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Short communication

Risk assessment and study of trace/heavy metals in three species of fish of commercial interest on the island of El Hierro (Canary Islands, eastern-central Atlantic)

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ABSTRACT

The levels of toxic heavy metals (Al, Cd, Pb), macroelements (Ca, K, Mg, Na) and microelements and trace elements (B, Ba, Co, Cr, Cu, Fe, Li, Mn, Mo, Ni, Sr, V, Zn) were determined in 54 muscle samples from three species of fish for human consumption, *Balistes capriscus* (grey triggerfish), *Canthidermis sufflamen* (oceanic triggerfish) and *Heteropriacanthus fulgens* (rock catalufa), using spectrometry of inductively coupled plasma optical emission (ICP-OES). The aims of this study is to determine if the three species are good bioindicators of environmental pollution and to verify whether they are suitable for human consumption. Significant differences were found in the levels of Al, B, Fe, K, Mn, Mo, Na and Zn between the three species studied. The results suggest that the underwater volcano off El Hierro influences the metallic content (Al, K the most characteristic) of *H. fulgens*. An evaluation of the toxic risk derived from the ingestion of *B. capriscus, C. sufflamen* and *H. fulgens* was carried out, analyzing the Admissible Daily Intake (ADI) and the Safety Margin (MoS). For the nutritional study, the Recommended Daily Intake (RDI) index was used. Therefore, once the study has been carried out and under the conditions established in terms of daily / weekly fish consumption, proposed by AESAN, there would not be any type of toxic risk after ingesting *B. capriscus, C. sufflamen* and *H. cruentatus.*

1. Introduction

The coastal pollution and especially the accumulation of toxic metals is a serious global problem, because they are not biodegradable and can bioaccumulate in organisms, thus being able to alter the physiology of some organisms, and accumulating through the trophic web (DeForest et al., 2007; Lozano-Bilbao et al., 2020a, 2020d). In the 20 st century, it is estimated that about 2 million cubic meters of water are contaminated every day. This contamination is also due to the massive human population increase, which leads to an increase of the environmental pollution (Costanzo et al., 2001; Guendouzi et al., 2020; Lozano-Bilbao et al., 2020b, 2020c).

A wide metals variety (Fe, Cu, Zn, etc.) are found in the organisms, some of these metals are essential for living organisms (Anandkumar et al., 2019). The metals are divided into several groups depending on whether they have harmful effects on the body or are required by the body for proper functioning of biological systems (Yildirim et al., 2009; Cherfi et al., 2014; Lozano-Bilbao et al., 2019a, 2020e,). There are also metals that can have beneficial or harmful properties in plants, animals or humans depending on their concentrations (Cherfi et al., 2014; Bost

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et al., 2016; Copat et al., 2018). In this way, they are called toxic metals, macroelements and microelements and trace elements, respectively. It is important to note that the deficit of these metals can cause diseases while the excess of others can cause poisoning. The toxic metals are distinguished by its role as environmental pollutants (Bozkurt and Cavas, 2009; Nava-Ruíz and Méndez-Armenta, 2011; Olmedo et al., 2013).

Fish are good bioindicators of environmental pollution by wastewater, microplastics and heavy metals (Alves et al., 2016; Bonanno and Orlando-Bonaca, 2018; Khristoforova et al., 2018), because they tend to accumulate high metals concentrations. This is because this metal intake accumulates directly in their tissues (Anandkumar et al., 2018). This could be a serious problem to the human health due to some species of fish are highly consumed, which makes it one of the main exposure routes to toxic metals for the consumers. The fish consumption has been increasing since the early 1970s (Wang et al., 2019), which is logical since it has several beneficial properties (Afonso et al., 2018), since it provides proteins, polyunsaturated fatty acids, fat-soluble vitamins and essential minerals (Craig et al., 2017).

