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Abstract: Ethnic foods are nowadays increasingly consumed by Western citizens. However, deficiencies in traceability and poor hygiene conditions have been often reported for ethnic foods. In this study, seafood products (fish, crustaceans and seaweeds) purchased in Southern Italy from ethnic food stores were analysed to assess their labelling compliance with EU law (Regulation EU No 1169/2011 and Regulation EU No 1379/2013) and the presence of microbiological, chemical and physical hazards. Over 96% of the collected products were found as non-compliant with EU law on labelling. Regarding biological contamination, the quantification of enterococci (22.1% of the samples), moulds -including the potential aflatoxigenic Aspergillus flavus- (36.4% of samples) and the detection of Vibrio alginolyticus (7.8% of samples) should be emphasized. The presence of foreign bodies (physical contamination) in 18.2% of the samples highlighted the lack of targeted control systems. Overall, the major concerns arose from the chemical contamination related to the presence of variable percentages of metals derived from anthropogenic activities. This hazard was especially found in seaweeds products, which should be therefore better monitored throughout the food chain in order to protect public health. Outcomes from this study integrates the scarce data present in the literature and provide an overview of the major risks related to the consumption of ethnic seafood sold within EU market.

Research Data Related to this Submission

There are no linked research data sets for this submission. The following reason is given:
No data was used for the research described in the article

Ethnic seafood products sold on the Italian market: labelling assessment and biological, chemical and physical risk characterization

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Abstract

Ethnic foods ~~stores~~ are nowadays increasingly ~~frequented~~ consumed by Western citizens. However, deficiencies in traceability and poor hygiene conditions have been often reported for ethnic foods. In this study, seafood products (fish, crustaceans and seaweeds) purchased in Southern Italy from ethnic food stores were analysed to assess their labelling compliance with EU law (Regulation EU No 1169/2011 and Regulation EU No 1379/2013) and the presence of microbiological, chemical and physical hazards. Over 96~~7~~% of the collected products were found as non-compliant with EU law on labelling~~, confirming previous studies~~. Regarding biological contamination, the quantification of enterococci (~~in~~ 22.1% of the samples), moulds ~~(~~(including the potential aflatoxigenic *Aspergillus flavus*~~)~~) (~~in~~ 36.4% of samples) and the detection of *Vibrio alginolyticus* ~~in~~(–7.8% of samples) ~~must~~should be emphasized~~. Biological contamination, as not including the major foodborne pathogens, was not considered a primary hazard, despite the presence in some samples of the pathogen *Vibrio alginolyticus* and the presence of the moulds *Aspergillus flavus, Aspergillus glaucus* and *Eurotium amstelodami* should be empathized~~. ~~Physical contamination, referring to t~~The presence of foreign bodies (physical contamination) in ~~several~~ 18.2% of the samples~~,~~ highlighted the lack of targeted control systems. Overall, the major concerns ~~arise~~ arose from the chemical contamination related to the presence of variable percentages of ~~toxic~~ metals ~~originating~~ derived from anthropogenic activities. This hazard was especially found in seaweeds products, which should be therefore better monitored throughout the food chain in order to protect public health. Outcomes from this study integrates the scarce data present in the literature and provide an overview of the major risks related to the consumption of ethnic seafood sold within EU market.

Keywords

Ethnic products, labelling, risk characterization, biological hazards, chemical hazards, physical hazards

1. Introduction

The growth of multiculturalism in Western societies has led to an increase of retail shops specialized in ethnic food that, in a broader sense, can be defined as an ethnic groups or a country’s cuisine that is culturally and socially accepted by consumers outside of the respective ethnic group (Kwon, 2015). These Ethnic shops, initially emerged as a response to the immigrants culinary needs, are have been nowadays increasingly also frequented by citizens who wish to vary their customary diet (Guidi et al., 2010; Armani, Castigliego, Gianfaldoni, & Guidi, 2011; Giorgi, Pavoletti, Arsieni, & Prearo, 2012; Grabowski, Klein, & López, 2013; Lee, Hwang, & Mustapha, 2014). In 2016, the share for “ethnic” household food amounted to about € 3 billion of the total € 321 billion distributed within the major markets in Western Europe (Germany, France, Italy and Spain) (MacroGeo, 2016). This figure has especially grown as a result of people becoming increasingly well-travelled, so their tastes are consequently more “adventurous” and “cosmopolitan” as well (Saraf, 2013). Moreover, the availability in local markets of such “low cost” ethnic commodities represents an attraction for a wide range of consumers (Lindgreen & Hingley, 2012; D’Amico et al., 2014).

This new socio-cultural scenario may explain the incredible success that exotic dishes such as *kebab*, *cous cous*, *sushi* and *sashimi* have achieved among western citizens, to the point that they are nowadays perfectly integrated in the daily cuisine (Armani et al., 2017; Niola, 2018), and also the increasing attention towards novel protein sources such as jellyfish or seaweeds (Armani et al., 2013; Van der Spiegel, Noordam, & Van der Fels- Klerx, 2013). Several edible varieties of seaweed are traditionally employed for human nutrition in Pacific countries such as China, Japan and Korea, and obviously in countries where ethnic Asian communities are present (Hwang, Park, Park, Choi, & Kim, 2010; Khan et al., 2015). In fact, the modern food trends have contributed to the popularity of seaweeds among western communities, as they basically represent one of the main ingredients of *sushi*. Seaweeds are in fact especially increasingly appreciated by Western citizens for their abundance of natural vitamins, minerals and plant-based protein which provide a variety of health benefits (Bocanegra, Bastida, Benedi, Rodenas, & Sanchez-Muniz, 2009; Li, Lin, Zheng, & Wang, 2011; Taboada, Millán, & Miguez, 2013). Their global market is currently estimated to be valued at USD 11.5 billion in 2016, of which about USD 5 billion are related to products for human consumption. ~~Therefore, seaweeds products can be nowadays found even outside the ethnic food stores context, in supermarket and hypermarkets, e-commerce and convenience stores.~~

A survey conducted in 2010 on a population of 1,000 Italian citizens reported that 24.1% had purchased in ethnic food stores~~, of which 14.1% in a usual way; an even higher percentage of citizens had purchased ethnic food within large distribution channels, where~~ and ~~-~~40.7% of the interviewed had bought and consumed such products at least once a month. ~~(Fondazione Leone Moressa, 2010). Such difference is probably due to the lack of confidence of Italian citizens towards ethnic food stores, since~~ However, 61.8% of the interviewed found ~~them~~ ethnic food stores poorly reliable (Fondazione Leone Moressa, 2010),~~.,~~ mainly due to the low quality of the sold products, as also reported by ~~. A~~ a more recent study by Mascarello, Pinto, Marcolin, Crovato, & Ravarotto (2017)~~ on a sample of 1,317 Italian consumers~~. ~~confirmed this hypothesis highlighting that, although the consumption of ethnic food products has grown over the last years, the consumers' confidence has remained doubtful.~~

~~During the past years, the number of international migrants has grown, reaching 244 million in 2015, up from 222 million in 2010 and 173 million in 2000 and today, ethnic minorities represent a significant and growing part of the population in US and EU countries (UN, 2016). In Italy, foreigners have more than doubled over the last thirty years and currently represent a percentage of just under 10% (MacroGeo, 2016). The Chinese community has seen experienced an exponential growth over the whole national territory, rapidly rising to the third place in the list of non-Community nations in terms of the number of residing citizens (Italian Ministry of Labour and Social Policies, 2016). Chinese communities have well activeated and organised "internal" food markets which commercialise both Asian and other ethnic foods coming from the EU or products~~

~~that are sometimes made in Italy because importation from the original countries has been banned (Guidi et al., 2010).~~

Regarding the origin of ethnic foodstuffs purchased by Italian citizens, they mostly choose those coming from Chinese and/or Japanese culture, followed by Mexican/South American, Middle Eastern, Southeast Asian, or other such as those from Africa or Eastern Europe (Mascarello et al., 2017). As sold within the EU market, food products found in ethnic stores should be compliant with the EU rules regarding food hygiene, which are reported in key acts, ~~(~~known as EU Hygiene Package, ~~) related to the principles and requirements provided by the EC General Food Law (Regulation (EC) No 178/2002). Food requirements are~~and also provided by a number of EU specific dispositions ~~completing those provided by the aforesaid flanking the Hygiene Package.~~ ~~, such as~~(~~–~~Commission Regulation (EC) No 2073/2005; ~~on microbiological criteria for foodstuff,~~ Commission Regulation (EC) No 1881/2006; ~~setting maximum levels for certain contaminants in foodstuff,~~ Regulation (EC) No 1333/2008;~~ on food additives,~~ Commission Regulation (EU) No 37/2010; ~~on pharmacologically active substances and their classification regarding maximum residue limits in foodstuffs of animal origin,~~ and others). Moreover, the labelling system should comply with the disposition provided by the Regulation (EU) No 1169/2011 and, in the case of some seafood, also the Regulation (EU) No 1379/2013. Official controls must be organised by the Member States for the verification of compliance with such dispositions based on the risk category of the Food Business Activity. Therefore, collecting information about the management of the Food Business Activity represents a key element to implement appropriate check along the supply chain.

~~Nonetheless, d~~Difficulties of ethnic food activities to conform to the European rules have been reported by some studies conducted in Central and Northern Italy. Issues particularly regarded deficiencies in traceability and poor hygiene conditions (Armani et al., 2012; Armani et al., 2015; D'Amico et al., 2014; Giorgi et al. 2012). Moreover, a copious number of recalls of ethnic foods have occurred worldwide due to their contamination with biological agents, bacterial toxins, mycotoxins, and hazardous chemicals~~, also including~~ and allergens (Lee et al., 2014; Fusco et al., 2015). Over the last years, the European Rapid Alert System for Food and Feed (RASFF) has especially notified several cases of contamination by the foodborne pathogens *Salmonella* spp. and *Listeria monocytogenes* in Asian products (http://ec.europa.eu/food/safety/rasff/index_en.htm). Recently, 58 tons of ethnic food products were ~~recently~~ impounded in Rome (Italy) during an official survey (www.coldiretti.it).

Most of the data on ethnic products non-compliances that are available in the literature generally include~~s~~ samples collected at several points of sale (at both wholesale and retail levels, restaurants and bars) thus not giving a clear picture of the ethnic food stores condition. In addition, to the best of the authors' knowledge, ~~, hitherto,~~ no studies have carried out a comprehensive survey specifically aimed at analysing the presence of biological, chemical and physical issues of the products sold within ethnic food stores. This lack of information is particularly relevant for seafood, whose potential risks associated with biological or chemical contaminants have been often notified on the RASFF portal. Asian seafood is, in fact, among the commodities that are most frequently notified for the presence of residues of veterinary drugs, histamine and poor hygienic conditions (D'Amico et al., 2018).

In this study, seafood samples purchased in Southern Italy from Asian ethnic food stores were analysed. The labelling compliance with EU law was first assessed, followed by the evaluation of the presence of microbiological, chemical and physical hazards. ~~This work represents a thorough attempt to contemporaneously assess different potential issues associated to ethnic seafood products sold on the EU market.~~ Outcomes from this study, besides integrating the scarce data present in the literature, represent an essential point for addressing the main shortcomings associated to products increasingly present on the EU market, thus ensuring an adequate level of consumers protection.

