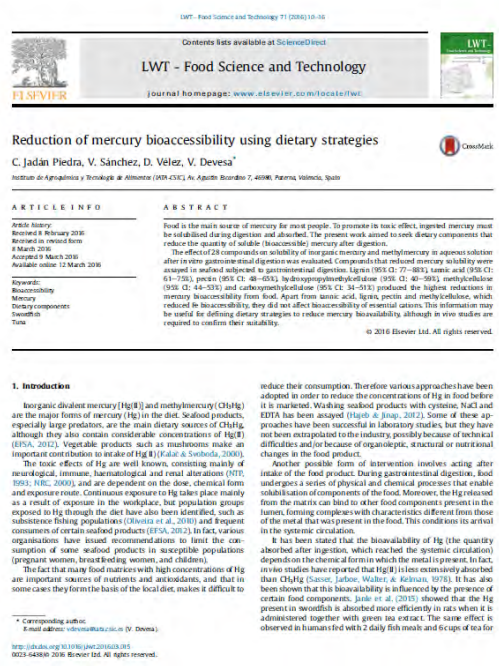
Sampling area	Typology	Hg (mg/kg)	Se (mg/kg)	Se/Hg (µmol/kg)	HBVSe	Ref.
Pez espada						
Hawaii	Wild	1.07	1.9	1.2	-	(Kaneko & Ralston, 2007)
Mediterranean area		0.64	0.84	1.8	4	(Barone et al., 2021)
EEUU		1.31	0.63	0.83	-	(Burger & Gochfeld, 2013)
Portugal		0.47	0.47	1	-	(Cabañero, Carvalho, Madrid, Batoréu, & Cámara, 2005)
Spain		0.51	0.80	1	3	(Calatayud et al., 2012)
Italy		0.249	0.98	1.3	-	(Plessi, Bertelli, & Monzani, 2001)
Spain		0.540	0.494	1	-	(Olmedo et al., 2013)
Shark (various species)						
Atlantic western central	Wild	1	1.24	1	-	(Amezcua, Ruelas-Inzunza, Coiraton, Spanopoulos-Zarco, & Páez-Osuna, 2022)
Pacific eastern central		1	0.86	−0.97	-	
Pacific western central		0.83	1	1	-	
Indian Ocean western		1	1.7	1.4	-	
All regions (FAO)		1.23	0.81 ±	1	3.06	

Ratio Se:Hg

Tabla 5. Contenido de Hg y Se en atún rojo diferentes áreas geográficas

Species	Sampling area	Typology	Se/Hg	Ref.
T. thynnus	Malta	Farm	5.48	(Annibaldi et al., 2019)
	Sardinia	Wild	1.32	
	Spain	Wild	-	(Falcó et al., 2006) (Annibaldi et al., 2019)
	Italy	Wild	-	(Di Bella et al., 2015) (Plessi et al., 2001)
		Farm	-	(Renzi et al., 2014)
	Turkey	Wild	5.49	(Ulusoy et al., 2019)
	Slovenia	Wild	-	(Miklavčič et al., 2011)
	New Jersey	Wild	2.07	(Burger & Gochfeld, 2012)
	Black Sea	Wild	-	(Kojadinovic et al., 2007)
	Arabian Sea			
	Medit. Sea			
	Central Pacific Ocean	Wild	5.26	(Annibaldi et al., 2019)

Ratio Se:Hg /Biodisponibilidad



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Reduction of mercury bioaccessibility using dietary strategies

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ABSTRACT

Food is the main source of mercury for most people. To promote its toxic effect, ingested mercury must be solubilized during digestion and absorbed. The present work aimed to seek dietary components that reduce the quantity of soluble (bioaccessible) mercury after digestion.

The effect of 28 compounds on solubility of inorganic mercury and methylmercury in aqueous solution after *in vitro* gastrointestinal digestion was evaluated. Compounds that reduced mercury solubility were assayed in seafood subjected to gastrointestinal digestion. Lignin (95% CI: 77–88%), tannic acid (95% CI: 61–75%), pectin (95% CI: 48–65%), hydroxypropylmethylcellulose (95% CI: 40–59%), methylcellulose (95% CI: 44–53%) and carboxymethylcellulose (95% CI: 34–51%) produced the highest reductions in mercury bioaccessibility from food. Apart from tannic acid, lignin, pectin and methylcellulose, which reduced Fe bioaccessibility, they did not affect bioaccessibility of essential cations. This information may be useful for defining dietary strategies to reduce mercury bioavailability, although *in vivo* studies are required to confirm their suitability.

