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Review

# Exploratory review on safety of edible raw fish per the hazard factors and their detection methods

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ABSTRACT

Fish and fish products are appreciated worldwide for their high nutritional value and delicate taste. To this end, it is extremely vital to guarantee the safety of edible fish in the international fish industry. Various research findings associated with the safety and quality of fish and fish products were discussed in the present review. The diverse hazard factors with regard to fish safety and quality were highlighted which could be classified into three groups; chemical factors, biological factors and physical factors. Many of these contaminants that accumulate in fish tissues are transferred to humans through the food chain and possible damage to human health. Hence, it is essential to develop analytical techniques to monitor these contaminants in fish prior to consumption for protecting of the consumers from potential risk of food-borne diseases. However, although most of these conventional analytical methods for fish contaminants determination are reliable and accurate, they are time-consuming, expensive and require highly skilled personnel. For that matter, there is no existing rapid detection system that could provide sufficient information associated with various of the contaminants for fish safety and quality evaluation. With the increasing demand of fish and fish products, there is the need for a rapid determination system for ensurence of fish safety and quality. The review would help to give some inspirations to the researchers studied in the areas of fish quality control.



## 1. Introduction

Fish and fish products have always been one of the most important components of human diets. As a result of the rapid development of fish culture and wild-catch technologies, fish production has increased rapidly in recent years (Dowlati, Guardia, & Mohtasebi, 2012). In 2011, there was about 154 million tons of fish supplied by the wild fisheries and aquaculture worldwide which increased by 18% over that of 2001 (Dowlati et al., 2012). Furthermore, the global seafood supply in the 1960 increased from 9.9 kg live weight equivalent per capita to 18.4 kg in 2009, which has increased at an annual average rate of 3.1% since 1961 (Villasante et al., 2013). Therefore, it could be inferred that fish and fish products will play an important role in human society for several years.

Fish fulfills an important role in human diet mainly results from its delicate taste, and moreover fish contains high beneficial nutrients such as biologically valuable proteins, fats and fat-soluble vitamins, etc. When compared with that of land animals, fish meat is easier to digest and therefore has a much lower nutritive saturation value. The cooking loss of fish is significantly less than that of many land animals such as beef, which is approximately 15%. Fish proteins show a higher nutritional value when the amino acid compositions are compared with that of the beef or milk casein. Fish and fish products are an important source of ω-3-polyenic acids with 5 and 6 double bonds, which are considered valuable from a physiological and nutritional point of view. Furthermore, fish fat and liver (liver oil) are significant sources of fat-soluble vitamin A and D (Belitz, Grosch, & Schieberle, 2009). In addition, fish has some reputed medicinal values. In line with this, epidemiological studies have established a positive correlation between marine food consumption and a reduced risk of common chronic diseases such as cardiovascular disease and cancers (Fotuhi, Mohassel, & Yaffe, 2009; Galli & Risé, 2009). The health benefits of some marine bioactives have been made known on the basis of nutritional and nutrigenomic studies (Puskas & Kitajka, 2006;

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Surette, 2013).

Human health is largely determined by the diet (Martí-Cid, Bocio, Llobet, & Domingo, 2007). Through increased economic globalization, public concerns have arisen regarding high-profile food-borne illness outbreaks due to various contaminations in food sources, which have serious impact and potential chronic long-term complications on the ever-increasing high-risk population groups (e.g., infants, aged, and the immuno-compromised) (Painter et al., 2013; Xue & Zhang, 2013). Presently, concern for the safety of edible fish is one of the topmost priorities of most countries across the globe. Generally, most safety concerns in food products are from chemical and microbial contaminations which have to be measured and controlled in order to increase the safety of the food supply. As for the raw fish, many groups offer special problems to which a lot of attention has to be given. For instance, fish may contain pathogenic bacteria, biotoxin (e.g. scombroid toxin, ciguatera, tetrodotoxin) and parasites (e.g. nematodes, cestodes) which can be harmful to humans when they enter into the human body. Fish from areas that are polluted (rivers, inshore waters, estuaries, etc.) could carry a high burden of environmental pollutants, such as, heavy metals, pesticide, etc. Overuse or abuse of fishery drugs in aquaculture could lead to contaminants in products. In this study, various contaminations in fish are broadly classified as chemical hazards, biological hazards, and physical hazards for the following discussion. The chemical hazards are naturally occurring poisons and other chemicals which include toxic heavy metals, fishery drugs, pesticides, etc. The biological hazards are living pathogenic microorganisms and parasites. Whiles, the physical contaminations are glass, hair, metals, stones, wood, plastic, bone, etc. that is not normally physical part of the fish products. Many of these contaminants accumulate in fish tissues and are subsequently transferred to humans through the food chain, damaging human health. Therefore, various analytical methods have been developed to detect these contaminants to evaluate the safety of edible fish for protecting the consumers from potential fish food-borne disease. Meanwhile, most of the conventional methods though reliable and accurate but are time-consuming, expensive and require highly skilled personnel. In addition, there is no a rapid detection system existing that could give sufficient information about the contaminations associated with the safety of edible fish. With the expansion of the fishery industry, there is an increasing demand for building a rapid determination system for fish safety and quality evaluation to ensure that consumers are protected from potential fish food-borne disease. Hence, it is vital to understand the main contaminants of fish and their determination methods to provide necessary knowledge for the establishment of rapid detection system. This would help in the building of rapid evaluation system for fish safety and quality and give some inspirations to the researchers studied in the areas of fish quality control.

