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Proximate, fatty acids and metals in edible marine bivalves from Italian market: Beneficial and risk for consumers health

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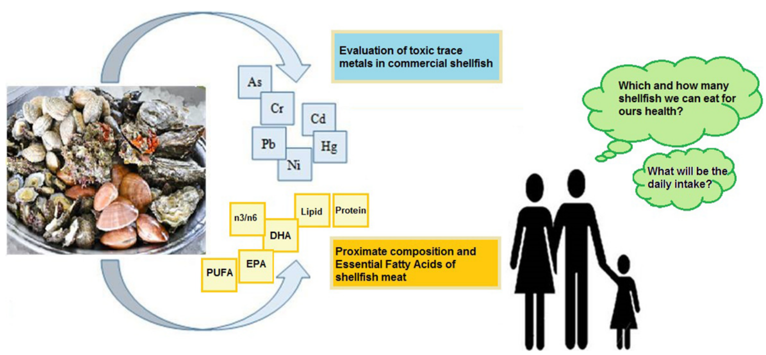
HIGHLIGHTS

- The benefit and risks for human health through the consumption of commercial bivalves.
- *M. varia*, *O. edulis*, *S. marginatus*, *M. galloprovincialis*, *M. barbatus* resulted the most beneficial for consumers.
- No species showed values above established concentrations for Cd, Hg and Pb.
- For the most part of species, the recommended ingestion rate was less 60 g/person/day.

GRAPHICAL ABSTRACT



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ABSTRACT

Seafood is recognized as a healthy food choice due to high contents of essential nutrients, including polyunsaturated fatty acids (PUFAs) of the n−3 family. However, seafood is often contaminated by toxic compounds, which have adverse effects on human health. The aim of this study was to provide information about the percentage of edible part, condition index and the benefit and risk for human consumers health associated to the consumption of eight bivalve species (*Flexopecten glaber*, *Mimachlamys varia*, *Modiolus barbatus*, *Mytilus galloprovincialis*, *Ostrea edulis*, *Ruditapes philippinarum*, *Solen marginatus* and *Venus verrucosa*) of high commercial value, purchased from Taranto local fish markets. High percentage of edibility and condition index were found in all analysed species. The relatively high protein content, low levels of lipid and high percentage of healthy n−3 PUFAs make *M. varia*, *O. edulis*, *S. marginatus*, *M. galloprovincialis*, *M. barbatus* more suitable for benefit to consumers.
Provisional tolerable weekly intake and hazard index calculated on the basis of trace metals in edible tissues, indicated specific recommendations for a responsible daily consumption of shellfish. For the most part of studied species, the estimated balance between beneficial and risk for consumers recommend a daily portion (RDP) lesser of 60 g/person/day than *M. galloprovincialis*, *O. edulis* and *R. philippinarum* (≥60 g/person/day). Careful risk-benefit considerations should promote seafood consumption while minimizing exposure to toxic contaminants.

1. Introduction

Seafood is a nutrient rich food source mainly consumed by people living along coastal areas. It has been widely acknowledged as an

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integral component of a well-balanced diet as Mediterranean diet (Prato and Biandolino, 2015; Prato et al., 2017).

Worldwide bivalve production has consistently increased over the years from 7.1 million in 1995 to 16.1 million in 2014, and the consumer demand is expected to further increase in the next future (FAO, 2016). In a country with a significant production of shellfish, there is need to provide useful, clear and relevant information for the protection of consumers' health. In Mediterranean Sea, Italy is the third largest producer of bivalve molluscs, after Spain and France (Bille et al., 2013). In general, consumption of bivalves in the EU is highest in southern countries.

In the recent years, there is an open debate concerning the benefits and risks of consuming seafood as to how much, or even if, seafood should be consumed, and by who. Traditionally, shellfish are considered a delicacy and play an important role in human's diet since their consumption leads to clear nutritional benefits. They are characterized by high-value proteins content, low content of fat, essential micronutrients, including vitamin D, A and B and minerals (Orban et al., 2002; Gil and Gil, 2015). However, the nutritive value of shellfish is to a large extent associated with the presence of polyunsaturated fatty acids (PUFAs) especially omega 3 (n−3) such as eicosapentaenoic acid (EPA, 20:5n−3) and docosahexaenoic acid (DHA, 22:6n−3). They play an important role in the prevention of human cardiovascular diseases and cancers, lowering of incidents of diabetes and in the development and function of nervous system. Regular intake of EPA and DHA prevents cardiovascular disease, neural and inflammatory disorders (Casula et al., 2013).

The consumers seem to be better informed about the benefits arising from the consumption of this food rather than on the risks. However, since bivalves are filter-feeding, they accumulate elements from food, water and inorganic particulate materials, and this can result in bioaccumulation, also of toxic substances when they are present (Liao and Ling, 2003; Amiard et al., 2008). If the concentrations exceed the permitted concentration, they can be considered as "potentially" hazardous for consumers (Liao and Ling, 2003; Amiard et al., 2008).