2. Materials and methods

2.1 Samples collection

Seventy-seven differently processed (only dried, dried and smoked ~~and dried,~~ ~~or roasted~~ and dried and roasted) seafood commercial products (CPs) were purchased in ethnic retail food markets located in Southern Italy (Messina and Catania). A convenience, non-probabilistic sampling was conducted, structured to include a proportional number of products per type. Specifically, ~~T~~they were ~~especially~~ composed ~~of~~ by a) fish (n=26) (whole, fillets, slices, diced), b) crustaceans (n=25) and c) seaweeds (n=26) (Table 1). All CPs were commercialized at room temperature. ~~On the CPs, the following analysis were performed: assessment of the label compliance with EU legislation, microbiological analysis, macroscopic and microscopic observations by Scanning Electron Microscopy (SEM) and X-ray microanalysis. All the analysis methodologies are detailed in the following sections.~~

2.2 Assessment of CPs label compliance with EU legislation

CPs labels were evaluated according the dispositions provided by the Regulation (EU) No 1169/2011 and Regulation (EU) No 1379/2013. In the first case, the presence and the correctness of the following mandatory information were assessed: a) the name of the food (which should be in a language understood in the nation where the product is sold); b) the list of ingredients; c) the net quantity of the food; d) the date of minimum durability or the ‘use by’ date; e) the nutrition declaration; f) the declaration of ingredients causing allergies or intolerances, properly emphasised through a typeset that clearly distinguishes it from the rest of the list of ingredients (only for CPs containing ingredients listed in the Annex II of the same regulation). In the second case, the presence and the correctness of the following mandatory information were assessed: a) the commercial designation of the species; b) the species scientific name; c) the production method; d) the area where the product was caught or farmed; e) the category of the fishing gear used for the capture. The validity of the species commercial designation and relative scientific name (where reported) was established on the basis of the disposition provided by the Article 37 of the same regulation, and especially assessed by a comparison with the Italian official list of seafood trade (Ministerial Decree No 19105, 2017). Currently, seaweeds species were not listed in the Ministerial Decree No 19105 of 22th September, 2017 and, consequently, the compliance between commercial designation and scientific name of the 11 seaweed CPs reporting both these info was assessed by consulting the official database on algae that includes terrestrial, marine and freshwater organisms (www.algaebase.org) and the available scientific literature.

2.3 Microbiological analysis: enumeration and detection of spoilage and pathogenic ~~bacteria~~microorganisms ~~: CPs bacteriological and mycological characterization, pathogens detection~~

All samples were transported ~~in~~ to the laboratory and processed within 24 hours. Samples were previously homogenised by using a blender (Oster® BRLY07-Z00-050, Mexico) according to ISO 6887:2017.

2.3.1 Enumeration of microorganisms. Afterwards, 10 grams of each sample was transferred to a stomacher bag and buffered peptone water (Biolife, Milan, Italy) ~~was~~ added with a ratio of 1:9 (w/v). The~~;~~ samples were then homogenized for 60 s at 230 rpm~~,~~ with a stomacher (Stomacher® 400 Circulator; International PBI s.p.a., Milan, Italy) and tenfold dilutions in buffered peptone water were prepared. Aliquots ~~of 1 ml (Limit of quantification – LOQ = 1 Log CFU/g) were~~ were plated ~~, in duplicate,~~ for the following bacteriological ~~parameters~~enumerations: i) *Enterobacteriaceae* count according to ISO 21528-2:2017 on Violet Red Bile Glucose Agar (Biolife, Milan, Italy) plates, incubated at 37 ± 1 °C for 24 hours; ii) sulphite-reducing bacteria count according to ISO 15213:2003 on TSC Agar Base (Biolife, Milan, Italy) plates, incubated at 37 ± 1 °C for~~per~~ 24 hours in anaerobic conditions; iii) *Vibrio cholerae* count on Thiosulfate Citrate Bile Salts Sucrose (TCBS) (Difco, Le Point de Claix, France) agar plates, incubated at 37 ± 1~~37~~°C for 24 hours; iv) count of halophilic *Vibrio* on TCBS (Difco, Le Point de Claix, France) agar plates supplemented with 2.5 % NaCl, incubated at 30 ± 1°C for 24 hours; v)~~.~~ ~~Aliquots of 0.1 ml (LOQ = 2 Log CFU/g)~~ yeast and mould count according to ISO 21527-2:2008 (aw ≤ 0.95) ~~were plated, in duplicate,~~ on DG18 (Biolife, Milan, Italy) agar plates, ~~for yeast and mould count according to ISO 21527-2:2008 (a_w ≤ 0.95)~~ incubated at 25 ± 1°C for 5-7 days; vi) enterococci count ~~and~~ on Slanetz Bartley Agar ~~plates~~ (Biolife, Milan, Italy) plates, incubated at 37 ± 1°C for 48 hours ~~for enterococci count~~. All enumerations were performed in duplicate for each sample. The limits of quantification (LOQ) were 1 lLog CFU/g for *Enterobacteriaceae*, sulphite-reducing bacteria, *Vibrio cholerae*, halophilic *Vibrio* and 2 lLog CFU/g for yeast, and mould and enteroccocci.

2.3.2 Detection of pathogenic bacteria. The presence of the following pathogen bacteria was performedinvestigated: i) *Salmonella* spp. according to ISO 6579-1:2017; ii) *Listeria monocytogenes* according to ISO 11290-1:2017; iii) potentially enteropathogenic *Vibrio parahaemolyticus*, *Vibrio cholerae* and *Vibrio vulnificus* according to ISO 21872-1:2017; iv) others halophilic *Vibrio* spp..

The Ssamples were homogenized, as previously described, with the following diluents: i) buffered peptone water (Biolife, Milan, Italy) for *Salmonella* spp., and then incubated at 37 ± 1°C for 18 hours; ii) Listeria Fraser Broth Half Concentration (Biolife, Milan, Italy) for *L. monocytogenes*, afterwards incubated at 30 ± 1°C for 24 hours; iii) Alkaline Salt Peptone Water (pH 8.6 ± 0.2 - Biolife, Milan, Italy) for *V. parahaemolyticus*, *V. cholerae* and *V. vulnificus*, subsequently incubated at 37 ± 1°C for 24 hours; iv) Alkaline Salt Peptone Water (pH 8.6 ± 0.2 - Biolife, Milan, Italy) for others halophilic *Vibrio* spp., and then incubated at 30 ± 1°C for 24 hours.

After the required enrichment in different specific liquid media, a loopful was spread on: i) Xylose Lysine Deoxycholate agar (Biolife, Milan, Italy) and Chromogenic Salmonella Agar Base (Biolife, Milan, Italy), both incubated both at 37 ± 1-°C for 24 hours for *Salmonella* spp.; ii) on Agar Listeria acc. to Ottaviani & Agosti (ALOA®) (Biolife, Milan, Italy) and Listeria PALCAM Agar Base (Biolife, Milan, Italy) both incubated both at 37 ± 1–°C for 48 hours for *L. monocytogenes*; iii) TCBS (Difco, Le Point de Claix, France) agar plates incubated at 37 ± 1-°C for 24 hours for *V. parahaemolyticus*, *V. cholerae* and *V. vulnificus*; iv) TCBS (Difco, Le Point de Claix, France) agar plates supplemented with 2.5 % NaCl incubated at 30 ± 1°C for 24 hours for others halophilic *Vibrio* spp..

The presence of the major foodborne pathogens was also investigated: i) detection of *Salmonella* spp. according to ISO 6579-1:2017; ii) detection of *Listeria monocytogenes* according to ISO

~~11290-1:2017; iii) detection of potentially enteropathogenic *Vibrio parahaemolyticus*, *Vibrio cholerae* and *Vibrio vulnificus* and others halophilic *Vibrio* spp. according to ISO 21872-1:2017.~~

2.3.3~~1~~ ~~Strains Iidentification of Mmicroorganisms~~ Identification of microorganisms. ~~Regarding~~ Colonies of *Listeria monocytogenes*, *Salmonella* spp. and enteropathogenic *Vibrio parahaemolyticus*, *Vibrio cholerae* and *Vibrio vulnificus*~~,~~ ~~no colonies~~ were not detected in selective agar media after the pre-enrichments and enrichments required. Therefore, it was not necessary to proceed with the identification by applying the subsequent procedures described in the respective ISO standards. The strains of halophilic *Vibrio* spp. not identifiable~~ed~~ by ISO 21872-1:2017 ~~as *Vibrio parahaemolyticus*, *Vibrio cholerae* and *Vibrio vulnificus*~~ were sub-cultured on Tryptic Soy agar (TSA) (Biolife, Milan, Italy) supplemented with 5% sheep blood (Biolife, Milan, Italy) ~~and~~ plus 2.5% of NaCl (Biolife, Milan, Italy) and incubated at 30 ± 1°C for 24 hours. In the samples in which moulds were the predominant or relevant flora, five colonies from DG18 were sub-cultured on Malt Extract Agar (MEA) and incubated at 25 ± 1°C for 5 days. The colonies so obtained were identified~~, for the identification~~ with MALDI-TOF mass spectrometry by using Vitek MS Axima Assurance mass spectrometer (bioMérieux, Firenze, Italy~~-Firenze, Italy~~) ~~(Vitek MS) (bioMérieux, France)~~ associated with ~~software~~ SARAMIS software (Spectral ARchive And Microbial Identification System - Database version V4.12 – Software year 2013;~~,~~ bioMérieux, Firenze, Italy~~Firenze, Italy~~)~~SARAMIS V4.12 (bioMeriéux, France)~~.

~~In the samples in which moulds were the predominant or relevant flora, five colonies from DG18 were sub-cultured on Malt Extract Agar (MEA) (Biolife, Milan, Italy) for the identification with MALDI-TOF MS (Vitek MS) associated with software SARAMIS V4.12.~~

2.4 Macroscopic and microscopic observations

All the products were primarily visually inspected under appropriate light condition in order to evaluate the presence of foreign bodies (FBs) and macroscopic alterations. FBs where mostly found in crustaceans and were not observed in fish and seaweeds (see 3.3.1). Therefore, SEM and X-ray microanalysis were mostly applied to randomly selected CPs belonging to these two latter categories for better examining them. Overall, about 30% of the samples collected in this study were analysed ~~by using these techniques~~with SEM and they are listed in~~.~~ Table 2SM.

2.4.1 Scanning Electron Microscopy (SEM) and X-ray microanalysis. A Phenom ProX (Thermo Fisher Scientific, USA) desktop scanning electron microscope (SEM) equipped with an Energy Disper~~n~~sive Spectrometer (EDS) was used to perform a Scanning Electron Microscopy (SEM) and X-ray microanalysis. Phenom ProX allowed to analyse samples without the standard preparation steps (fixation, dehydration and shading); in fact, only a drying procedure was required and, since all samples were ~~naturally~~ dried, no extra treatment ~~were~~ was performed. SEM analysis was conducted to investigate the presence of foreign bodies (FBs) or other anomalies on 5 portions (1.2 x 1.2 cm) of each sample. X-ray microanalysis was applied to evaluate CPs elemental composition by analysing random spots on the 5 portions of each sample surface. This technique was even applied to determine the elemental composition of the foreign bodies/alterations eventually observed during SEM analysis by comparing spots onto the anomalies to spots onto the remaining standard tissue. The Phenom ProX ~~related~~ performs a semi-quantitative analysis, indicating the weight percentage and the percentage of certainty of each element found in a specific point~~software indicates the quantity of each element found (weight percentage~~ ~~semi quantitative analysis) and the percentage of certainty~~. Only the chemical elements with a certainty greater than 95% were considered.