The El Hierro island has a total of 146 natural environments, with environmental protection managed by the Government of the Canary Islands (Spain). The natural reserve of La Restinga-Mar de Las Calmas, with an area of 1180 ha, has an approximate shape of a quadrilateral, shared between external waters (50 %) and internal waters (50 %). The waters are characterized by being in continuous calm. Marine nature reserves are measures for the management of fishing resources, habitats and ecosystems, whose main objective is to recover overfished populations, and thus prolong artisanal fishing activity in adjacent areas (Mendoza et al., 2020). In different regions of the world, these marine protected areas considerably increase the abundance and size of different types of species of commercial interest, given the level of overexploitation to which we have subjected the oceans, the role of marine reserves is even more important since that there are hardly any pristine places left, that is, without polluting and without anthropic effects on the planet (Hernández et al., 2008). The relevance of the marine reserve on the island of El Hierro, takes on special importance when it comes to counteracting three major problems that the island has suffered in recent decades: overfishing, climate change and the eruption of the underwater volcano in the Mar de Las Calmas (Tagoro Volcano), which occurred on October 12, 2011 and considered a great natural catastrophe (Fraile-Nuez et al., 2012; Lozano-Bilbao et al., 2018). On the island of El Hierro the species of fish *Balistes capriscus* and *Canthidermis sufflamen* are widely consumed all year round due to their high density, while *Heteropriacanthus fulgens* presents a seasonal consumption pattern (summer-autumn). Therefore, the objectives of the present study were to determine if the three species analyzed (*Balistes capriscus*, *Canthidermis sufflamen, Heteropriacanthus fulgens*) are good bioindicators of environmental pollution, and to assess the nutritional value from the intake of essential metals and elements from the consumption of these species) to assess the toxic risk by the intake of toxic metals from the consumption of these species.

2. Material and methods

A total of 54 species of fish were bought in the fish markets around the island of El Hierro in July to 2019, of which 28 are from *Balistes capriscus*, 6 from *Canthidermis sufflamen* and 20 from *Heteropriacanthus fulgens* (Fig. 1).

About 10−15 g of muscle were taken, which were placed in porcelain capsules (Staalich, Germany) and dried in an oven (Nabertherm, Germany) at a temperature of 70 °C for 24 h. Subsequently, the samples were incinerated in a muffle furnace for 24 h at 450 °C ± 25 °C, with a progressive rise in temperature of 50 °C per hour, until white ash was obtained. The white ashes were filtered with a 1.5 % HNO_3 solution (Merck, Germany) to a total volume of 25 mL for the subsequent determination of the metal content by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) measuring the metals and elements in mg / kg. A quality control solution was used to assess the determinations accuracy every 10 samples. Moreover, certified reference materials (DORM-2, fish muscle and DORM-4, fish protein) were