One potential risk of dietary shellfish intake is its content of heavy metals that can easily accumulate in organic tissue and have been linked to a variety of health risks (Vieira et al., 2011; Bosch et al., 2015).

Because of their high degree of toxicity, arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb), nickel (Ni) and mercury (Hg) rank among the priority metals that are of public health significance, even at low concentrations. These metallic elements are considered systemic toxicants and are known to induce the production of free radicals, which are able to cause lipid peroxidation, DNA damage and oxidation of the sulfhydryl groups of proteins, leading to several diseases, such as cardiovascular disease (CVD) (Flora et al., 2008; Carocci et al., 2014).

Among them, mercury comes in different forms within the environment. The most common cause of mercury poisoning is from consuming too much methylmercury (MeHg), which is linked to eating fish and shellfish. Methylmercury is a powerful neurotoxin that may lead to adverse health effects with the brain and nervous system as the primary target tissues for the effects of MeHg (Davidson et al., 2011).

The aim of this paper was to characterize and compare eight commercially important bivalve species (*Flexopecten glaber*, *Mimachlamys varia*, *Modiolus barbatus*, *Mytilus galloprovincialis*, *Ostrea edulis*, *Ruditapes philippinarum*, *Solen marginatus* and *Venus verrucosa*) in term of their marketability (percentage edibility (PE) or the condition index (CI)), nutritional properties (proximate composition, fatty acids profile) and toxic elements As, Ni, Hg, Cd, Pb, Cr, and. As far it is known, no previous study was published regarding a so extended nutritional characterization of these bivalves. Data on contaminants, proximate composition and fatty acids levels in shellfish from particular regions could allow people to make informed decisions about which species to eat to reduce their risk from the contaminants and increase health benefits.

2. Materials and methods

2.1. Collection, samples preparation and percentage edibility and condition index of bivalves

Specimens of scallops *F. glaber* and *M. varia*, mussels *M. barbatus* and *M. galloprovincialis*, oyster *O. edulis*, clams *R. philippinarum* and *V. verrucosa*, and razor clam *S. marginatus*, were purchased from Taranto local fish markets (southern Italy), between April and May 2014. Samples (of maximum 24–48 h after harvesting) were immediately iced and transported to the laboratory within 1 h of purchase, inside boxes. Upon arrival, each sample ($N = 3$) of about 30 individuals, for each replicates, was split up in two sub-groups: one for biochemical determinations ($n = 15$) and one chemical analysis ($n = 15$). Adult samples of each species with similar shell length were selected to ensure that any analytical differences were not size dependent.

Individuals were measured using a precision calliper (to 0.05 mm) and weighted to the nearest 0.01 g. Then, bivalves were cleaned and rinsed with deionized water and then manually shucked by cutting the adductor muscle with a knife, and the meat was pressed with blotting paper to remove excess moisture before weighting and homogenized. The soft body was not separated into organs or body parts to avoid leakage of intracellular fluids. Three replicate samples were obtained. All samples were packed in a polyethylene bag, sealed and stored at −20 °C until use. The storage time was not longer than 15 days. Percentage edibility (PE) and condition index (CI) were determined. PE was calculated as: $PE = (\text{wet meat weight} / \text{total weight}) \times 100$ (Mohite et al., 2009).

CI was calculated as: $CI = (\text{wet meat weight} / \text{shell weight}) \times 100$ (Okumus and Stirling, 1998).

2.2. Proximate analysis

Moisture, ash, protein, lipid and carbohydrate contents of bivalves were analysed in triplicate according to AOAC methods. The moisture was measured by oven drying at 105 °C to constant weight (AOAC, 2005). The crude protein content was measured by the Kjeldahl procedure ($6.25 \times N$).

Total lipid (TL) content was determined gravimetrically after chloroform-methanol extraction according to Folch et al. (1957). Carbohydrates were quantified according to the phenol–sulfuric acid method (Dubois et al., 1956), using glucose as the standard. All analyses were conducted in triplicate.

2.3. Fatty acids analysis

Fatty acids of total lipids were prepared according to the procedure described by Prato et al. (2018a).

Analysis of Fatty acids methyl esters (FAMEs) was performed by gas chromatography (GC) using an HP 6890 series GC (Hewlett Packard, Wilmington, DE, USA), equipped with flame ionization detector. FAMEs were separated with an Omegawax 250 capillary column (Supelco, Bellafonte, PA, USA) (30 m long, 0.25-mm internal diameter, and 0.25-mm film thickness). Helium was used as the carrier gas at a flow rate of 1-mL/min. The column temperature program was as follows: 150 to 250 °C at 4 °C/min and then held at 250 °C. FAMEs were identified by comparing retention times with a standard (Supelco 37 Component FAME Mix). Relative quantities were expressed as weight % of total fatty acids. Percent of total fatty acids data were converted to amounts per 100 g wet fillet according to Greenfield and Southgate (2003).

2.4. Lipids nutritional quality indices (LNQI)

The data from fatty acids composition analysis were used to determine the nutritional quality of the lipid fraction by means of three indices using the following calculations: