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A systematic review and meta-analysis of metal concentrations in canned tuna fish in Iran and human health risk assessment

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ABSTRACT

Human consumption of fish protein, including canned tuna fish, is increasing steadily worldwide. However, there are some concerns about the potential exposure to elevated concentrations of metals in canned tuna fish. Several studies have been conducted in Iran regarding the concentration of metals in seafood, including copper (Cu), selenium (Se), iron (Fe), zinc (Zn), mercury (Hg), lead (Pb), chromium (Cr), arsenic (As), nickel (Ni), tin (Sn), and cadmium (Cd) in canned tuna fish. The main aim of this study was to gather data from existing papers and to perform a meta-analysis of the pooled concentrations of metals to evaluate their non-carcinogenic and carcinogenic risks in children and adults consumers. Search was conducted retrieving data from the international biomedical databases with highly public access and consultation, e.g., Web of Science, PubMed, Science Direct, and Scopus, and national database (SID and Irandoc) between 1983 and November of 2017. Data from 23 articles and 1295 samples were assessed and extracted. The ranking order of metals based on mean concentrations (μg/g wet weight) were Fe (13.17) > Zn (9.31) > Se (2.23) > Al (1.8) > Cr (1.63) > Cu (1.52) > As (0.38) > Ni (0.33) > Pb (0.24) > Cd (0.14) > Hg (0.11) > Sn (0.1). Except for Cd and Se, concentrations of other metals in the canned tuna fish were lower than the limits recommended by the United States Environmental Protection Agency (USEPA), World Health Organization (WHO), Food and Agriculture Organization (FAO) and Iran National Standards Organization (INSO). The minimum and maximum target hazard quotient (THQ) for adults were 5.55E-5 for Al and 2.23E-08 for Cr. For children, they were 7.23E-05 for Al and 2.91E-08 for Cr. THQ, and total target hazard quotient (TTHQ) were ≤1.0 for adult and children consumers. The Incremental Lifetime Cancer Risk (ILCR) of As was 3.21E-5 in adults and 4.18E-5 in children. Adults and children that consume canned tuna fish in Iran are not at non-carcinogenic risk but have a carcinogenic risk due to As.

1. Introduction

Seafood provides a good source of protein, omega-3 fatty acids, unsaturated fatty acids, vitamins, micro- and macronutrients in the human diet and their consumption is increasing all over the world (Pieniak et al., 2010). Fish consumption reduces chronic non-communicable diseases such as cardiovascular diseases, psychological disorders, rheumatoid arthritis and some cancers, but it also contributes to

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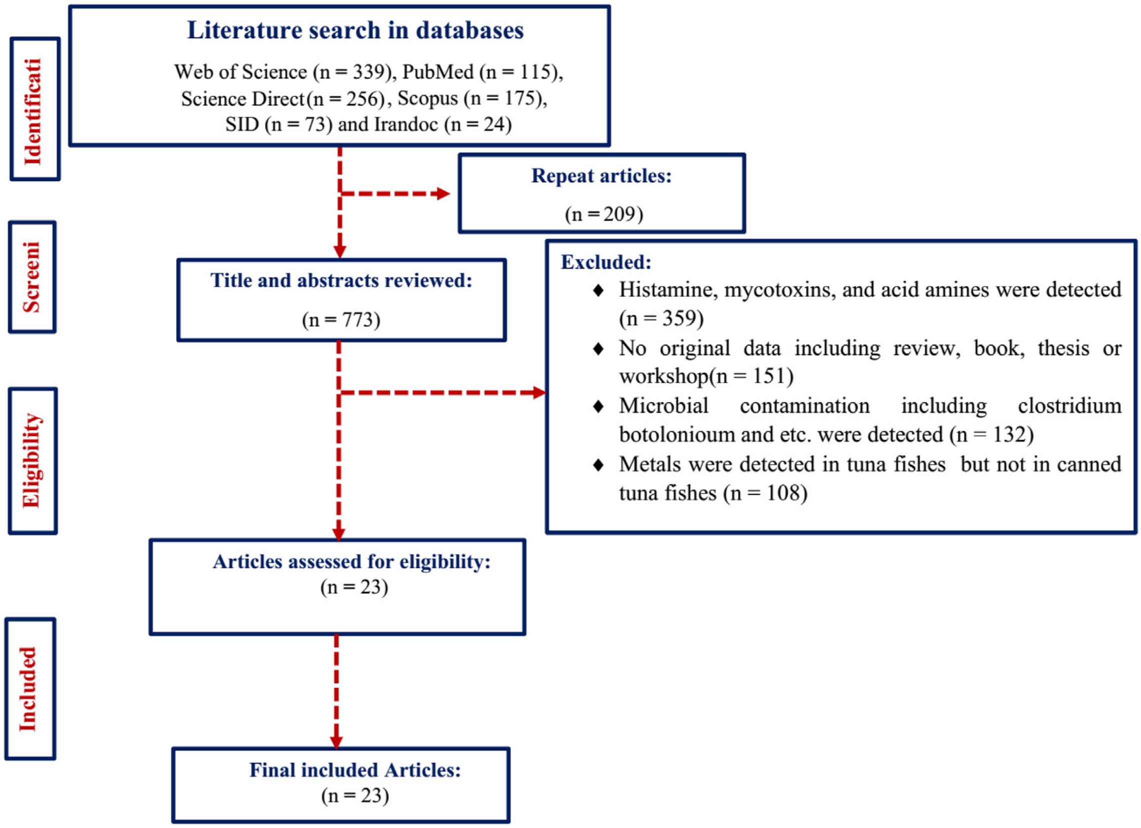