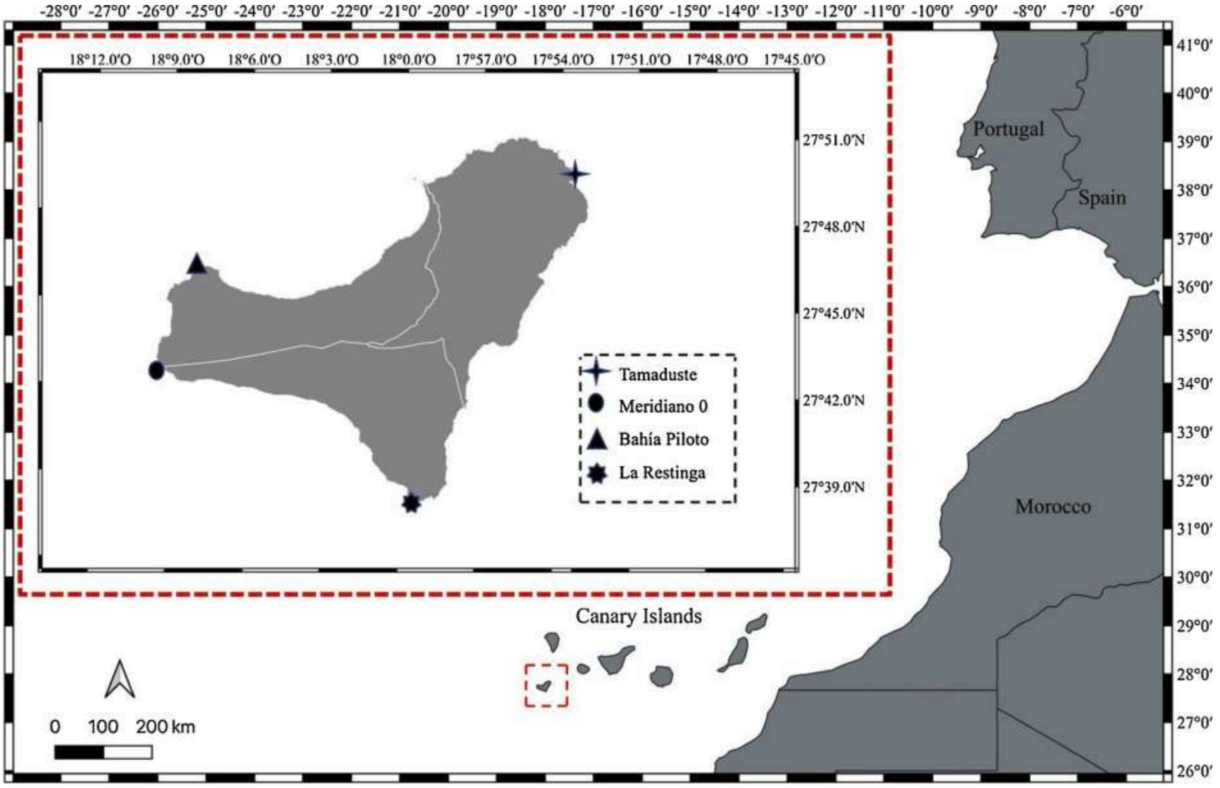

Fig. 1. Map of the island of El Hierro and the capture locations.

used to ensure the precision and accuracy of the results. All data is presented as milligrams per kilogram, wet weight (mg/kg w.w.). Blanks and standard reference materials were run together with samples. The metals and trace elements sampled were: Al, Cd, Pb, Ca, K, Mg, Na, B, Ba, Co, Cr, Cu, Fe, Li, Mn, Mo, Ni, Sr, V, Zn

In order to determine whether there were variations in the content of heavy metals and trace elements among the analyzed samples, a statistic was carried out using a multivariate permutational analysis of variances (PERMANOVA) with Euclidean distances (Anderson and Braak, 2003).

In all the analyzes, 4999 interchangeable unit permutations and posterior comparisons were used to determine the differences between the levels of the significant factors according to the concentrations of metals and trace elements (p-value <0.05) (Anderson, 2004). For statistical analyzes, the PRIMER 7 and PERMANOVA + v.1.0.1 statistical package were used. The first analysis was designed with one way with the fixed factors "Species" with three levels (*Balistes capriscus, Canthidermis sufflamen and Heteropriacanthus fulgens*). The second analysis was designed with one way to *Balistes capriscus* with the fixed factors "locations" with two levels (La Restinga and Meridiano 0). The last analysis was designed with one way to *Heteropriacanthus fulgens* with the fixed factors "locations" with two levels (La Restinga and Bahía Piloto) (Lozano-Bilbao et al., 2021).

To carry out the nutritional study and the risk assessment, the Acceptable Daily Intake (ADI) has been determined according to the formulas given in Renwick (1991). For the calculation of the recommended Daily Intakes (RDI) the formulas have been used in Meyers et al. (2006) and for the calculation of the Margin of Safety (MoS) the formulas used in Hathcock (1996). The nutritional and toxic assessment was carried out by following the recommendations of AESAN (Spanish Agency for Food Safety and Nutrition) on the consumption of fish throughout the week (between 3 and 4 servings of 150 g) and taking into account the reference values of Recommended Daily Intakes (RDIs) given by FESNAD, Estimated Daily Intake (EDIs) and Acceptable Daily Intakes (ADIs) (FESNAD, 2010).