3. Results

3.1 Overall ~~A~~assessment of CP~~S~~s label compliance with EU legislation

Thirty-seven of the 77 collected products (48%) were not labelled at all. In particular, they were represented by 14 out of 26 ~~almost~~ (53.84%) ~~(14/26)~~ and actually 23 out of 25 (92%) ~~(23/25)~~ of the fish and crustacean categories, respectively. ~~More or less detailed info were instead provided o~~Of~~n~~ the ~~label of the~~ remained 40 products, represented by all the seaweeds (n=26), 12 fish and ~~only~~ 2 crustaceans (Table 2),~~). Overall,~~ only 3 products (7.5%) (CP-24, CP-56 and CP-76) were found as totally compliant with both the EU regulations (Table 2). According to these outcomes, the overall products non-compliance with EU requirements was over 96% (74/77).

3.1.1 Labels compliance with the Regulation (EU) No 1169/2011. Thirty out of the 40 labelled CPs (75%),,(obtained by subtracting the 37 not labelled CPs (which were obviously not analysed) to the overall 77 CPs,)) were found as totally compliant with the disposition of the Regulation (EU) No 1169/2011 and they were represented by all the seaweeds and 4 fish (Table 2). By analysing each mandatory information detailed in section 2.2, we observed that the Italian name of the food was provided in almost 88% of the labelled CPs (n=35) (Table 2). It is however interesting to highlight that grossly inaccurate Italian translations from the original languages sometimes existed, such as "*alche*" instead of "*alghe*" (the Italian translation of seaweeds) or the definition "*gambero grosso*", that we assumed could be the wrong translation of "Giant prawn" (Table 1); moreover, in one case, the too generic designation "*pesce secco*" (which means dry fish) was provided (Table 1). The ingredient list, the net quantity of the food, the date of minimum durability and the nutrition declaration were provided in 93% (n=37), 98% (n=39), 100% (n=40) and 88% (n=35) of the labelled CPs, respectively (Table 2). The assessment of the declaration of ingredients causing allergies or intolerances was only conducted on fish and crustacean products (n=14), while seaweeds products were excluded as not listed in the Annex II, and therefore not reported as allergenic ingredients by EU law, and even because they do not report any other allergenic substance in the ingredient list. Among the considered CPs, the allergenic hazard was emphasized in 9 labels (64%) (Table 2).

3.1.2 Labels compliance with the Regulation No 1379/2013. All the CPs collected in this study fell within the scope of the Regulation No 1379/2013 as represented by fish, crustaceans and seaweed products, which are reported in the Annex I of the same regulation with the CN (combined nomenclature) codes 0305, 0306 and 12122000, respectively. Overall, only 3 samples (1 fish and 2 seaweeds) out of the 40 labelled CPs (8%) were found as totally compliant, while the remained CPs presented absence or incorrectness of one or more of the required information (Table 2).

The 35 labelled CPs that reported the Italian commercial designation (section 3.1.1) were associated to a relative species scientific name in 63% (n=22) of the cases, only in products included in fish or seaweeds categories (Table 1 and Table 2). As regards fish, the compliance between the commercial designation and the scientific name was only observed for 2 products (CP-13 and CP-24), as the species *Katsuwonus pelamis* correctly matches with the Italian designation “*tonnetto striato*” (Ministerial Decree No 19105, 2017).

Amongs~~ regards~~ seaweeds, the designations “Wakame” and “Arame” were correctly~~as~~ ~~ere correctly~~ associated to the species *Undaria pinnatifida* (CP-56) and *Eisenia bicyclis* (CP-57 and CP-58), respectively, and *Porphyra spp.* (CP-66, CP-71, CP-72, CP-74 and CP-76) was~~is~~ associated to the name “Nori” at international level (Delaney, Frangoudes, & Ii, 2016); t~~T~~he nomenclature *Laminariaceae longissima* (CP-53 and CP-54)~~,~~ was considered as invalid as referring to a family (Laminariaceae) instead to the species *Laminaria longissimi*a, which is actually known as Kombu seaweed; *Pulva pertusa* (CP-59) is not associated to “Nori” at all. Therefore, out of the 22 CPs reporting both commercial designation and scientific name (Table 2), 10 (2 fish and 8 seaweeds) (45%) ~~could be~~were considered as correctly ~~matching~~ labelled.

As regards the other mandatory information, 53% (21/40), 50% (20/40) and 25% (10/40) of the samples reported the production method, the area where the product was caught or farmed and the fishing gear, respectively (Table 2).

3.2 Microbiological analysis: enumeration and detection of spoilage and pathogenic ~~bacteria~~microorganisms ~~Microbiological analysis~~

3.2.1 Enumeration of microorganisms. ~~On~~Overall, ~~the total of 77 CPs, the 55% of samples (42 CPs~~55% (42/77) of the CPs~~)~~ were ~~Outcomes of CPs found as positive~~characterized by the presence of at least one of the investigated microorganisms ~~for the bacteriological and/or mycological characterization were reported in (~~Table 3). The readers can also refer to Table 1SM for observing more detailed data relative to the outcomes obtained from all the analysis performed on positive samples. Regarding the three different~~Overall, 55% (42/77) of the CPs were found as contaminated~~

~~by biological agents, and this percentage did not seem apparently related to the product typology the presence of at least one of the investigated microorganisms was reported in 22 of 25 , origin and label correctness, even though crustaceans CPs (88.0%), are higher involved (88% of the crustaceans CPs) respect tofollowed by fish with 12 on 26 CPs (46.2% of fish CPs) and seaweeds with 8 on 26 CPs (30.18% of seaweeds CPs).~~ *Enterobacteriaceae* were found in 5 CPs (6.5% of all CPs): 1 crustacean (1.00 l~~L~~og~~0~~ CFU/g) and 4 seaweeds (~~from 1.1 x 10^2 to 4.6 x 10^2 CFU/g;~~ mean value 2.25 ± 0.29~~1 x 10^2~~ l~~L~~og CFU/g). Enterococci were found in 17 CPs (22.1% of all CPs): 6 fish (~~from 3.0 x 10^2 to 1.8 x 10^5 CFU/g;~~ mean value 3.~~3~~66 ± 0.91 l~~L~~og ~~x 10^4~~ CFU/g), 8 crustaceans (~~from 1.0 x 10^2 to 2.7 x 10^5 CFU/g;~~ mean value ~~1~~4.08 ± 1.72 l~~L~~og ~~3 x 10^5~~ CFU/g) and 3 seaweeds (~~from 1.5 x 10^2 to 3.0 x 10^2 CFU/g;~~ mean value 2.32 ± 0.15 l~~L~~og ~~x 10^2~~ CFU/g). Sulphite-reducing bacteria were found in three CPs (3.9% of all CPs): 2 fish (CP-20 and CP-23) in concentration of 1.00~~0~~ l~~L~~og CFU/g and 1.60~~40~~ l~~L~~og CFU/g, respectively, and in 1 seaweed (CP-63) with value ~~in concentration of~~ of 2~~1~~.15~~4 x 10^2~~ l~~L~~og CFU/g. Yeasts were found in 6 CPs (7.8% of all CPs): 2 fish (CP-9 and CP-10) in concentration of 6.00 l~~L~~og CFU/g and 5.40 l~~L~~og CFU/g, respectively, and 4 crustaceans (mean value 2.87 ± 0.78 l~~L~~og CFU/g). Moulds were found in 28 CPs (36.4% of all CPs): 8 fish (~~from 1.0 x 10^2 to 7.6 x 10^4 CFU/g;~~ mean value ~~2~~3.~~5~~90 ± 1.01 ~~x 10^4~~l~~L~~og CFU/g), 17 crustaceans (~~from 1.0 x 10^2 to 1.1 x 10^3 CFU/g;~~ mean value 2.~~9~~38 ± 0.25~~x 10^2~~ l~~L~~og CFU/g), 3 seaweeds (~~from 1.0 x 10^2 to 4.0 x 10^2 CFU/g;~~ mean value 2.30 ± 0.30 l~~L~~og ~~x 10^2~~ CFU/g). The moulds that were found in high concentration in fish CPs were identified as *Aspergillus flavus* (CP-11 and CP-12), *Aspergillus glaucus* (CP-20 and CP-22) and *Eurotium amstelodami* (CP-9 and CP-10).~~Yeasts were found in 6 CPs (7.8% of all CPs): 2 fish (CP-9 and CP-10) in concentration of 16.00 x 10^6Log CFU/g and 52.405 x 10^5 Log CFU/g, respectively, and 4 crustaceans (from 3.0 x 10^2 to 1.1 x 10^4 CFU/g; mean value 32.87 ± 0.78 x 10^3 Log CFU/g).~~

3.2.2 Detection of pathogenic bacteria. *Salmonella* spp., *L. monocytogenes* and enteropathogenic *Vibrio* spp. (*V. parahaemolyticus*, *V. cholerae* and *V. vulnificus*) were ~~instead~~ not detected in any analyzed sample.

~~However, o~~Other "~~"~~non~~-~~enteropathogenic *Vibrio* spp."~~"~~ (different from *V. parahaemolyticus*, *V. cholerae* and *V. vulnificus*) were found in 7.8% (n=6) of the CPs: 2 fish (CP-3 and CP-26), 2 crustaceans (CP-27 and CP-51) and 2 seaweeds (CP-52 and CP-63).

~~*3.2.3 Identification of microorganisms.*~~ Of the total 14 strains collected, the MALDI-TOF permitted the identification of 13 *Vibrio alginolyticus*, while the last one was identified only at genus level.

~~The moulds that were found in high concentration in fish CPs were identified as *Aspergillus flavus* (CP-11 and CP-12), *Aspergillus glaucus* (CP-20 and CP-22) and *Eurotium amstelodami* (CP-9 and CP-10).~~

3.3 Macroscopic and microscopic observations

~~CP-20 and CP-22 were characterized by the presence of whitish powder on the fish surface, probably related to the mould presence (see section 3.2).~~ A total of 44 foreign bodies ~~(FBs)~~ or animal matrices different from those that compound the products were found in thirteen crustaceans CPs (52% of all crustaceans) during the visual inspection (Table 4), with a mean value for positive samples of 3.38 ± 1.85 FBs (from 1 to 6 FBs/sample). Among the FBs, 3 (6.8%) "rock"; 1 (2.3%) "paper"; 1 (2.3%) "wood fragment" were found (Fig.1); among the different matrices, 31 (70.5%) "fish/fish fragment", 7 (15.9%) "crab/crab fragment" and 1 "squid" (2.3%) were also observed (Table 4). Among the other sample categories, only fish samples CP-20 and CP-22 were characterized by the presence of whitish powder on the ~~fish~~ surface, probably related to the mould presence (see section 3.2).

3.3.1 Scanning Electron Microscopy (SEM). Differently from crustacean category, no FBs neither different matrices were visually observed in fish and seaweeds, so that SEM analysis was mostly applied to randomly selected CPs belonging to these two latter categories for better examining them. In particular, 11 fish (42% of the whole fish category) and 7 seaweeds (27% of the whole seaweeds category). Anyway, even 3 crustacean CPs (12% of all the crustacean CPs) were randomly selected and analysed with SEM. The selected samples were listed in Table 2SM. The preliminary analysis highlighted anomalous structures in CP-13, CP-20, CP-22 and CP-65. In the CP-13 sample (Skipjack tuna flakes) several confluent elongate-shape structures 30 x 5 µm average length were observed (Fig. 2). In CP-20 and CP-22 samples (dried fish) many fungal hyphae were found (Fig. 3), corroborating the outcomes of the microbiological analysis (section 3.2) that highlighted high concentration of *A. glaucus* in these samples. Finally, in the CP-65 sample (roasted "Nori" seaweeds) three approximately 30 x 18 µm triangular structures were found in one observation field (Fig. 4).

