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Effect of cooking on total mercury content in Norway lobster and European hake and public health impact

Monia Perugini [a,*], Daniela Zezza [a], Serena Maria Rita Tulini [a], Maria Cesarina Abete [b], Gabriella Monaco [b], Annamaria Conte [c], Vincenzo Olivieri [d], Michele Amorena [a]

[a] Facoltà di Bioscienze e Tecnologie Agro-alimentari e Ambientali, Teramo University, Località Piano d'Accio, 64100 Teramo, Italy
[b] C.Re.A.A., National Reference Centre for Surveillance and Monitoring Animal Feed, Via Bologna 148, 10154 Torino, Italy
[c] Istituto Zooprofilattico Sperimentale "G. Caporale", Via Campo Boario, 64100 Teramo, Italy
[d] Executive Veterinary A.S.L. Pescara, 65100 Pescara, Italy

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ABSTRACT

The risk of Hg poisoning by eating seafood is considered real from the several international agencies that recommended, by fish consumption advisories, to pregnant women and young children to avoid or severely limit the consumption of the fish and shellfish with a high-range mercury levels. The analyses of two common species, European hake and Norway lobster, collected from an area of Central Adriatic Sea, reported high mercury levels in crustaceans. For Norway lobster total mercury exceeded, in six out of ten analysed pools, the recommended 0.5 mg/kg wet weight European limit. Moreover the increased amount of Hg concentrations in Norway lobster cooked samples suggests the necessity to review current procedures of Hg control in food, considering also consumption habits of consumers. The Hg values found in all European hake samples are below the legal limits and, in this species, the boiling did not modify the concentrations in fish tissues.

1. Introduction

Lifestyle and particularly diet play a crucial role in personal exposure to environmental chemicals. For example, the consumption of fish and shellfish represents for humans the major pathway of exposure to mercury (Hg) and its organic and most toxic form, methylmercury (MeHg) (Liu et al., 2014). Mercury is a ubiquitous heavy metal, naturally present in the environment, but its accumulation is highly influenced by human activities.

In the environment Hg is submitted to a various transformations and in the aquatic system, Hg partition into the sediments is regulated by different factors through the activity of iron-reducing bacteria and sulfate-reducing bacteria that are mainly responsible for its methylation. Fish and shellfish could be exposed to Hg and MeHg through water column, sediment and diet. Toxicological studies have demonstrated that MeHg is the most toxic and the major chemical form of mercury in fish muscle (80–90% of the total Hg) (Blum et al., 2013) and in crustaceans (85% of MeHg in red shrimp muscle tissue) (Minganti et al., 1996). This is a neurotoxic agent that affects the development of the nervous system, resulting in psychological disturbance, impaired hearing, loss of sight, ataxia, loss of motor control and general debilitation. Childhood exposure to MeHg gives permanent harmful effects on the cognitive development. A study conducted in Spain using hair of preschoolers has shown that children with a higher daily fish intake were associated with cognitive development delay (Freire et al., 2010). Hazards of MeHg are often exacerbated by bioaccumulation and biomagnification via food webs in aquatic systems (Kidd et al., 2012) also if the correlations among exposure, animal size and tissue concentrations are still unclear (Tong et al., 2012).

Perugini et al., (2009, 2013, 2014) described the presence of Hg in the Central Adriatic Sea species, showing the highest levels in crustaceans for which the white meat is the most Hg-contaminated portion. It is well documented that this contamination could came from natural sources, as the presence of natural cinnabar (HgS) deposits (Northern Adriatic Sea), but the anthropogenic pollution, derived from pollutant transported by rivers and industrial complexes clustered along the coast, should be important, especially in Adriatic Sea. Indeed contaminant distribution is mainly determined by the surface circulation pattern, that in Adriatic Sea is cyclonic, with a flow toward south east along the western side (Italian coast) and toward the northwest along the eastern side (Croatian coast) (Covelli et al., 2009).

The purpose of this study is to evaluate the variability of total Hg concentrations in two marine species originated from a polluted area and, if the cooking process, that alter nutritional values of food, can also affect the solubility and bioaccessibility of Hg, considering that this could influence the intake of consumers that have different preferences and consumption habits.

* Corresponding author.
E-mail address: mperugini@unite.it (M. Perugini).

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Indeed the variability of Hg concentrations after different culinary treatment in fish and shellfish is still an evidence that generate different results and many controversies as reported to the recent studies (Ouédraogo and Amyot, 2011; Costa et al., 2016).

2. Materials and methods

2.1. Sampling

The investigated marine species were European hake (*Merluccius merluccius*, L. 1758) and Norway lobster (*Nephrops norvegicus*, L. 1758) because, in our previous studies (Perugini et al., 2009, 2013, 2014), these species showed high Hg concentrations. The fishing area, near Jabuka Pit, (Fig. 1) represents the most important nursery site in the Adriatic Sea for these two demersal species (Morello et al., 2009) but at the same time it receives important amounts of material mainly supplied by rivers, and in terms of pollution, the water quality is largely influenced by the human activities.