$$ADI = \frac{NOAEL}{F} \, EDI = \frac{C \ metal \ x \ Cons}{Bw} \, MoS = \frac{IDE}{IDA}$$

Where NOAEL is toxicity index determined in the "toxicological evaluation" process, and F is a factor which we take as 100 since the interspecific (10) and intraspecific (10) variables are taken into account (Afonso et al., 2018), EDI characterizes the estimated daily intake of metal through the consumption of aquatic organism for an adult (μg Kg−1 /day); C_{metal} is the concentration of metal in organism (μg Kg^{-1}) wet weight; Cons signifies the day-to-day consumption of seafood (g/day), wet weight; Bw is the body weight (Kg) of an adult (Anandkumar et al., 2017).

3. Results and discussion

Table S1 shows the biometric data for the total length and weight of each specimen studied. *C. sufflamen* is the specie that presents a greater weight with 1900.83 ± 257.81 g and a greater length with 45.37 ± 2.82 cm, while *H. fulgens* presents a lower weight with 257.65 ± 57.8 g and shorter length 24.73 ± 1.92 cm. In the three species analyzed, the males presented greater weight and length than the females.

Table 1 represents the mean concentrations of metals and trace elements in mg / kg of each of the three species. Table S3 shows the results of the one-way PERMANOVA analysis comparing the concentrations of the elements analyzed by species. Comparisons between *C. sufflamen* and *H. fulgens* showed that only Zn differed significantly between the two, registering its highest concentration (7.35 ± 2.79 mg Zn / kg) in the species *C. sufflamen*. Between *B. capriscus* and *H. fulgens*, significant differences were found in Al, B, Fe, K, Mn and Zn, with *B. capriscus* exhibiting a higher concentration of all metals and trace elements, except for Zn. Between *B. capriscus* and *C. sufflamen*, significant differences were observed between both species in the content of B, Mo, Na and Zn, being *B. capriscus* the one with the highest concentration of B and Mo (Fig. S1) and *C. sufflamen* that of higher concentration of Ni and Zn (Fig. S1).

Table 1
Mean concentrations ± standard deviation by species (mg/kg ww) in muscle tissue.

Element	*B. capriscus*	*C. sufflamen*	*H. fulgens*
Al	6.43 ± 3.32	10.01 ± 5.54	4.85 ± 1.83
Cd	0.08 ± 0.23	0.03 ± 0.035	0.02 ± 0.04
Pb	0.53 ± 0.49	0.37 ± 0.29	0.40 ± 0.41
Ca	272.2 ± 265.6	1719 ± 2668	2304 ± 5036
K	2639 ± 517	2768 ± 365	2543 ± 411
Mg	222.2 ± 30.8	207.1 ± 33.8	268.6 ± 76.7
Na	1095 ± 255	1147 ± 430	1257 ± 431
B	0.70 ± 0.02	0.25 ± 0.28	0.31 ± 0.47
Ba	0.42 ± 0.27	0.73 ± 0.64	0.40 ± 0.23
Co	0.14 ± 0.01	0.02 ± 0.01	0.15 ± 0.01
Cr	0.27 ± 0.43	0.14 ± 0.05	0.31 ± 0.74
Cu	0.85 ± 0.59	1.23 ± 0.62	1.24 ± 0.71
Fe	4.95 ± 4.11	3.57 ± 0.94	2.98 ± 1.35
Li	1.55 ± 1.19	1.33 ± 0.37	1.98 ± 1.35
Mn	0.32 ± 0.47	0.34 ± 0.34	0.29 ± 0.40
Mo	0.14 ± 0.01	0.01 ± 0.01	0.02 ± 0.01
Ni	0.09 ± 0.11	0.51 ± 0.03	0.08 ± 0.09
Sr	1.69 ± 2.55	2.89 ± 6.11	4.32 ± 8.04
V	0.04 ± 0.02	0.03 ± 0.01	0.04 ± 0.01
Zn	4.18 ± 0.95	7.35 ± 2.79	5.47 ± 4.25