3.3.2 X-ray microanalysis. Although the X-ray analysis was conducted on all CPs preliminary analysed by SEM, only results from those showing an elemental composition different from the standards of the related matrix or presenting anomalous structures within the matrix (section 3.3.1) were reported. Toxic substances were found as part of the elemental composition of three fish CPs (CP-13, CP-20 and CP-22) (Fig. 5) and four seaweed CPs (CP-52, CP-64, CP-65 and CP-66) (Fig. ~~6~~1SM). In detail, CP-13 analysis highlighted the presence ~~of trace~~ of rhodium (3.6% max), zirconium (3.5% max) and lead (2.8% max) (Fig. 4a); in CP-20, zirconium (17.1% max) and arsenic (9.0% max) were found (Fig. 4b); similarly, zirconium and arsenic were found in CP-22 (13.2% max and 7.9% max, respectively) (Fig. 4c); in all these three samples, the toxic substances were mainly found within salt concretions on the samples surface. About the seaweeds CPs, rhodium (45.3% max) and strontium (38.7% max) were found in CP-52 (Fig. 5a); in CP-64 and CP-66 the presence of lead (14.0% max and 17.8% max, respectively) and arsenic (4.1% max and 6.7% max, respectively) was observed (Fig. 5b and Fig. 5d); CP-65 contained lead (11.0% max) (Fig. 5c). The analysis of CPs presenting anomalies resulted as follow: in CP-13, three chemical elements were found within the elongate-shaped structures (Fig. 1), represented by potassium (about 55%), chloride (about 40%) and carbon (about 5%). We therefore deduced they almost certainly were salts aggregates, although they did not have their relative typical appearance. In CP-65, presence of strontium (about 13.1%), silicon (about 9.7%), lead (about 5.5%) and arsenic (about 1.9%) was found within the triangular structures (Fig. 3), leading to assume the presence of shards of glass or other material probably used for the seaweeds cutting during the product manufacturing.

4. Discussion

4.1 Gaps in ethnic products' labelling system

~~On December the 13th~~th, ~~of December 2014 the Union law on food information was fully harmonised by virtue of the Food Information Regulation (EU) No 1169/2011. Novelties in the EU law have even been brought, such as the requirement of certain nutrition information for majority of prepacked processed foods and the clearer and harmonised presentation of allergens for prepacked foods in the list of ingredients. By integrating the provisions of the Regulation (EU) No 1169/2011, the EU, within the renewal plan of the Common Fisheries Policy and the Common Market Organization, with the Chapeter IV of the Regulation (EU) No 1379/2013 have also introduced new requirements for the labelling of fisheries and aquaculture products improving and facilitating their traceability and limiting illegal fishing.~~

In the last years, the difficulty of food products sold within ethnic stores in complying with EU labelling system has been highlighted in many studies (Armani et al., 2012; Giorgi et al. 2012; Armani et al., 2013; D'Amico et al., 2014; Armani et al., 2015; Di Muri, Vandamme, Peace, Barnes, & Mariani, 2018). ~~A serious l~~Labelling deficiency ~~and mislabelling cases~~ in unconventional seafood products purchased in Chinese ethnic stores were highlighted in two consecutive surveys conducted in Central Italy (Armani et al. 2012; Armani et al., 2013). In the same way, D'Amico et al. (2014) found that 83% of ~~the one hundred examined ethnic~~ Chinese seafood products imported to Italy did not meet the EU traceability requirements ~~for traceability~~. ~~Such issue had been also highlighted by Armani et al. (2015), which found that almost half of the ethnic seafood products analysed presented discrepancies between labelling and molecular identification. The picture has not changed with the implementation of the current food labelling regulations.~~ Similarly, the study by Di Muri et al. (2018) unveiled a 41% of labelling non-compliance ~~,~~ examining ~~the label accuracy~~

~~of~~ ethnic seafood ~~purchased~~ sold in –UK~~Britain~~.~~, unveiled a high level of non-compliance (mislabelling rate 41%).~~

According to our outcomes, the framework described above has essentially remained the same as ~~almost hal f~~48% of the collected products were not labelled at all ~~(to the point that, in some cases, it was necessary to directly asked the stores traders about the product category)~~ and of those labelled, the percentage of compliant labels ~~compliant with both the Regulation (EU) No 1169/2011 and the Regulation (EU) No 1379/2013~~ was found as ~~extremely~~ low (8%) ~~in the case~~according to the requests -of Regulation No 1379/2013.

The shortcomings were mostly represented by ~~the relatively confusing way the products are presented to the consumers: cases of crass~~ misspelling or labels not reporting the commercial designations in Italian language~~ limit consumers' understanding~~. ~~This aspect is especially inconsistent with the Article 15 of the regulation, reporting that "*the mandatory food information shall appear in a language easily understood by the consumers of the Member States where a food is marketed*".~~ Another consistent shortcoming was found in the fish and crustacean CPs that did not emphasize allergenic hazard related to the presence of fish and crustaceans, which may result in a threat for allergic consumers.

In accordance with the findings of D'Amico et al. (2014), mismatches between the commercial designation and the scientific name were found. In addition,~~,~~ ~~also in this case mainly due the fact that~~ many fish species, as well as all the seaweeds, ~~are~~ are still ~~were~~ not included in the Italian official list of seafood trade (Ministerial Decree No 19105, 2017). It should be however underlined that this latter issue cannot be considered a proper label non-compliance, given the fact that a broad type if newly imported products and species continuously enter in the internal market and the on-time updating of the official list is understandably hard. Therefore, the regular monitoring and the checks performed on such types of products is undoubtedly fundamental for the list updating process.

On the whole, such default of the ethnic food labelling system unavoidably leads to a lowering of consumers' confidence for these products, primarily as they are not allowed to wholly know what they purchased. ~~This especially represents a topical theme as many consumers are increasingly aware of nutritional and environmental issues regarding fisheries, leading to shifts in attitude regarding acceptable species (particularly if overexploited and/or endangered fish species are used), catch location and catch methods (Potts, Brennan, Pita, & Lowrie, 2011).~~ Moreover, the potential health risk that mislabelling may represent for consumers should not be underestimated (Jacquet & Pauly, 2008).

4.2 Ethnic seafood contamination

Generally, contaminants are substances that have not been intentionally added to food but that can be present as a result of the various stages of production, packaging, transport or storage or also result from environmental contamination. Some contaminants may represent a safety hazard, defined by the Codex Alimentarius as a biological, chemical or physical agent in a food with the potential to cause an adverse health effect (Codex Alimentarius Commission, 2003). ~~To the best of our knowledges, this is the first study thoroughly evaluating the safety hazard of ethnic food products sold within the EU market.~~ Results obtained for each hazard category, involving biological, chemical and physical contaminants, respectively, are discussed below.

4.2.1 Biological hazard. Enterobacteriaceae, sulphite-reducing bacteria and enterococci include a number of important ~~a number of important foodborne pathogens/opportunistic~~ pathogens ~~that, in addition to their aetiology in foodborne illness~~ (e.g. *Salmonella* spp., *Clostridium perfringens*, *Enterococcus faecalis*) and some bacteria often associated with ~~, are often associated with~~ food spoilage ~~bacteria~~ (e.g. *Serratia* ~~marcescens~~spp., *Clostridium butyricum*, *Enterococcus faecium*) (Moreno, Sarantinopoulos, Tsakalidou, & De Vuyst, 2006; Baylis, Uyttendaele, Joosten, & Davies, 2011; ~~Doyle,~~Hernandez, 2017; Doyle, O'Toole, & Cotter, 2018). In this study, *Enterobacteriaceae* and sulphite-reducing bacteria were found in very low concentrations~~;~~, probably due to the halophile nature of the analysed products~~,~~ incompatible with the growth of these microbial groups.

Enterococci were detected in seventeen CPs (six fish CPs, eight crustaceans CPs and three seaweeds CPs) (see Table 2). The detection of this microbial group in dried and salted seafood has already been reported (Kung et al., 2008; Scano, Rosa, Pisano, Piras, & Cosentino, 2013)~~ and could result from primary and/or secondary contamination~~. Overall, the biological contamination, as involving low micro-organisms concentration and not including the major foodborne pathogens (*Salmonella* spp., *L. monocytogenes* and enteropathogenic *Vibrio* spp.), may be not considered a primary hazard. However, the presence in some samples of halophilic *V~~v~~ibrio*, and especially *V. alginolyticus*, should be empathized because they are recognized as important intestinal and extraintestinal pathogens (Uh et al., 2001). Particularly, *V. alginolyticus* is considered an emerging pathogen carrying virulence genes (trh) and expressing virulence factors such as the thermolabile haemolysin (tlh) (Xie, Hu, Chen, Zhang, & Ren, 2005; Mustapha, Mustapha, & Nozha, 2013). *V. alginolyticus* is commonly associated to wound infections, otitis media, and otitis externa, has been reported as linked to episodes of gastroenteritis, enterocolitis or diarrhoea in humans (Uh et al., 2001; Cao, Liu, Zhang, Chen, & Hu, 2013; Economopoulou et al., 2017). Interestingly, this micro-organism is reported as the dominant *Vibrio* species found both in seawater and in farmed marine animals on the coast of southern China (Xie, Hu, Chen, Zhang, & Ren, 2005). Considering ~~that he high diffusion~~the broad distribution in marine environment and the reported presence ~~the presence of other halophilic *vibrio* ~~in dried seafood from the Far East ~~has been reported ~~(Yang et al., 2008; Xu et al., 2014), halophilic *Vibrio* ~~also~~and especially *V. alginolyticus* can represent, if not appropriately monitored, a hazard linked to consumption of these products.~~However, the presence in some samples of halophilic vibrios, and especially *V. alginolyticus*, just reported in dried seafood from the Far East (Yang et al., 2008; Xu et al., 2014) detected in some samples should be empathized because their presence in dried seafood from the Far East has already been reported (Yang et al., 2008; Xu et al., 2014). Halophilic vibriosas they are recognized as important intestinal and extraintestinal pathogens (Uh et al., 2001). Particularly, *V. alginolyticus* is considered an emerging pathogen carrying virulence genes (*trh*) and expressing virulence factors such as the~~

thermolabile haemolysin (*tlh*) (….). *V. alginolyticus* is commonly associated to wound infections, otitis media, and otitis externa, has been reported as linked to episodes of gastroenteritis, enterocolitis or diarrhoea in humans (Uh et al., 2001; Cao, Liu, Zhang, Chen, & Hu, 2013; Economopoulou et al., 2017). Pathogenicity of this bacterium, linked to its high diffusion in marine environment (Xie, Hu, Chen, Zhang, & Ren, 2005), , although corepresent for consumers a hazard in seafood especially if not appropriately monitored.

mmonly associated to wound infections, otitis media, and otitis externa, has been even reported as linked to episodes of gastroenteritis, enterocolitis or diarrhoea in humans (Uh et al., 2001; Cao, Liu, Zhang, Chen, & Hu, 2013; Economopoulou et al., 2017). The route of infection is the direct contact with contaminated seawater or ingestion of raw seafood, same as that of other *Vibrio* spp. infections (Economopoulou et al., 2017). Interestingly, this micro-organism is reported as the dominant *Vibrio* species found both in seawater and in farmed marine animals on the coast of southern China (Xie, Hu, Chen, Zhang, & Ren, 2005). This aspect, associated to the remarkable specific resistance of *Vibrio* spp. in seafood with low a_w (Yang et al., 2008; Xu et al., 2014) could explain the substantial presence of this pathogen in the sampling of this study. Therefore, the potential health risk that ethnic seafood (especially from Asian origin) may represent for consumers cannot be excluded.