Fig. 1. Flow diagram showing the search and selection process, following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

the normal neuronal development in children (Di Giuseppe et al., 2014; Swanson et al., 2012; Virtanen et al., 2008).

There are several ways to preserved fish such as freezing, smoking, salting, drying and canning (Jedrychowski et al., 2007). Tuna fish is one of the most widely consumed worldwide, in part due to its quality and flavor when canned. Consumption of canned tuna in the world, United States, and Iran have been estimated to be as high as 1.0, 1.36 and 1.1 Kg per year per capita in the 2015 (Lee and Chang, 2014; NOAA, 2015).

The primary source of metals in the fish tissue is the marine environment, polluted by heavy metals and industrial wastes (Fakhri et al., 2018c). Contamination of aquatic environment originates from natural sources such as metals leak from the Earth's crust and humans activities such as industrial discharge, municipal and agricultural wastewater and solid wastes (Domingo et al., 2007). Furthermore, besides those sources, tuna fish can be contaminated during canning process (Mol, 2011).

From a nutritional point of view, metals can be divided into essentials and non-essential. Essential metals such as copper (Cu), selenium (Se), iron (Fe), chromium (Cr), manganese (Mn), and zinc (Zn), are all crucial for the right metabolism in the human body in trace levels. Non-essential metals, such as mercury (Hg), lead (Pb), and cadmium (Cd), lack an essential role in the human body and may cause damage at high concentrations (Ogundiran and Fasakin, 2015; Pirsaheb et al., 2013; Shahsavani et al., 2017a; Sharafi et al., 2015; Yılmaz et al., 2010). Although toxic trace metals are usually present at low concentrations in marine macro-environments, they are particularly dangerous because of their bioaccumulation and biomagnification properties in the food chain, which can also endanger human health (Alahabadi et al., 2017; Copat et al., 2018; Dadar et al., 2017; Pirsaheb et al., 2016; Sadeghi et al., 2015; Shahsavani et al., 2017b). Consuming foods containing metals may cause serious health hazards such as, renal dysfunction and cancer in the case of Cd (Godt et al., 2006), Alzheimer like dementia and dysarthria in the case of Hg (Zahir et al., 2005), cognitive and neurological deficits in the case of Pb (Goyer, 1990); hair loss and mild nerve damage in the case of Se (Fraga, 2005); cramps and nausea in the case of Cu (Fraga, 2005); genetic and metabolic diseases in the case of Fe (Fraga, 2005); skin and eye irritation in the case of tin (Sn) (Winship, 1988), pigmentation and keratosis in the case of arsenic (As) (Jaishankar et al., 2014), cytotoxicity in the case of Zn (Plum et al., 2010), DNA damage(O'Brien et al., 2001), immunologic, neurologic and carcinogenic problems in the case of nickel (Ni) (Cempel and Nikel, 2006), and aluminium (Al)-induced adynamic bone disease and Al-induced osteomalacia in the case of Al (Cannata Andia, 1996).

Therefore, United States Environmental Protection Agency (USEPA), Food and Agriculture Organization (FAO), World Health Organization (WHO) and the Iran National Standards Organization (INSO), have established guidelines and standards limits in order to decrease the health risks of metals due to the ingestion of canned tuna fish (Iran., 2009; WHO, 2004).

Although several studies assessed the concentration of metals in canned tuna fish in Iran (Andayesh et al., 2015; Hosseini et al., 2015a, 2015b; Nazari Khorasgani et al., 2017; Pourjafar et al., 2014; Sobhanardakani, 2017; Zazouli et al., 2016), no systematic review, meta-analysis and health risk assessment for the consumers has been conducted to date. Therefore, the aims of the present study were to perform a meta-analysis of all data available to date in order to estimate mean concentrations of metals in canned tuna fish, compare those mean concentrations with FAO, WHO, USEPA, and national standard limits, estimate current non-carcinogenic and carcinogenic risks in adults and children consumers.