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1. Introduction

Inorganic divalent mercury [Hg(II)] and methylmercury (CH_3Hg) are the major forms of mercury (Hg) in the diet. Seafood products, especially large predators, are the main dietary sources of CH_3Hg, although they also contain considerable concentrations of Hg(II) (EFSA, 2012). Vegetable products such as mushrooms make an important contribution to intake of Hg(II) (Kalac & Svobodová, 2006).

The toxic effects of Hg are well known, consisting mainly of neurological, immune, haematological and renal alterations (NTP, 1993; NRC, 2000), and are dependent on the dose, chemical form and exposure route. Continuous exposure to Hg takes place mainly as a result of exposure in the workplace, but population groups exposed to Hg through the diet have also been identified, such as subsistence fishing populations (Oliveira et al., 2010) and frequent consumers of certain seafood products (EFSA, 2012). In fact, various organisations have issued recommendations to limit the consumption of some seafood products in susceptible populations (pregnant women, breastfeeding women, and children).

The fact that many food matrices with high concentrations of Hg are important sources of nutrients and antioxidants, and that in some cases they form the basis of the local diet, makes it difficult to reduce their consumption. Therefore various approaches have been adopted in order to reduce the concentrations of Hg in food before it is marketed. Washing seafood products with cysteine, NaCl and EDTA has been assayed (Hajeb & Jinap, 2012). Some of these approaches have been successful in laboratory studies, but they have not been extrapolated to the industry, possibly because of technical difficulties and/or because of organoleptic, structural or nutritional changes in the food product.

Another possible form of intervention involves acting after intake of the food product. During gastrointestinal digestion, food undergoes a series of physical and chemical processes that enable solubilisation of components of the food. Moreover, the Hg released from the matrix can bind to other food components present in the lumen, forming complexes with characteristics different from those of the metal that was present in the food. This conditions its arrival in the systemic circulation.

It has been stated that the bioavailability of Hg (the quantity absorbed after ingestion, which reached the systemic circulation) depends on the chemical form in which the metal is present. In fact, *in vivo* studies have reported that Hg(II) is less extensively absorbed than CH_3Hg (Sasser, Jarboe, Walter, & Kelman, 1978). It has also been shown that this bioavailability is influenced by the presence of certain food components. Janke et al. (2015) showed that the Hg present in swordfish is absorbed more efficiently in rats when it is administered together with green tea extract. The same effect is observed in humans fed with 2 daily fish meals and 6 cups of tea for

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Tabla 6. Bioaccesibilidad en muestras de pez espada

Muestra	Hg	Se	Se/Hg
Pez espada	0,43 ± 0,02 (15%)	0,45 ± 0,04 (92%)	2,66
	0,21 ± 0,04 (51%)	0,51 ± 0,03 (101%)	6,17
	1,07 ± 0,08 (85%)	0,44 ± 0,01 (94%)	1,04
	0,27 ± 0,03 (29%)	0,42 ± 0,06 (63%)	3,95
	0,28 ± 0,03 (20%)	0,42 ± 0,04 (66%)	3,81
	0,07 ± 0,01 (17%)	0,24 ± 0,002 (64%)	8,71
	0,46 ± 0,001 (37%)	0,46 ± 0,03 (90%)	2,54
	0,90 ± 0,01 (76%)	0,46 ± 0,02 (103%)	1,30
	0,45 ± 0,01 (73%)	0,69 ± 0,02 (98%)	3,90
	1,54 ± 0,02 (82%)	0,94 ± 0,03 (96%)	1,55
	0,11 ± 0,004 (27%)	0,56 ± 0,02 (97%)	12,93
	0,33 ± 0,003 (36%)	0,54 ± 0,001 (96%)	4,16
	0,33 ± 0,001 (45%)	0,52 ± 0,02 (79%)	4,00
	1,09 ± 0,02 (65%)	0,52 ± 0,03 (99%)	1,21
	0,24 ± 0,003 (27%)	0,73 ± 0,04 (101%)	7,73

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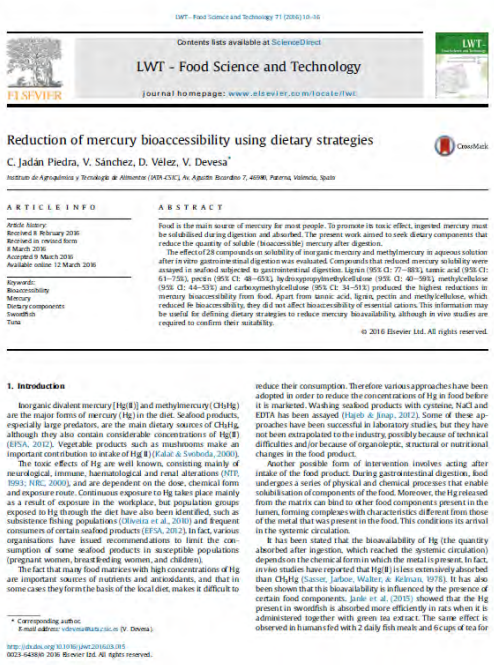
Interacción



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Reduction of mercury bioaccessibility using dietary strategies

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ABSTRACT

Food is the main source of mercury for most people. To promote its toxic effect, ingested mercury must be solubilized during digestion and absorbed. The present work aimed to seek dietary components that reduce the quantity of soluble (bioaccessible) mercury after digestion.