The issue of fungal contamination of dried fishery products should be also pointed out. Moulds are especially considered as important spoilage agents in dried seafood from Asian countries (Wheeler, Hocking, Pitt, & Anggawati, 1986; Park et al., 2014); *Poeciliomyces variotii*, *Eurotium amstelodami* and *Aspergillus* spp. were reported as major contaminants in dried fish from Indonesia and Sri Lanka (Wheeler & Hocking, 1988; Atapattu, & Samarajeewa, 1990). Our study confirmed that moulds are the most common biological contaminants in ethnic dried seafood, indeed they were found in 36.4% of all CPs; *Eurotium amstelodami* and *Aspergillus* spp. were found in the samples characterized by the highest number of moulds. Regarding the moulds of genus *Aspergillus*, the presence of *A. glaucus*, is probably related to technological reasons. Indeed, xerophilic fungi, such as *A. glaucus* and *A. repens*, are commonly used for ripening and fermentation of typical Asian products, e.g. *Katsuobushi* (dried bonito) (Takenaka, Lim, Fukami, Yokota, & Doi,~~Takenaka et al.,~~ 2018). *A. flavus*, instead, can represents a biological hazard for its potential aflatoxigenic activity (Ikutegbe & Sikoki, 2014).

4.2.2 Chemical hazard. Although not all the samples were analysed, outcomes from this study highlighted chemical contamination related to the presence of variable percentages of heavy metals (lead, arsenic, zirconium, tin and rhodium) that are known to possibly toxic for consumers (Reilly, 2008).~~ The significant alterations of industrial development have led to an increased discharge of heavy metals into the marine environment, damaging marine species and whole ecosystem due to their accumulative behaviour (Sivaperumal, Sankar, & Nair, 2007). In particular, coastal areas of China are facing serious problems of heavy metal contamination related to the rapid urbanization and industrialization (Chen, Pan, Huang, & Han, 2018)~~ . ~~The~~ Heavy metal represent a very important issue ~~concern has~~ especially ~~been highlighted~~ in seaweeds, due to their high ~~uptaking~~ capacity to uptake them~~ofto~~ ~~uptake and accumulate metals~~ (Sánchez-Rodrıguez, Huerta-Diaz, Choumiline, Holguın-Quinones, & Zertuche-González, 2001). Indeed, several studies have already underlined ~~this issue~~the presence of high concentration of heavy metals in seaweeds (Rose et al., 2007; ~~Dìiaz~~Díaz et al., 2012; Yokoi & Konomi, 2012; Khan et al., 2015; Chen, Pan, Huang, & Han, ~~Chen et al.,~~ 2018). Reported cases of heavy metals accumulation were in-depth reviewed by Van der Spiegel et al. (2013) and include arsenic, copper, cadmium, chromium, nickel, vanadium, iron, magnesium, mercury, lead, caesium and radium. At European level, a study by Almela, Clemente, Vélez, & Montoro (2006), aimed at assessing the total arsenic, inorganic arsenic, lead and cadmium contents in edible seaweed sold in Spain, found failures to comply with legislated values for all the contaminants.

The arsenic contamination especially represents the major critical point related to these products. In this respect, a scientific opinion by the EFSA (European Food Safety Agency) Panel on Contaminants in the Food Chain (CONTAM) included seaweed within the major worldwide food sources of total arsenic (EFSA, 2009). Factually, the high metals content in wild seaweed~~,~~ seems to still act as restraints for the market (https://www.mordorintelligence.com/industry-reports/commercial-seaweed-market).

Despite the metals amount has not been quantified and therefore it is not possible to compare our data with available limits for heavy metals, ~~This background clearly reflects in~~ the outcomes obtained from the seaweed products analysed in ~~our~~ this study are worrying~~.~~. ~~, although the metals amount has not been quantified.~~ In fact, the percentages of toxic metals found in a large proportion of the samples ~~, which~~ sometimes even ~~exceeded~~ exceed the percentages of the natural elemental components. This~~,~~ might suggest a consumer risk related to metals contamination~~. The~~ ~~observed percentage of the lead, was found as especially high, suggesting the worrying contamination status of the waters where the seaweeds are harvested. In the same way, the presence of arsenic, zirconium, tin and rhodium is unquestionably related to the environment pollution, as all typically originate from activities linked to the industrial manufacturing or intensive farming.~~ ~~Of the whole, our findings, which has been added to the numerous alarming data already available, should~~ and the need ~~focus the attention to the necessity~~ to better monitoring seaweeds products throughout the food chain~~. Basically, it is essential, in order to protect public health, to keep contaminants at levels which are toxicologically acceptable~~. USA, Australia and New Zealand have established specific regulations for toxic elements in edible seaweed (Besada, Andrade, Schultze, & González, 2009; Rubio et al., 2017). At EU level, the Commission Regulations (EC) 1181/2006 setting maximum levels for certain contaminants in foodstuffs and its amendments factually exclude this category with respect to the maximum levels of metals, except for the case of cadmium in food supplements consisting exclusively or mainly of dried seaweed or products derived from seaweed. France was the first European country to set up national regulations on the use of seaweeds for human consumption as non-traditional foods. ~~Currently, 12 macroalgae and 2 microalgae are authorised as vegetables and dressings/flavourings and French limits for edible seaweeds are: lead <5 mg/kg dry~~

~~weight (mg/kg d.w.); cadmium <0.5 mg/kg d.w.; mercury <0.1 mg/kg d.w.; inorganic arsenic <3 mg/kg d.w (Besada et al., 2009).~~

4.2.3 Physical hazard. Physical hazards~~, resulting from the inadvertent inclusion of harmful extraneous materials in the final product,~~ are the most commonly reported consumer complaints because the injury occurs immediately or soon after eating, and the source of the hazard is often easy to identify. The majority of all reported incidents of illness or injury related to physical contaminants involve dental complaints, oral injury or laceration, trauma to the oesophagus, abdomen or other organs of the alimentary canal (Keener, 2001). Most often, they result from an outside source that may include the manufacturing environment, raw materials and ingredients, plant equipment, contractors and employees (Hutchings, 2016). ~~The majority of all reported incidents of illness or injury related to physical contaminants involve dental complaints, oral injury or laceration, trauma to the oesophagus, abdomen or other organs of the alimentary canal (Keener, 2001).~~ Currently, the strategies employed for the control of foreign materials are as wide-ranging as the sources, and often include on-line visual inspection, in-line metal detection, the use of magnets, on-line automated vision systems, X-ray technology, screens, filters and sieves. Such strategies may sometimes represent a considerable cost for the food industries lawfully operating. In this study, the detection of several foreign bodies in most crustaceans CPs and the presence of microscopic shards of glass found in one seaweed sample highlighted the relatively poor observation of the health and hygiene requirements during the product manufacturing, as well as the actual lack of targeted control systems. These results must be added to the numerous issues involving Asian food industry, especially reporting not standardized operating procedures, not calibrated or not objective monitory devices, broken down equipment or ~~not competent person in charge~~anthropogenic factors.

Conclusion

This study led to some discussion points on the risk associated to ethnic seafood products sold on the EU market. Risks concretize in non-compliances with the EU labelling system, as well as in the presence of biological, physical and chemical hazards related to the presence of toxic metals. The survey, as the first conducted on food products purchased within ethnic stores located in Southern Italy (the available literature reported in fact analysis of sampling collected in the central and northern area of the peninsula), also contributed to provide a broader framework of this topic in the Italian context.

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Figures captions:

Fig. 1. Foreign bodies (FBs) found in some CPs by visual inspection. FBs ~~were~~ circled in red were represented by:~~.~~ a) rock; b) paper; c) wood fragment.

Fig. 2. Scanning Electron Microscopy (SEM) performed on CP-4 (Skipjack tuna flakes) highlighting the presence of confluent elongate-shape structures (30x5 µm average length) within the sample.

Fig 3. Scanning Electron Microscopy (SEM) performed on dried fish (a) CP-6 and (b) CP-8 highlighting the presence of numerous fungal hyphae within the samples.

Fig. 4. Scanning Electron Microscopy (SEM) performed on CP-20 (roasted seaweeds) highlighting the presence of triangular structures (~ 30x18 μm) within the sample.

Fig. 5. X-ray microanalysis performed on (a) CP-4 (Skipjack tuna flakes), (b) CP-6 (dried fish) and (c) CP-8 (dried fish). Spots were differently coloured; the percentages of chemical elements found in each spot were reported in descending order in the respective coloured column within the table below the image; toxic elements were highlighted in bold.

Table 1. Ethnic commercial products (CPs) collected in this study. CD: commercial designation (translation in English from Italian that were made in this study are highlighted in bold); SN: species scientific name. NR: not reported; *mistake in the Italian translation.

Category	Sample code	Type of product	Label information			
			English CD	Italian CD	SN	Origin
Fish	CP-1	Dried	Anchovies	Acciughe	*Stolephorus spp*	Thailand
	CP-2		Anchovies	Acciughe	*Stolephorus spp*	Thailand
	CP-3		Anchovy	NR	*Stolephorus spp*	Sri Lanka
	CP-4		Anchovy	Alici	*Stolephorus spp*	Sri Lanka
	CP-5		NR (anchovies)	NR	NR	NR
	CP-6		NR (anchovies)	NR	NR	NR
	CP-7		NR (anchovies)	NR	NR	NR
	CP-8		NR (sardines)	NR	NR	NR
	CP-9		NR (Skipjack tuna slices)	NR	NR	NR
	CP-10		NR (Skipjack tuna slices)	NR	NR	NR
	CP-11		NR (Skipjack tuna slices)	NR	NR	NR
	CP-12		NR (Skipjack tuna slices)	NR	NR	NR
	CP-13		**Skipjack tuna flakes**	Fiocchi di tonnetto striato	*Katsuwonus pelamis*	Sri Lanka
	CP-14		NR (diced amberjack)	NR	NR	NR
	CP-15		NR (diced amberjack)	NR	NR	NR
	CP-16		NR (queen fish)	NR	NR	NR
	CP-17		Katta fish / queen fish	NR	*Scomberoides commersonniaus*	Sri Lanka
	CP-18		Katta fish / queen fish	NR	*Scomberoides commersonniaus*	Sri Lanka
	CP-19		Katta fish / queen fish fillets	Pesce secco	*Scomberoides commersonniaus*	Sri Lanka
	CP-20		NR ~~(Fish)~~	NR	NR	NR
	CP-21		NR ~~(Fish)~~	NR	NR	NR
	CP-22		NR ~~(Fish)~~	NR	NR	Sri Lanka
	CP-23		NR ~~(Fish)~~	NR	NR	NR
	CP-24	~~Smoked and~~Dried and smoked ~~dDried /Smoked~~	Bonito flakes	Fiocchi di tonnetto striato	*Katsuwonus pelamis*	Spain
	CP-25		Catfish	Pesce Gatto	*Clarias spp.*	Thailand
	CP-26		Giant Catfish	Pesce Gatto gigante	*Arius thalassinus*	Thailand
Crustaceans	CP-27	Dried	Crayfish	NR	NR	Thailand
	CP-28		NR (shrimp)	NR	NR	NR
	CP-29		NR (shrimp)	NR	NR	NR
	CP-30		NR (shrimp)	NR	NR	NR