Table S2 shows the concentrations of metals and trace elements of *B. capriscus* in the locations of La Restinga and Meridiano 0. La Restinga was chosen to know if the underwater volcano off El Hierro is providing nutrients the marine environment, which through the trophic web accumulates in the species (González-Vega et al., 2020), only K showed significant differences in the two localities, being in La Restinga where it presented the highest concentration with 2746.08 ± 408.24 mg/kg (Fig. S1, Table S3). The effect that the volcano has on this species is practically null because *B. capriscus* is a highly migratory species and does not remain in the same location (Kurz, 1995; Simmons and Szedlmayer, 2012; Bacheler et al., 2018).

Table S4 shows the concentrations of metals and trace elements in each location for *H. fulgens*, in the statistical study it was found that there were significant differences in Al, B, Ca, Co, Cu, Fe, K, Mg, Mn, Mo, Na, V and Zn, only Al and K had a higher concentration in the specimens from Bahía Piloto (Fig. S2), this species is much less migratory than *B. capriscus*, so it remains in the same areas (Báez et al., 2019) therefore, the higher concentrations of metals and trace elements found in La Restinga may be due to the influence of the underwater volcano of El Hierro that is located in this locality, and which is currently in the degassing phase and emits nutrients (González-Vega et al., 2020). Table S5 shows the comparisons between the species under study with other similar species from the Atlantic Ocean. Table S6 shows the comparison between the species of this study with those of other authors in other parts of the world. Al and K are two metals that are known to be emitted by the volcanic eruption of 2011 (Lozano-Bilbao et al., 2018) and affected organisms, it is currently in the degassing phase and these two metals are among the most emitted but many others are not emitted or are mitigated very quickly and are scattered in the ocean. The Government of Spain and the Government of the Autonomous Community of the Canary Islands carried out numerous surveys and technical reports on the quality of the water along all the coasts of the Canary Islands, in 2011 in the South of the Island of El Hierro there was a volcanic eruption producing two rounds of mortality of all the surrounding organisms (Ariza et al., 2014). The South of the Island of El Hierro is an integral marine reserve (Tuya et al., 2006), so the recovery of the biodiversity of the area occurred very quickly.

Regarding toxic metals (Al, Cd, Pb), our study presented the highest concentrations. Al levels differ among authors, being 1.456 mg Al / kg in the *Diplodus sargus* species in the study carried out by Afonso et al. (2018), up to 4.438 mg Al / kg in *Mullus surmuletus* (Lozano-Bilbao et al., 2019b). In the case of Cd, the concentrations were similar between the different authors, ranging from 0.015 mg Cd / kg in *Sparisoma cretense* (Afonso et al., 2018) to 0.107 mg Cd / kg in *Serranus cabrilla* (Fernández-Echevarría Trujillo, 2017). Regarding Pb, the highest concentration was recorded in the *B. capriscus* species of our study (0.53 mg Pb / kg), while the lowest was recorded in the *D. sargus* species (Afonso et al., 2014) with a total concentration of 0.017 mg Pb / kg. The metals that showed the highest concentration in the species of our study and those carried out by other authors were the macroelements Ca, K, Mg and Na due to their important role in the body. Presenting concentrations like those recorded in our study in all studies. In the case of microelements (B, Ba, Co, Cr, Cu, Fe, Li, Mn, Mo, Ni, Sr, V and Zn), it should be noted that, in almost all cases, the concentrations are similar to those collected in our study. Sidoumou et al. (2005) recorded the highest concentrations of Cu (6.99 mg / kg) and Zn (7.73 mg / kg) in the species *Pagrus auriga*. Also noteworthy is the concentration of Zn (16.33 mg / kg) recorded in *D. sargus* (Gutiérrez, 2016). In Table S6 the highest concentrations of toxic metals are those recorded in our study. The lowest level of Al, of 0.02 mg Al / kg in the species *Pseudobalistes flavomarginatus*, has been recorded by Rayment and Barry (2000) from the Pacific Ocean (Raine Island, Australia). While, in the case of Cd, the lowest concentration was found in *S. cabrilla* (<0.0006 mg Cd / kg) by Abdallah (2007) and 0.341 mg Cd / kg in the same species by El-Said and Youssef (2009), both studies were conducted in the Mediterranean Sea, Egypt. Regarding Pb, the highest concentration was recorded in the species *S. cabrilla* (0.921 mg Pb / kg) (Abdallah, 2008) in the Mediterranean Sea (Egypt), while the lowest content of Pb was found in the species *Canthidermis maculata* (Bodin, 2016) from the Indian Ocean (EEZ from India) with a concentration of <0.001 mg / kg.