The effect of 28 compounds on solubility of inorganic mercury and methylmercury in aqueous solution after *in vitro* gastrointestinal digestion was evaluated. Compounds that reduced mercury solubility were assayed in seafood subjected to gastrointestinal digestion. Lignin (95% CI: 77–88%), tannic acid (95% CI: 61–75%), pectin (95% CI: 48–65%), hydroxypropylmethylcellulose (95% CI: 40–59%), methylcellulose (95% CI: 44–53%) and carboxymethylcellulose (95% CI: 34–51%) produced the highest reductions in mercury bioaccessibility from food. Apart from tannic acid, lignin, pectin and methylcellulose, which reduced Fe bioaccessibility, they did not affect bioaccessibility of essential cations. This information may be useful for defining dietary strategies to reduce mercury bioavailability, although *in vivo* studies are required to confirm their suitability.

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1. Introduction

Inorganic divalent mercury [Hg(II)] and methylmercury (CH_3Hg) are the major forms of mercury (Hg) in the diet. Seafood products, especially large predators, are the main dietary sources of CH_3Hg, although they also contain considerable concentrations of Hg(II) (EFSA, 2012). Vegetable products such as mushrooms make an important contribution to intake of Hg(II) (Kalac & Svobodová, 2006).

The toxic effects of Hg are well known, consisting mainly of neurological, immune, haematological and renal alterations (NTP, 1993; NRC, 2000), and are dependent on the dose, chemical form and exposure route. Continuous exposure to Hg takes place mainly as a result of exposure in the workplace, but population groups exposed to Hg through the diet have also been identified, such as subsistence fishing populations (Oliveira et al., 2010) and frequent consumers of certain seafood products (EFSA, 2012). In fact, various organisations have issued recommendations to limit the consumption of some seafood products in susceptible populations (pregnant women, breastfeeding women, and children).

The fact that many food matrices with high concentrations of Hg are important sources of nutrients and antioxidants, and that in some cases they form the basis of the local diet, makes it difficult to reduce their consumption. Therefore various approaches have been adopted in order to reduce the concentrations of Hg in food before it is marketed. Washing seafood products with cysteine, NaCl and EDTA has been assayed (Hajeb & Jinap, 2012). Some of these approaches have been successful in laboratory studies, but they have not been extrapolated to the industry, possibly because of technical difficulties and/or because of organoleptic, structural or nutritional changes in the food product.

Another possible form of intervention involves acting after intake of the food product. During gastrointestinal digestion, food undergoes a series of physical and chemical processes that enable solubilisation of components of the food. Moreover, the Hg released from the matrix can bind to other food components present in the lumen, forming complexes with characteristics different from those of the metal that was present in the food. This conditions its arrival in the systemic circulation.

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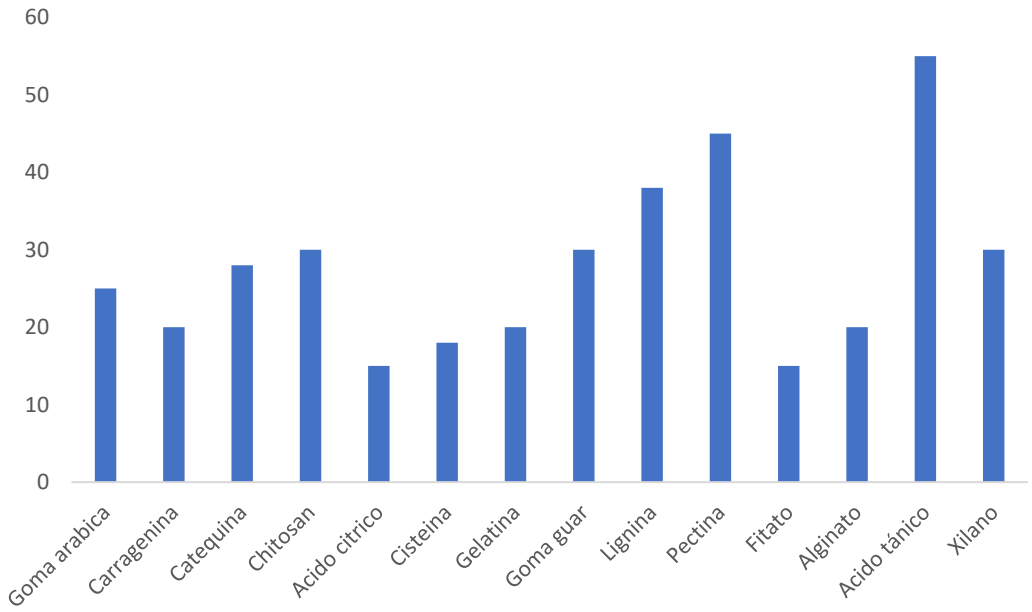
Figura. 3 Disminución de la biodisponibilidad de Hg