	CP-31		NR (shrimp)	NR	NR	NR
	CP-32		NR (shrimp)	NR	NR	NR
	CP-33		NR (shrimp)	NR	NR	NR
	CP-34		NR (shrimp)	NR	NR	NR
	CP-35		NR (shrimp)	NR	NR	NR
	CP-36		NR (shrimp)	NR	NR	NR
	CP-37		NR (shrimp)	NR	NR	NR
	CP-38		NR (shrimp)	NR	NR	NR
	CP-39		NR (shrimp)	NR	NR	NR
	CP-40		NR (shrimp)	NR	NR	NR
	CP-41		NR (shrimp)	NR	NR	NR
	CP-42		NR (shrimp)	NR	NR	NR
	CP-43		NR (shrimp)	NR	NR	NR
	CP-44		NR (shrimp)	NR	NR	NR
	CP-45		NR (shrimp)	NR	NR	NR
	CP-46		NR (shrimp)	NR	NR	NR
	CP-47		NR (shrimp)	NR	NR	NR
	CP-48		NR (shrimp)	NR	NR	NR
	CP-49		NR (shrimp)	NR	NR	NR
	CP-50		NR (shrimp)	NR	NR	NR
	CP-51	~~Smoked and dried~~Dried and smoked	**Giant prawn**	Gambero grosso*	NR	Thailand
Seaweeds	CP-52	Dried	**Laminaria ("Kombu") seaweed**	Alga Laminaria ("Kombu")	NR	China
	CP-53		**"Kombu" seaweed**	Alghe "Kombu"	*Laminariaceae longissima*	Japan
	CP-54		**"Kombu" seaweed**	Alghe "Kombu"	*Laminariaceae longissima*	Japan
	CP-55		"Wakame" **seaweeds**	Alghe "Wakame"	NR	China
	CP-56		"Wakame" **seaweeds**	Alghe "Wakame"	*Undaria pinnatifida*	China
	CP-57		"Arame" **seaweeds**	Alghe "Arame"	*Eisenia bicyclis*	Japan
	CP-58		"Arame" **seaweeds**	Alghe "Arame" (alghe brune giapponesi)	*Eisenia bicyclis*	Germany
	CP-59		"Nori" **seaweeds**	Fiocchi di Nori (alghe verdi giapponesi)	*Pulva pertusa*	Germany
	CP-60		"Nori" seaweeds	Alghe secche	NR	Korea
	CP-61		"Nori" seaweeds	NR	NR	Korea
	CP-62		**Seaweeds**	Alche*	NR	Korea
	CP-63		**Green seaweed (agar agar)**	Alga verde agar agar	NR	Philippines
	CP-64	~~Roasted and dried~~Dried and roasted	**"Nori" seaweeds**	Alghe "Nori"	NR	China
	CP-65		**"Nori" seaweeds**	Alghe "Nori"	NR	China

	CP-66		**“Nori” seaweeds**	Alghe “Nori”	*Porphyra tenera*	Korea
	CP-67		**“Nori” seaweeds**	Alghe “Nori”	NR	China
	CP-68		**“Nori” seaweeds**	Alghe “Nori”	NR	China
	CP-69		**“Nori” seaweeds**	Alghe “Nori”	NR	China
	CP-70		**“Nori” seaweeds**	Alghe “Nori”	NR	China
	CP-71		**“Nori” seaweeds**	Alghe “Nori” (alghe rosse giapponesi)	*Porphyra tenera*	Germany
	CP-72		“Nori” seaweeds	Alghe verdi giapponesi	*Porphyra yezoensis*	China
	CP-73		“Nori” seaweeds	Alga marina	NR	Korea
	CP-74		Nori” seaweeds	Alga oro	*Porphyra yezoensis*	China
	CP-75		“Nori” seaweeds	Alghe “Nori”	NR	China
	CP-76		“Nori” seaweeds	Alghe “Nori”	*Porphyra tenara*	Korea
	CP-77		Seaweed salad	Insalata di alghe	NR	Korea

Table 2. Evaluation of the CPs label compliance with EU legislation. Only the labelled CPs were listed. Compliant labels were highlighted in grey boxes. CD: commercial designation; NM: not mandatory info for this category

Category	Sample code	Reg. 1169/2011						Reg. 1379/2013				
		Italian CD	**ingredient list**	**net quantity**	**minimum durability**	**nutritional declaration**	**allergies declaration**	**Italian CD**	**Scientific name**	**production method**	**catching area**	**fishing gear**
Fish	CP-1	√	√	√	√	√	-	√	√	√	√	-
	CP-2	√	√	√	√	√	-	√	√	√	√	-
	CP-3	-	√	√	√	√	√	-	√	-	-	-
	CP-4	√	√	√	√	√	√	√	√	√	√	-
	CP-13	√	√	√	√	√	√	√	√	√	√	-
	CP-17	-	√	√	√	√	√	-	√	√	√	-
	CP-18	-	√	√	√	√	√	-	√	√	√	-
	CP-19	√	√	√	√	√	√	√	√	√	√	-
	CP-22	-	-	-	√	-	-	-	-	-	-	-
	CP-24	√	√	√	√	√	√	√	√	√	√	√
	CP-25	√	√	√	√	-	√	√	√	√	√	-
	CP-26	√	√	√	√	-	√	√	√	√	√	-
Crustaceans	CP-27	-	-	√	√	-	-	√	-	-	-	-
	CP-51	√	-	√	√	-	-	√	-	-	-	-
Seaweeds	CP-52	√	√	√	√	√	NM	√	-	-	-	-
	CP-53	√	√	√	√	√	NM	√	√	-	-	-
	CP-54	√	√	√	√	√	NM	√	√	-	-	-
	CP-55	√	√	√	√	√	NM	√	-	-	-	-
	CP-56	√	√	√	√	√	NM	√	√	√	√	√
	CP-57	√	√	√	√	√	NM	√	√	-	-	-
	CP-58	√	√	√	√	√	NM	√	√	-	-	-
	CP-59	√	√	√	√	√	NM	√	√	-	-	-
	CP-60	√	√	√	√	√	NM	√	-	√	√	√
	CP-61	√	√	√	√	√	NM	√	-	√	√	√
	CP-62	√	√	√	√	√	NM	√	-	-	-	-
	CP-63	√	√	√	√	√	NM	√	-	-	-	-
	CP-64	√	√	√	√	√	NM	√	-	-	-	-
	CP-65	√	√	√	√	√	NM	√	-	-	-	-
	CP-66	√	√	√	√	√	NM	√	√	√	√	-

CP-67	√	√	√	√	√	NM	√	-	√	√	√
CP-68	√	√	√	√	√	NM	√	-	√	√	√
CP-69	√	√	√	√	√	NM	√	-	√	√	√
CP-70	√	√	√	√	√	NM	√	-	√	√	√
CP-71	√	√	√	√	√	NM	√	√	-	-	-
CP-72	√	√	√	√	√	NM	√	√	-	-	-
CP-73	√	√	√	√	√	NM	√	-	-	-	-
CP-74	√	√	√	√	√	NM	√	√	-	-	-
CP-75	√	√	√	√	√	NM	√	-	√	√	√
CP-76	√	√	√	√	√	NM	√	√	√	√	√
CP-77	√	√	√	√	√	NM	√	-	√	-	-

Table 3. ~~Bacteriological and mycological characterization~~Microbiological analysis of positive CPs. EB: *Enterobacteriaceae* count~~ (LOQ 10 CFU/g)~~; SR: sulphite-reducing bacteria count~~ (LOQ 10 CFU/g)~~; YE: yeast count~~ (LOQ 100 CFU/g)~~; MO: mould count~~ (LOQ 100 CFU/g)~~; EC: enterococci count~~ (LOQ 100 CFU/g)~~; VHd: other halophilic *Vibrio* spp. detection.

		Count (l~~L~~og CFU/g)					Detection (+/-)
Category	**Sample code**	**EB**	**SR**	**YE**	**MO**	**EC**	**VHd**
Fish	CP-3	-	-	-	-	-	+
	CP-9	-	-	~~1~~6.00~~0 x 10^6~~	~~2~~4.34~~2 x 10^4~~	~~4~~3.64~~ x 10^3~~	-
	CP-10	-	-	5~~2~~.40~~5 x 10^5~~	4~~7~~.88~~6 x 10^4~~	~~1~~3.26~~8 x 10^3~~	-
	CP-11	-	-	-	4~~3~~.59~~ x 10^4~~	~~5~~3.70~~ x 10^3~~	-
	CP-12	-	-	-	4.65~~ x 10^4~~	~~1~~5.26~~8 x 10^5~~	-
	CP-14	-	-	-	-	~~3~~2.48~~0 x 10^2~~	-
	CP-16	-	-	-	2~~1~~.00~~ x 10^2~~	-	-
	CP-20	-	1.00	-	3~~8~~.93~~5 x 10^3~~	-	-
	CP-21	-	-	-	~~6~~2.78~~0 x 10^2~~	-	-
	CP-22	-	-	-	4~~1~~.01~~ x 10^4~~	-	-
	CP-23	-	~~40~~1.60	-	-	~~4~~3.65~~ x 10^3~~	-
	CP-26	-	-	-	-	-	+
Crustaceans	CP-27	-	-	-	-	-	+
	CP-28	-	-	-	2.30~~ x 10^2~~	~~2~~5.~~5 ~~40~~x 10^5~~	-
	CP-29	-	-	-	-	~~2~~5.44~~7 x 10^5~~	-
	CP-30	-	-	-	-	~~2~~5.30~~ x 10^5~~	-
	CP-31	1.00~~0~~	-	-	2.30~~ x 10^2~~	5~~1~~.~~5 ~~18~~x 10^5~~	-
	CP-32	-	-	~~3~~2.48~~0 x 10^2~~	2~~3~~.48~~0 x 10^2~~	-	-
	CP-33	-	-	-	3~~1~~.04~~1 x 10^3~~	-	-
	CP-34	-	-	-	~~1~~2.00~~ x 10^2~~	2~~1~~.00~~ x 10^2~~	-
	CP-35	-	-	-	2.30~~ x 10^2~~	-	-
	CP-37	-	-	-	2~~3~~.48~~0 x 10^2~~	-	-
	CP-38	-	-	-	2.30~~ x 10^2~~	-	-
	CP-39	-	-	-	2~~1~~.00~~ x 10^2~~	~~1~~2.00~~ x 10^2~~	-
	CP-40	-	-	-	-	~~1~~2.00~~ x 10^2~~	-
	CP-41	-	-	-	2.30~~ x 10^2~~	-	-
	CP-42	-	-	-	2.30~~ x 10^2~~	5~~2~~.32~~1 x 10^5~~	-
	CP-43	-	-	4.03~~1.1 x 10^4~~	~~4~~2.60~~ x 10^2~~	-	-
	CP-44	-	-	-	2.70~~5.0 x 10^2~~	-	-
	CP-45	-	-	-	2.30~~ x 10^2~~	-	-
	CP-46	-	-	2~~3~~.48~~0 x 10^2~~	2.30~~ x 10^2~~	-	-
	CP-47	-	-	-	2~~3~~.48~~0 x 10^2~~	-	-
	CP-48	-	-	2~~3~~.48~~0 x 10^2~~	2.30~~ x 10^2~~	-	-

	CP-51	-	-	-	-	-	+
Seaweeds	CP-52	1.1 x $10^2$2.06	-	-	-	32.480 x 10^2	+
	CP-54	-	-	-	21.00 x 10^2	-	-
	CP-58	1.7 x $10^2$2.23	-	-	-	-	-
	CP-62	-	-	-	24.60 x 10^2	-	-
	CP-63	1.1 x $10^2$2.04	21.415 x 10^2	-	-	12.185 x 10^2	+
	CP-64	24.66 x 10^2	-	-	-	-	-
	CP-66	-	-	-	2.30 x 10^2	-	-
	CP-67	-	-	-	-	2.30 x 10^2	-

Table 4. Foreign bodies found during visual inspection and SEM/ X-ray microanalysis observation