In the case of microelements (B, Ba, Co, Cr, Cu, Fe, Li, Mn, Mo, Ni, Sr, V and Zn), the concentrations found by other authors are similar to those recorded in the present study. Cr has the highest concentration in the Mediterranean Sea (Egypt) in *S. cabrilla* with 7.1 mg / kg (Abdallah, 2008), compared to 0.025 mg / kg of *C. maculata* (Bodin et al., 2016) (Seychelles). The highest concentration in the case of Cu is presented by *Beryx splendens* with a maximum of 15.54 mg / kg (Rao and Sreedhar, 2017), EEZ from India, the lowest concentration of Cu would be reflected in the Hassan-Youssef study (2006) in *S. cretense* with a concentration of 0.1 mg / kg, in the Mediterranean (Egypt). Fe presented its maximum concentration of 49.80 mg / kg in *B. spl*endens in EEZ from India (Rao and Sreedhar, 2017) and in *P. flavomarginatus* from the Gulf of Mannar, India, with a total concentration of 20.26 mg / kg (Ajeeshkumar et al., 2015). The lowest concentrations observed are present in our study. Regarding Ni, the highest concentrations are those published by El-Said and Youssef (2009), in the Mediterranean (Egypt) with 1.23 mg / kg *in S. cabrilla* and 1.34 mg / kg in *S. cretense*. The lowest concentration of Ni (0.0285 mg / kg) was found in *D. sargus* in waters of Girona (north-western Mediterranean) (Ragonnet Carrasco, 2019). V had the highest concentration (5.9 mg / kg) in *P. flavomarginatus* from the Pacific Ocean, on Raine Island (Rayment and Barry, 2000), the lowest concentrations being those of our study. Finally, regarding Zn, the highest concentrations were found in *B. splendens* (28.31 mg / kg) from (Raine Island) (Rao and Sreedhar, 2017), and in *B. capriscus* (24 mg / kg) from the Gulf of Mexico (Vazquez et al., 2001). The lowest concentration of V was found in *S. cretense* (with a maximum of 3.9 mg / kg) from Egypt (Mediterranean) (Abdallah, 2008).

3.1. Toxicological risk assessment of the non-essential elements

To assess the toxic risk, four servings of 150 g each throughout the week have been estimated as adequate intake of the three species in the study. Table 2 shows the estimated daily intake of each metal for the study species (IDA), in addition to the calculation of the Margin of Safety (MoS). Regarding the safety margin, this must give a value lower than 1 so that there is no risk of metal ingestion due to the consumption of fish in both men and women, and finally the maximum intake, expressed in grams, which is it could be consumed daily without toxic risk from the consumption of these fish species. The metals are those with fixed ADIs (Al, Cd, Pb, B, Ba, Sr and Ni) (Table 2).