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Interacción

Tabla 7. Ejemplos recientes de nutrientes/alimentos con efectos sobre el transporte intestinal de MeHg.

Food or Nutrient	Hg Exposure	Model	Description of Interaction	Reference
Tea, coffee	1–4 µg/g dry weight Hg in fish (tuna, shark, mackerel)	in vitro digestion—bioaccessibility	Tea and coffee reduced total Hg bioaccessibility 10%–60%, depending on species	[54]
Corn starch	1–4 µg/g dry weight Hg in fish (tuna, shark, mackerel)	in vitro digestion—bioaccessibility	Corn starch reduced total Hg bioaccessibility by 20% (tuna only)	
Tropical Fruits	Hg in fish meals	Human, prospective study	Consumption of 1 fruit/day was associated with lower hair Hg than consumption of <1 fruit/day	[71]
Green tea extract	fish tissue	in vitro digestion—bioaccessibility	reduced Hg bioaccessibility by 82%–92%	[70]
Black tea extract	fish tissue	in vitro digestion—bioaccessibility	reduced Hg bioaccessibility by 88%–91%	
Soy protein	fish tissue	in vitro digestion—bioaccessibility	reduced Hg bioaccessibility by 44%–87%	
Grapefruit juice	fish tissue	in vitro digestion—bioaccessibility	no reduction of bioaccessible Hg	
Wheat bran	fish tissue	in vitro digestion—bioaccessibility	reduced Hg bioaccessibility by 84%	
OAT bran	fish tissue	in vitro digestion—bioaccessibility	reduced Hg bioaccessibility by 59%–85%	
Psyllium	fish tissue	in vitro digestion—bioaccessibility	reduced Hg bioaccessibility by 15%–31%	

Estrategias Dietéticas

Mercurio

Evaluación de Riesgos

- 100 % Hg – MeHg
- Absorción MeHg 100%
- Se:Hg
- Efectos matriz
- Interacción con otros alimentos /nutrientes

Perspectivas

- **Evaluaciones de riesgo:**

- **Tomar en cuenta** todos los factores que pueden influir
  - Relación Se : Hg
  - Biodisponibilidad
  - Efecto matriz (MeHg – Metionina o cisteína)
  - Accion de cocción de los alimentos
  - Interacción con otros alimentos - nutrientes

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Evaluation of the risk/benefit associated to the consumption of raw and cooked farmed meagre based on the bioaccessibility of selenium, eicosapentaenoic acid and docosahexaenoic acid, total mercury, and methylmercury determined by an *in vitro* digestion model

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ABSTRACT

The bioaccessibility of total lipids, EPA, DHA, Se, Hg, and MeHg in raw and cooked meagre (*Argyrosomus regius*) was studied by using an *in vitro* digestion method. A risk–benefit assessment of raw and cooked meagre on the basis of the bioaccessibility data was carried out. The bioaccessibility of total lipids was generally high in raw and cooked meagre with exception of grilled fish. For EPA and DHA, bioaccessibility percentages were low never surpassing the 50% in raw, boiled, and grilled meagre. The bioaccessibility percentage of Se was equal or higher than 82% (grilling treatment). Likewise, for Hg and MeHg, high bioaccessibility values were determined with exception of grilled meagre, displaying lower values of 54% and 64%, respectively. The risk–benefit probabilistic assessment brought about a recommendation of a maximum consumption of two weekly meals for boiled or roasted meagre and three weekly meals for grilled meagre.

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5 Conclusión

- La composición nutricional de las especies *Xiphias gladius* (**pez espada**), *Prionace glauca* (**tintorera**), *Isurus oxyrinchus* (**marrajo**) y *Thunnus thynnus* (**atún rojo**), describe su rico aporte en proteínas y aminoácidos esenciales, pudiendo aportar hasta 30% de la recomendación diaria de proteínas para un adulto, además de importantes cantidades de ácidos grasos poliinsaturados, principalmente EPA y DHA.

- Estas especies también destacan por el contenido de vitaminas como la vitamina A y D y minerales como el Se, que es un importante protector del daño oxidativo, ayudando a contrarrestar el daño causado por el MeHg del pescado

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