Sample code	Category	*n*	Type
Visual inspection			
CP-28	Crustaceans	2	fish
CP-30	Crustaceans	1	fish
CP-34	Crustaceans	5	crab fragment; fish (2); paper; rock
CP-35	Crustaceans	6	crab (2); fish fragment; fish (2); rock
CP-36	Crustaceans	5	crab fragment; fish (4)
CP-37	Crustaceans	5	crab fragment (2); fish (2); fish fragment
CP-38	Crustaceans	5	crab fragment; fish (3); rock
CP-39	Crustaceans	5	fish
CP-40	Crustaceans	3	fish (2); squid
CP-41	Crustaceans	3	fish
CP-43	Crustaceans	2	fish; wood fragment
CP-45	Crustaceans	1	fish
CP-46	Crustaceans	1	fish
SEM and X-ray microanalysis			
Sample code	**Category**	***n***	**Type**
CP-65	Seaweeds	3	glass shard

Fig. 1

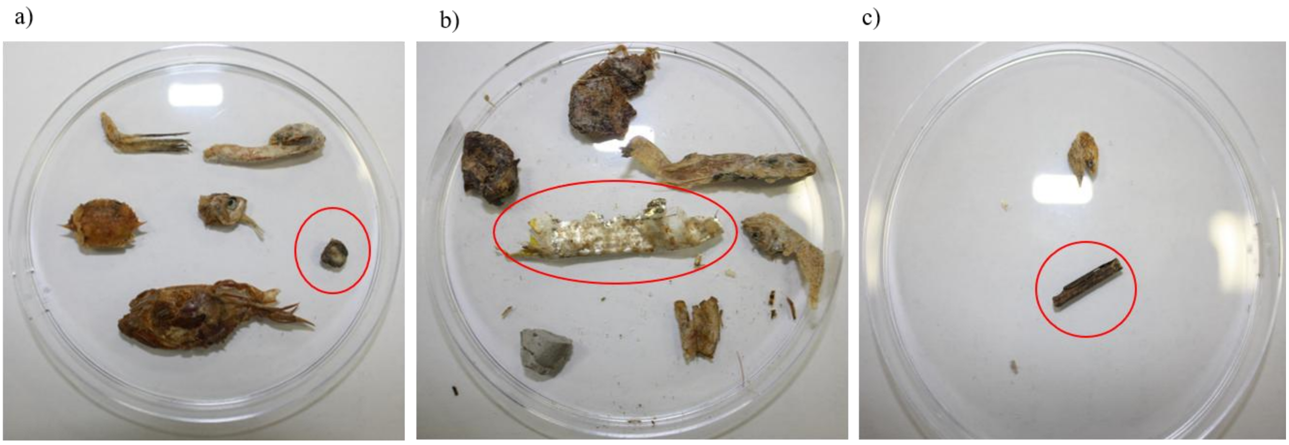


Fig. 2

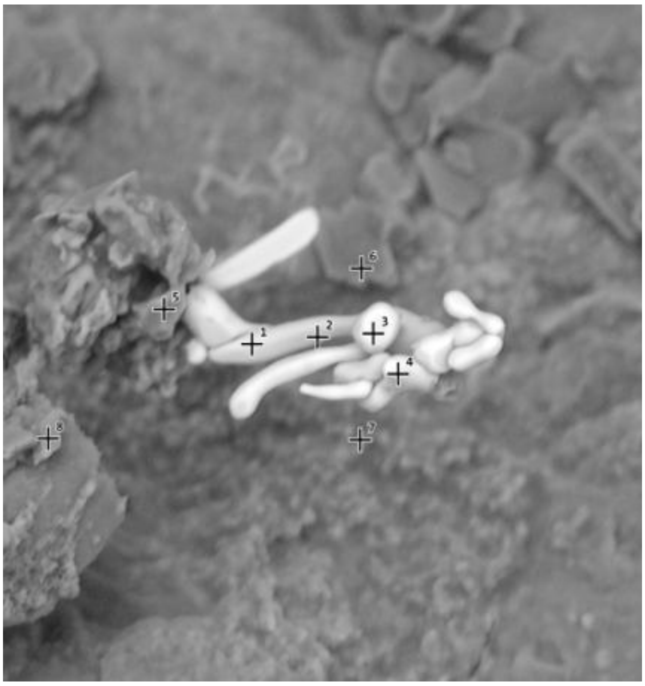


Fig. 3

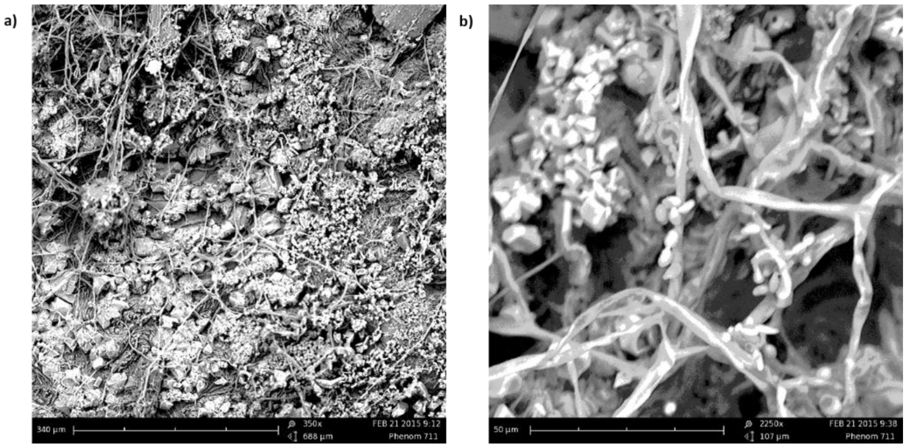

a)
b)
340 µm
350x
FEB 21 2015 9:12
688 µm
Phenom 711
50 µm
2250x
FEB 21 2015 9:38
107 µm
Phenom 711

Fig. 4

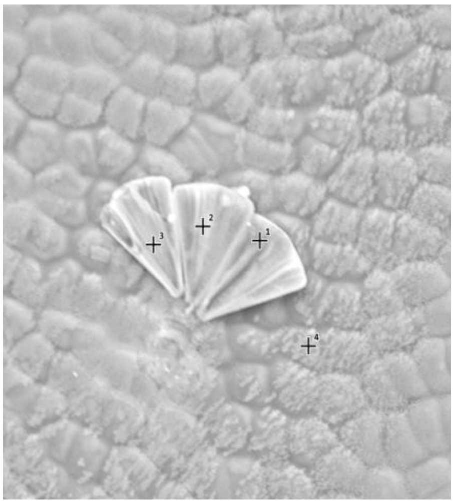
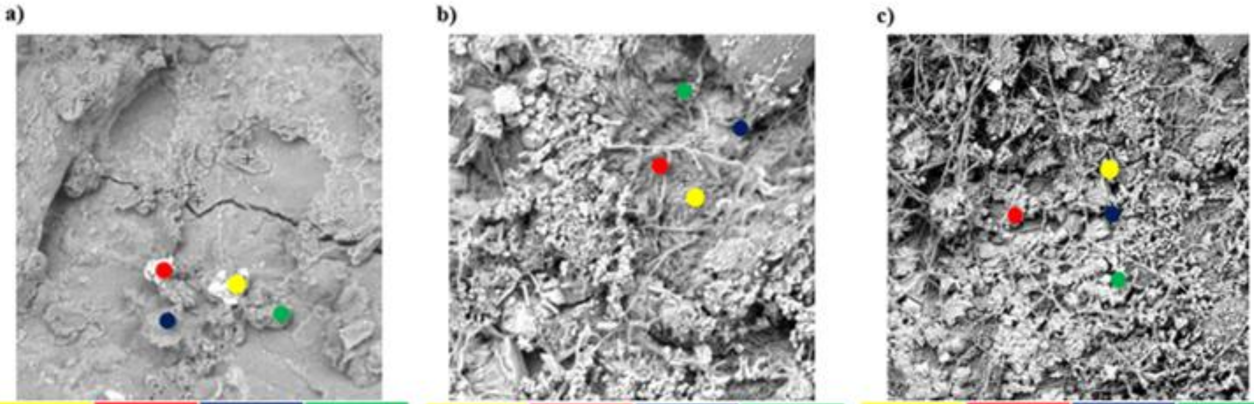


Fig. 5

a) b) c)



a)

O 49.7%	O 51.4%	O 50.9%	O 54.5%
Na 20.3%	Na 15.6%	C 19%	N 11.4%
C 12.6%	C 15%	N 12.4%	Na 10.5%
N 12.6%	N 13.5%	Na 12%	C 9.4%
Rh 3.6%	**Zr 2.5%**	**Zr 2.5%**	Cl 4.2%
Cl 3.2%	Cl 2.2%	**Rh 1.6%**	**Zr 3.5%**
Zr 2%		Cl 1.5%	**Pb 2.8%**
			Mg 2.8%
			K 0.9%

b)

O 58.1%	O 60%	O 71.1%	O 56.2%
N 23.8%	N 25.4%	**As 9%**	**As 17.1%**
C 9.5%	C 9.6%	C 8.5%	N 11.2%
Mg 2.2%	**As 2.7%**	**Zr 7.9%**	P 10%
Zr 2.1%	**Zr 1.6%**	K 1.7%	C 4.5%
Na 1.5%	K 0.4%	P 0.9%	K 1.1%
P 1.5%	Cl 0.3%	Cl 0.8%	
Cl 0.8%			
K 0.5%			

c)

O 58.7%	O 56.4%	O 47%	O 62.1%
Zr 13.2%	N 25%	N 20.1%	N 20.1%
N 12%	C 10%	**Zr 7.9%**	C 9.4%
As 7.2%	Mg 2.4%	**As 6.5%**	**As 4.3%**
C 5.5%	**Zr 2.3%**	C 5.5%	**Zr 2.2%**
K 1.2%	Na 1.7%	K 1.7%	P 0.7%
Cl 1%	P 1.6%	P 1.6%	Cl 0.6%
Na 1%	K 0.6%	Na 1%	K 0.6%
		Cl 0.8%	

***Highlights (for review)**

In this study, seafood products purchased in Southern Italy from ethnic food stores were analysed

The percentage of products non-compliant EU labelling requirements was high (96%)

Biological, chemical and physical contamination were found in some products

The major risk for consumer was the chemical contamination by variable percentages of toxic metals

***Conflict of Interest Form**

Dear Editor,

The manuscript has not been published elsewhere nor is it being considered for publication elsewhere.

All authors have approved this manuscript, agree to the order in which their names are listed.

Finally, the authors declare that no conflict of interests exists and disclose any commercial affiliation.

Andrea Armani on behalf of all authors.

Table 1SM. Outcomes of CPs positive for the ~~bacteriological and mycological characterization~~microbiological analysis. EB: *Enterobacteriaceae* count; ~~(LOQ 10 CFU/g);~~ SR: sulphite-reducing bacteria count; ~~(LOQ 10 CFU/g);~~ VCc: *Vibrio cholerae* count; ~~(LOQ 10 CFU/g);~~ VHPc: enteropathogenic halophilic *Vibrio* spp. count (*Vibrio parahaemolyticus* or *Vibrio vulnificus*); ~~(LOQ 10 CFU/g);~~ VHc: other halophilic *Vibrio* spp. c~~C~~ount; ~~(LOQ 10 CFU/g);~~ YE: yeast count ~~(LOQ 100 CFU/g);~~ ; MO: mould count; ~~(LOQ 100 CFU/g);~~ EC: enterococci count; ~~(LOQ 100 CFU/g);~~ SAL: *Salmonella* spp. detection; LMO: *Listeria monocytogenes* detection; VCd: *Vibrio cholerae* detection; VHPd: enteropathogenic halophilic *Vibrio* spp. detection (*Vibrio parahaemolyticus* or *Vibrio vulnificus*); VHd: other halophilic *Vibrio* spp. detection.