No metal exceeds or approaches MoS, so, considering the proposed consumption scenario, there is no toxic risk to the health of consumers since the reference values established by the European Food Safety Authority (EFSA) are not exceeded, regarding the consumption of these species, following the recommended consumption guidelines. With the data obtained in Table 2 it can be found that our specimens do not exceed the intake limits for fish, since the EFSA recommends not to exceed the intake of 750 g of fish per week. Merciai et al. (2018) studied the concentrations of metals in *Diplodus sargus* on the coasts of Catalonia in Spain, finding that this species can have high concentrations of Hg in muscle, posing a danger to human health. Therefore, it is clear that an evaluation of the risk of Hg in these species must be made since the study species can present the same lengths.

Table 2
Average values of admisible daily intake (EDI), safety margin (MoS) and maximum tolerable intake (g) by species.

		IDA (mg / day)	MoS		Maximum tolerable intake (g)	
			Men	Women	Men	Women
Balistes capriscus	Al	0.551	0.008	0.009	10,886	9331
	Cd	0.007	0.004	0.005	21,875	18,750
	Pb	0.045	0.002	0.003	39,623	33,962
	B	0.060	0.005	0.006	17,000	14,571
	Ba	0.036	0.001	0.001	2,333,333	2,000,000
	Sr	0.145	0.001	0.001	5,798,817	4,970,414
	Ni	0.008	0.001	0.001	1,197,778	1,026,667
Canthidermis sufflamen	Al	0.858	0.012	0.014	6993	5994
	Cd	0.003	0.001	0.002	58,333	50,000
	Pb	0.032	0.002	0.002	56,757	48,649
	B	0.021	0.002	0.002	47,600	40,800
	Ba	0.063	0.001	0.000	1,342,466	1,150,685
	Sr	0.248	0.001	0.000	3,391,003	2,906,574
	Ni	0.044	0.001	0.000	211,373	181,176
Heteropriacanthus fulgens	Al	0.416	0.006	0.007	14,433	12,371
	Cd	0.002	0.001	0.001	87,500	75,000
	Pb	0.034	0.002	0.002	52,500	45,000
	B	0.027	0.002	0.003	38,387	32,903
	Ba	0.034	0.001	0.001	2,450,000	2,100,000
	Sr	0.370	0.001	0.001	2,268,519	1,944,444
	Ni	0.007	0.001	0.001	1,347,500	1,155,000

3.2. Nutritional assessment of the essential elements

Table 3 shows the estimated daily intake (EDI) values of the metals and essential elements from the consumption of the species analyzed. As well as the recommended daily intake (RDI) and the contribution percentage to the RDI.

None of the essential elements analyzed covers the daily needs set as RDI, assuming the consumption scenarios previously exposed, except Cr. However, the contribution percentages of Mo stand out, after consuming a 150 g ration of *B. capriscus*, the daily contribution would be 26.67 % for both men and women. In turn, Ca would contribute 16.38 % for both men and women in the consumption of *C. sufflamen* and 21.95 % in the consumption of *H. fulgens*. Cr is the metal with the highest daily contribution that is generated after consuming the 150 g of our three species in the study. Regarding *B. capriscus*, it would contribute 66.12 % in men and up to 92.57 % in women. After the consumption of *C. sufflamen*, the daily contribution would be between 34.29 % and 48 % for men and women respectively. Finally, after consuming the recommended *H. fulgens*, the daily chromium intake will reach 75.92 % in men and 106.29 % in women, being the most abundant metal in the three species of the study. Therefore, once the study has been carried out and under the conditions established in terms of daily / weekly fish consumption, proposed by AESAN, there would not be any type of toxic risk after ingesting *B. capriscus*, *C. sufflamen* and *H. cruentatus*. Gbogbo et al. (2018) studied PTWI in river and coastal fish from Ghana, obtaining values below the limits established by the WHO, with the exception of As in *C. nigrodigitatus*, but in this case it is a river species, and being Ghana a country with little legislation and control of contamination, these high values of As can be found. Suggesting that *C. nigrodigitatus* should only be taken three times a week. Observing the results obtained in the nutritional study and the evaluation of the toxic risk, the three species are suitable for human consumption, but this study should be implemented with the help of the Government of Spain for these studies, such as vitamins, fatty acids, proteins, etc. in order to characterize each species, thus giving it great commercial value thanks to the nutritional value that these species may have.