The same fishing area was previously investigated by Perugini et al. (2013) and resulted of particular interest for the heavy metals present in marine biota. All samples were of medium commercial size. The size of Norway lobster was measured as the total length (11–13 cm), from the tip of the rostrum to the rear end of the telson, not including the setae, while those (26–31 cm) of hake from the tip of the snout to the tip of the longer lobe of the caudal fin. Following immediate transport to the laboratory and recording the biometric data, all samples were washed several times with distilled water to remove debris. Norway lobster raw white meat from the abdomen (excluding its chitinous outer shell) and the dorsal muscle tissue of hake (excluding skin) were the portions used for the total Hg determination. To asses Hg concentrations in Norway lobster we decided to analyse only white meat, being the most contaminated portion (Perugini et al., 2013) and because is the part used for official controls to evaluate the respect of European limit (EC., 2006). Stainless tools were used to remove the skin and homogenize fish tissues. Total Hg was determined in ten pooled samples, consisting of 10 individuals per pool. All samples were immediately frozen and stored at −20 °C before the analyses. Hg contents were measured before and after boiling.

2.2. Cooking process

Boiling was performed in an analytical glass (Duran) saucepot filled with ultrapure water. Samples were dipped into boiling water for 15 min at 80 °C. The weight/weight ratios of water:fish were 1. In order to exclude the concentration effect caused by boiling and to express data on dry weight (d.w.) basis, the moisture content of raw and boiled samples was determined by drying the different portions in an oven at 105 °C until a constant weight was obtained (AOAC, 1995). Finally, raw and boiled portions were analysed.

2.3. Analytical procedures and quality assurance

The determination of Hg levels in raw and boiled samples was carried out in Istituto Zooprofilattico Sperimentale del Piemonte, Liguria e Valle d'Aosta (IZSTO) using the direct mercury analyser (DMA). The use of DMA has some advantages; it does not require any sample preparation or other wet chemistry prior the analysis, this means ease of use, low running cost and no need for hazardous chemicals to purchase, handle and dispose. During sample handling special care was taken to prevent metal contamination by laboratory and cooking equipment.

About 0.08–0.10 g of sample was weighed and directly analysed without mineralization. Hg concentrations were measured by thermal decomposition amalgamation and atomic absorption spectrophotometry using the DMA-80, (Milestone Srl, Italy) for the analysis. This equipment contains an automatic sampler, a quartz furnace, a cobalt-manganese oxide catalyst, a gold-coated sand amalgamator and an atomic absorption detection cell with three different path lengths (165, 120 and 4 mm). The sample is introduced into the quartz furnace, where it is heated up in 15 s to 200 °C (drying temperature) for 70 s and in 60 s to 650 °C for 60 s, which allows Hg volatilization and reduction.

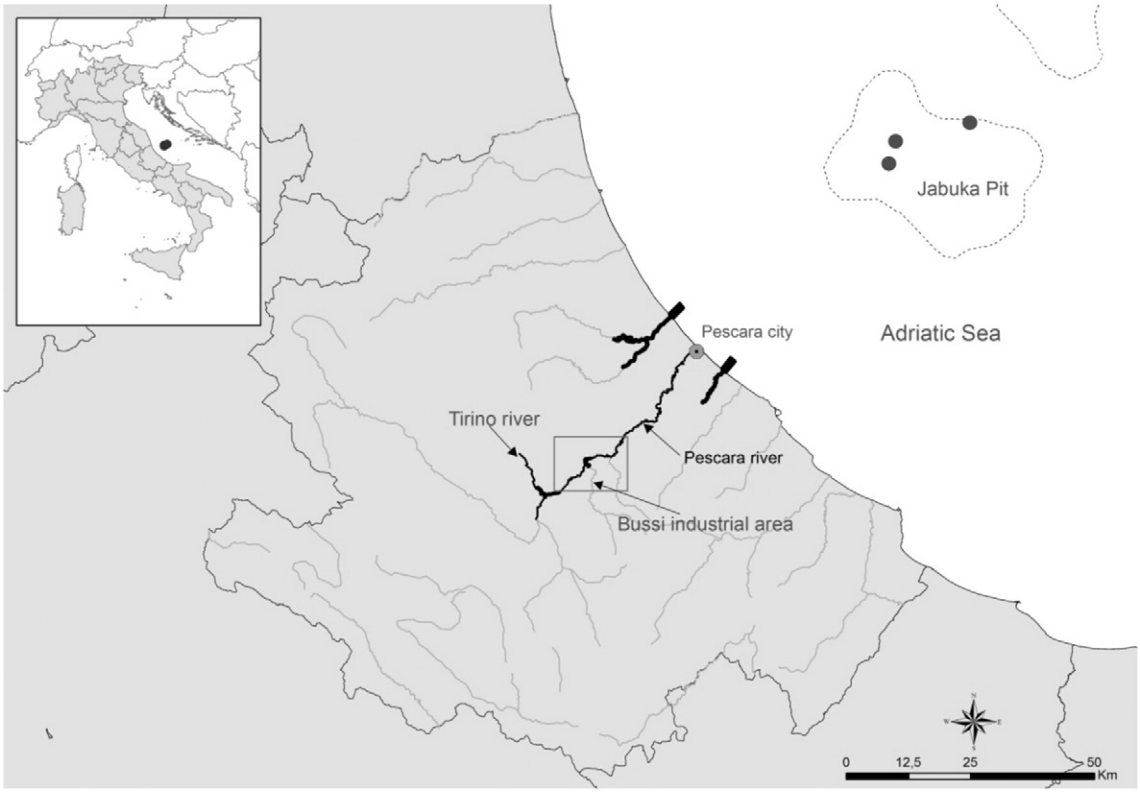

Fig. 1. Map shows the Abruzzi coast with the sampling sites (•), the Tirino and Pescara rivers, the Bussi industrial area, the Pescara harbour and the Jabuka Pit.