## 2. The main hazards associated with safety of edible fish

### 2.1. Chemical hazards

#### 2.1.1. Heavy metals

Heavy metals are molecules of specific gravity >5.0 of metals and non-biodegradable in nature. Recent reports indicate that pollution of toxic heavy metals in aquatic ecosystem is growing at an alarming rate and has become an important problem worldwide (Malik, Biswas, Qureshi, Borana, & Virha, 2010). Generally, heavy metals (e.g. Pb, Cd, and Hg, etc.), especially at higher concentrations, threaten human health due to their high toxicity, persistence, and tendency to accumulate in the food chain, and they cause ecological damage and have carcinogenic and other adverse effects on human health due to biomagnifications over time (Has-Schön, Bogut, & Strelec, 2006; Malik et al., 2010). These health concerns are quite enormous. For example, cancers and damage to the nervous system, etc. as a result of metals consumption have been documented (Malik et al., 2010). There are various sources of heavy metals arising mainly due to atmospheric deposition, erosion of the geological matrix, or various anthropogenic activities like industrial effluent and mining wastes, etc. (Yusà et al., 2008). Actually, to ensure the food safety for the consumers, several authorities and organized bodies around the world have established the maximum residue limits (MRLs) for many toxic heavy metals (e.g. lead, cadmium, mercury, etc.) in various tissues including fish muscle. The MRLs are the upper legal concentration limits for contaminant residues in or on food or feed. They are set for a wide range of food commodities of plant and animal origin, and they usually apply to the product as placed on the market (LeDoux, 2011).

#### 2.1.2. Fishery drugs

In recent years, various kinds of fishery drugs have been used in aquaculture worldwide because of the need to treat and prevent disease, control parasites, reproduction and growth, and provide tranquilization (e.g., for weighing) (Wen, Wang, & Feng, 2006). The fishery drugs residue in the fish tissues have raised the problem of safety of edible fish as food. Undoubtedly, the use of unapproved drugs or misuse of approved drugs in aquacultured fish poses a potential human health hazard. These substances may be toxic, allergenic, or carcinogenic, and/or may cause antibiotic resistance in pathogens that affect humans (Wen et al., 2006). Actually, to ensure food safety for the consumers, several authorities around the world have established the MRLs for many fishery or animal drugs (e.g. malachite green, fluoroquinolones, chloromycetin, etc.) in various tissues including fish muscle (Wen et al., 2006).

Malachite green (MG) is a triphenylmethane dye, originally used as a dyeing agent in the textile industry, which was introduced as an ectoparasiticide, fungicide and antiseptic in aquaculture in 1933 (Alderman, 1985). Indeed, MG has been extensively used in fisheries for many decades due to its low cost, ready availability and high efficacy for treatment or prevention of external fungal and parasitic infections in fish (Martínez Bueno et al., 2010). However, due to its potential carcinogenic, genotoxic, mutagenic and teratogenic properties, MG has been banned in aquaculture industry in the European Commission and U.S, and also not approved in China (Ministry of Agriculture Bulletin No. 193) (Shen et al., 2011). To this end, the use of MG in aquatic food animals is highly restricted or banned in many countries. Also, MG residues have still been detected in monitoring schemes performed in the EU member states and will probably continue to be used in aquaculture in some parts of the world (Martínez Bueno et al., 2010).

Chloramphenicol (CAP) is an effective broad-spectrum antibiotic used in aquaculture as a prophylactic or disinfectant to prevent diseases, or as a chemotherapeutic agent to control diseases (Bilandžić, Tanković, Varenina, Kolanović, & Smajlović, 2012; Lu, Dang, & Yang, 2009; Shi, Wu, Zheng, Li, & Zhang, 2007). However, the drug is well known to have serious toxic effect in humans. CAP is an inhibitor of protein synthesis and has shown dose-related reversible bone marrow depression and a severe aplastic anaemia, which is non-dose related and often irreversible Siqueira, Luiz Donato, de Nucci, & Reyes, 2009). Therefore, the use of CAP in aquaculture is banned by many countries, including the USA, European Union, Japan, and China (Shi et al., 2007). Yet, due to its low cost and high effectiveness against certain fish diseases, it is still used illegally in aquaculture on a relatively large scale (Lai et al., 2011).

Broad-spectrum antibiotics, fluoroquinolones (FQs) (effective for both gram negative and gram positive bacteria), play an