Table 3
Average values of estimated daily intake (EDI), recommended intake expressed in grams and daily percentage for macroelements, microelements and trace elements by species.

		EDI (mg/day)	RDI (mg/day)		% Contribution to Elements	
			Men	Women	Men	Women
B. capriscus	**Ca**	23.331	3306	3306	2.59	2.59
	K	226.22	1330	1330	6.45	6.45
	Mg	19.053	1575	1125	5.44	7.62
	Na	93.90	1095	1095	7.83	7.83
	Cr	0.023	130	93	66.12	92.57
	Cu	0.073	1294	1294	6.62	6.62
	Fe	0.424	1818	3838	4.71	2.23
	Mn	0.027	7188	5625	1.19	1.52
	Mo	0.012	321	321	26.67	26.67
	Sr	0.145	82,840	82,840	0.10	0.10
	Zn	0.358	2273	1675	3.77	5.12
C. sufflamen	**Ca**	147.3	523	523	16.38	16.38
	K	237.2	1268	1268	6.76	6.76
	Mg	17.75	1690	1207	5.07	7.10
	Na	98.39	1045	1045	8.20	8.20
	Cr	0.012	250	179	34.29	48.00
	Cu	0.105	894	894	9.58	9.58
	Fe	0.306	2521	5322	3.40	1.61
	Mn	0.029	6765	5294	1.27	1.62
	Mo	0.001	4500	4500	1.90	1.90
	Sr	0.248	48,443	48,443	0.18	0.18
	Zn	0.63	1293	952	6.63	9.00
H. fulgens	**Ca**	197.5	390	390	21.95	21.95
	K	217.9	1380	1380	6.21	6.21
	Mg	23.02	1303	931	6.58	9.21
	Na	107.7	954	954	8.98	8.98
	Cr	0.027	113	81	75.92	106.29
	Cu	0.106	887	887	9.66	9.66
	Fe	0.255	3020	6376	2.84	1.34
	Mn	0.025	7931	6207	1.08	1.38
	Mo	0.002	2250	2250	3.81	3.81
	Sr	0.370	32,407	32,407	0.26	0.26
	Zn	0.469	1737	1280	4.94	6.70

4. Conclusions

The underwater volcano off El Hierro seems to have some influence on the concentration of metals and trace elements (Al and K). The concentrations of the different toxic heavy metals (Al, Pb and Cd) in the muscle tissue of the three species in the study, *H. fulgens, B. capriscus* and *C. sufflamen*, are within the provisions of the legal framework of the European Union, Commission Regulation (EC) 1881/2006 of December 19, 2006.

Regarding the concentrations of the macroelements (Ca, K, Mg and Na) in the three species in the study, it remains in the same range, although the case of Ca, which presents a low concentration for the species *B. capriscus* (272.20 ± 265.67 mg / kg). For the concentrations of the microelements (B, Ba, Co, Cr, Fe, Li, Mn, Mo, Ni, Sr, V and Zn) in the muscle tissue of the three species of the study, there are no concentrations that exceed the middle range in the three species of the study. Significant differences between the three species were found for metals Al, B, Fe, K, Mn, Mo, Na and Zn.

Regarding the evaluation of the contribution to the RDIs and ADIs of metals, there is no obvious risk regarding the consumption of the species analyzed.

With the results obtained from the nutritional study and with the risk assessment, we recommend these species for human consumption following the recommendations to ingest a maximum of 750 g of fish per week determined by FESNAD

Author statement

Introduction: ELB, DD, GL, AH, AJG.

Material and Methods: ELB, DD, JAG, JML, CR, DGW.

Results and Discussion: ELB, DD, JAG, JML, GL, AH, CR, DGW, SP, AJG.

Conclusions: ELB, DD, JAG, JML, GL, AH, CR, DGW, SP, AJG.

Declaration of Competing Interest

The authors report no declarations of interest.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.jfca.2021.103855.

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