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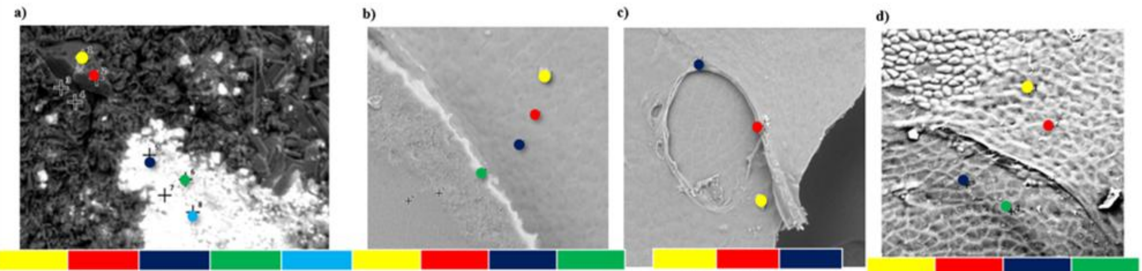
		Count (log CFU/g)								Detection (+/-)				
Category	**Sample code**	**EB**	**SR**	**VCc**	**VHPc**	**VHc**	**YE**	**MO**	**EC**	**SAL**	**LMO**	**VCd**	**VHPd**	**VHd**
Fish	CP-3	-	-	-	-	-	-	-	-	-	-	-	-	+
	CP-9	-	-	-	-	-	~~1.0 x 10^6~~6.00	~~2.2 x 10^4~~4.34	~~4.4 x 10^3~~3.64	-	-	-	-	-
	CP-10	-	-	-	-	-	~~2.5 x 10^5~~5.40	~~7.6 x 10^4~~4.88	~~1.8 x 10^3~~3.26	-	-	-	-	-
	CP-11	-	-	-	-	-	-	~~3.9 x 10^4~~4.59	~~5.0 x 10^3~~3.70	-	-	-	-	-
	CP-12	-	-	-	-	-	-	~~4.5 x 10^4~~4.65	~~1.8 x 10^5~~5.26	-	-	-	-	-
	CP-14	-	-	-	-	-	-	-	~~3.0 x 10^2~~2.48	-	-	-	-	-
	CP-16	-	-	-	-	-	-	~~1.0 x 10^2~~2.00	-	-	-	-	-	-
	CP-20	-	1.00~~0~~	-	-	-	-	~~8.5 x 10^3~~3.93	-	-	-	-	-	-
	CP-21	-	-	-	-	-	-	~~6.0 x 10^2~~2.78	-	-	-	-	-	-
	CP-22	-	-	-	-	-	-	~~1.1 x 10^4~~4.01	-	-	-	-	-	-
	CP-23	-	~~40~~1.60	-	-	-	-	-	~~4.5 x 10^3~~3.65	-	-	-	-	-
	CP-26	-	-	-	-	-	-	-	-	-	-	-	-	+
Crustaceans	CP-27	-	-	-	-	-	-	-	-	-	-	-	-	+
	CP-28	-	-	-	-	-	-	~~2.0 x 10^2~~2.30	~~2.5 x 10^5~~5.40	-	-	-	-	-
	CP-29	-	-	-	-	-	-	-	~~2.7 x 10^5~~5.44	-	-	-	-	-
	CP-30	-	-	-	-	-	-	-	~~2.0 x 10^5~~5.30	-	-	-	-	-
	CP-31	1.00~~0~~	-	-	-	-	-	~~2.0 x 10^2~~2.30	~~1.5 x 10^5~~5.18	-	-	-	-	-
	CP-32	-	-	-	-	-	~~3.0 x 10^2~~2.48	~~3.0 x 10^2~~2.48	-	-	-	-	-	-
	CP-33	-	-	-	-	-	-	~~1.1 x~~	-	-	-	-	-	-

								~~10^2~~3.04						
	CP-34	-	-	-	-	-	-	~~1.0 x 10^2~~2.00	~~1.0 x 10^2~~2.00	-	-	-	-	-
	CP-35	-	-	-	-	-	-	2.~~0 x 10^2~~30	-	-	-	-	-	-
	CP-37	-	-	-	-	-	-	~~3.0 x 10^2~~2.48	-	-	-	-	-	-
	CP-38	-	-	-	-	-	-	2.~~0 x 10^2~~30	-	-	-	-	-	-
	CP-39	-	-	-	-	-	-	~~1.0 x 10^2~~2.00	~~1.0 x 10^2~~2.00	-	-	-	-	-
	CP-40	-	-	-	-	-	-	-	~~1.0 x 10^2~~2.00	-	-	-	-	-
	CP-41	-	-	-	-	-	-	2.~~0 x 10^2~~30	-	-	-	-	-	-
	CP-42	-	-	-	-	-	-	2.~~0 x 10^2~~30	~~2.1 x 10^5~~5.32	-	-	-	-	-
	CP-43	-	-	-	-	-	~~1.1 x 10^4~~4.03	~~4.0 x 10^2~~2.60	-	-	-	-	-	-
	CP-44	-	-	-	-	-	-	~~5.0 x 10^2~~2.70	-	-	-	-	-	-
	CP-45	-	-	-	-	-	-	2.~~0 x 10^2~~30	-	-	-	-	-	-
	CP-46	-	-	-	-	-	~~3.0 x 10^2~~2.48	2.~~0 x 10^2~~30	-	-	-	-	-	-
	CP-47	-	-	-	-	-	-	~~3.0 x 10^2~~2.48	-	-	-	-	-	-
	CP-48	-	-	-	-	-	~~3.0 x 10^2~~2.48	2.~~0 x 10^2~~30	-	-	-	-	-	-
	CP-51	-	-	-	-	-	-	-	-	-	-	-	-	+
Seaweeds	CP-52	~~1.1 x 10^2~~2.06	-	-	-	-	-	-	~~3.0 x 10^2~~2.48	-	-	-	-	+
	CP-54	-	-	-	-	-	-	2.00~~1.0 x 10^2~~	-	-	-	-	-	-
	CP-58	~~1.7 x 10^2~~2.23	-	-	-	-	-	-	-	-	-	-	-	-
	CP-62	-	-	-	-	-	-	~~4.0 x 10^2~~2.60	-	-	-	-	-	-
	CP-63	~~1.1 x 10^2~~2.04	~~1.4 x 10^2~~2.15	-	-	-	-	-	~~1.5 x 10^2~~2.18	-	-	-	-	+
	CP-64	~~4.6 x 10^2~~2.66	-	-	-	-	-	-	-	-	-	-	-	-
	CP-66	-	-	-	-	-	-	2.~~0 x 10^2~~30	-	-	-	-	-	-
	CP-67	-	-	-	-	-	-	-	2.~~0 x 10^2~~30	-	-	-	-	-

Table 2SM. List of CPs analysed with SEM

Category	Sample code	Type of product	Label information			
			English CD	**Italian CD**	**SN**	**Origin**
Fish	CP-1	Dried	Anchovies	Acciughe	*Stolephorus spp*	Thailand
	CP-2		Anchovies	Acciughe	*Stolephorus spp*	Thailand
	CP-3		Anchovy	NR	*Stolephorus spp*	Sri Lanka
	CP-13		**Skipjack tuna flakes**	Fiocchi di tonnetto striato	*Katsuwonus pelamis*	Sri Lanka
	CP-16		NR (queen fish)	NR	NR	NR
	CP-20		NR (Fish)	NR	NR	NR
	CP-21		NR (Fish)	NR	NR	NR
	CP-22		NR (Fish)	NR	NR	Sri Lanka
	CP-23		NR (Fish)	NR	NR	NR
	CP-25		Catfish	Pesce Gatto	*Clarias spp.*	Thailand
	CP-26		Giant Catfish	Pesce Gatto gigante	*Arius thalassinus*	Thailand
Crustaceans	CP-27	Dried	Crayfish	NR	NR	Thailand
	CP-50		NR (shrimp)	NR	NR	NR
	CP-51	Smoked	**Giant prawn**	Gambero grosso*	NR	Thailand
Seaweeds	CP-52	Dried	**Laminaria (“Kombu”) seaweed**	Alga Laminaria (“Kombu”)	NR	China
	CP-55		“Wakame” **seaweeds**	Alghe “Wakame”	NR	China
	CP-62		**Seaweeds**	Alche*	NR	Korea
	CP-63		**Green seaweed (agar agar)**	Alga verde agar agar	NR	Philippines
	CP-64	Roasted	**“Nori” seaweeds**	Alghe “Nori”	NR	China
	CP-65		**“Nori” seaweeds**	Alghe “Nori”	NR	China
	CP-66		**“Nori” seaweeds**	Alghe “Nori”	*Porphyra tenera*	Korea

Fig. 1SM. X-ray microanalysis performed on seaweeds CPs: (a) CP-15; (b) CP-19; (c) CP-20; (d) C-21. Spots were differently coloured; the percentages of chemical elements found in each spot were reported in descending order in the respective coloured column within the table below the image; toxic elements were highlighted in bold.



a)

O 67.8%	O 70.1%	**Rh 41.1%**	**Rh 41.7%**	**Rh 45.3%**
N 10.8%	N 12%	**Sn 34.5%**	**Sn 38.7%**	**Sn 26.9%**
C 8.7%	C 10.8%	O 18.7%	O 13.5%	O 21.7%
Sn 6.5%	**Sn 3.7%**	K 3.5%	K 4.1%	N 3.1%
Rh 6.2%	**Rh 3.5%**	N 1.9%	N 1.4%	K 2.6%
		C 0.3%	C 0.2%	C 0.4%

b)

O 55.1%	O 47.8%	O 52.1%	O 52.6%
C 10.9%	**Pb 14%**	**Pb 13.2%**	Na 12.3%
Pb 8.8%	Na10.6%	Na 9.1%	**Pb 10.7%**
Na 8.5%	N 8.3%	N 8.5%	K 9.1%
K 4.9%	C 7.4%	C 7.4%	C 8%
As 3.9%	**As 4.1%**	Cl 2.8%	**As 3.8%**
Zr 3%	Cl 3%	K 2.7%	Cl 2.8%
Cl 2.9%	K 2.8%	**Zr 2.1%**	K 1.4%
S 2%	**Zr 2%**	Mg 2.1%	Ca 0.5%

c)

O 65.7%	O 61.9%	O 58.2%
Pb 9.6%	**Pb 11%**	C 14.6%
C 8.3%	C 7.6%	Na 9.8%
Na 6.1%	Na 5.8%	K 7.7%
K 3.8%	K 5.7%	**Pb 6.5%**
S 2.2%	Cl 2.5%	Cl 1.5%
Cl 1.9%	S 2.3%	S 1.3%
Ca 1.5%	Ca 1.6%	Ca 0.4%
P 1%	P 1.5%	

d)

O 49.7%	O 43.7%	O 45.4%	O 53.2%
Pb 17.8%	Na 20%	Na 18.5%	**Pb 15.4%**
C l 17.5%	**Pb 11.5%**	**Pb 10.2%**	Cl 12.5%
C 8.5%	C 7.6%	C 7.6%	C 6.5%
K 3.7%	Cl 6.8%	**As 6.7%**	K 4.7%
Ca 2.9%	**As 5.7%**	Cl 5.5%	Ca 3.9%
	S 2.4%	S 3.4%	S 2.1%
	K 1.6%	K 1.8%	**As 1.7%**
	Ca 0.6%	Ca 0.9%	