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Risk–benefit evaluation of fish from Chinese markets: Nutrients and contaminants in 24 fish species from five big cities and related assessment for human health

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ABSTRACT

The risks and benefits of fish from markets in Chinese cities have not previously been fully evaluated. In the present study, 24 common fish species with more than 400 individual samples were collected from markets from five big Chinese cities in 2007. The main nutrients and contaminants were measured and the risk–benefit was evaluated based on recommended nutrient intakes and risk level criteria set by relevant authorities. The comprehensive effects of nutrients and contaminants in marine oily fish were also evaluated using the data of two related human dietary intervention trials performed in dyslipidemic Chinese men and women in 2008 and 2010, respectively. The results showed that concentrations of contaminants analyzed including DDT, PCB_7, arsenic and cadmium were much lower than their corresponding maximum limits with the exception of the mercury concentration in common carp. Concentrations of POPs and n-3 LCPUFA, mainly EPA and DHA, were positively associated with the lipid content of the fish. With a daily intake of 80–100 g marine oily fish, the persistent organic pollutants in fish would not counteract the beneficial effects of n-3 LCPUFA in reducing cardiovascular disease (CVD) risk markers. Marine oily fish provided more effective protection against CVD than lean fish, particularly for the dyslipidemic populations. The risk–benefit assessment based on the present daily aquatic product intake in Chinese urban residents (44.9 and 62.3 g for the average values for all cities and big cities, respectively) indicated that fish, particularly marine oily fish, can be regularly consumed to achieve optimal nutritional benefits from n-3 LCPUFA, without causing significant contaminant-related health risks. However, the potential health threat from contaminants in fish should still be emphasized for the populations consuming large quantities of fish, particularly wild fish.

1. Introduction

Fish, particularly marine oily fish, have been demonstrated to play beneficial effects in preventing cardiovascular diseases (CVD) in many western countries (He et al., 2004; Undeland et al., 2004). The beneficial effects of oily fish in reducing CVD risk are mainly related to the high content of n-3 long chain polyunsaturated fatty acids (LCPUFA), particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (Harris, 1997). The proposed mechanisms by which n-3 LCPUFA protect against CVD is related to the incorporation of EPA and DHA into membrane phospholipids, thereby changing the membrane properties and leading to various beneficial effects, including lowering blood pressure, reducing serum triglycerides, thrombotic tendency, inflammation and improving endothelial function (He et al., 2009; Moore et al., 2006; Psota et al., 2006). In addition, fish also contain highly digestible protein and a number of beneficial micronutrients, such as Vitamins E and D, niacin, calcium, zinc, and selenium, which are essential for maintaining normal physiological functions in human being. Based on the benefits of fish, particularly oily fish, the American Heart Association recommends eating at least two servings of fish per week. Each serving is 100 g cooked, or about ¾ American cup of flaked fish (AHA, 2010; Smith and Sahyoun, 2005).

Due to global pollution, fish also contain contaminants including heavy metals, such as mercury (Hg), and persistent organic pollutants

Abbreviations: AHA, American Heart Association; DDT, dichlorodiphenyltrichloroethane; DHA, docosahexaenoic acid; CVD, cardiovascular disease; EFSA, European Food Safety Authority; EPA, eicosapentaenoic acid; FDA, Food and Drug Administration; JECFA, Joint FAO/WHO Expert Committee on Food Additives; LCPUFA, long chain polyunsaturated fatty acid; MeHg, methyl mercury; MRL, minimum risk level; MUFA, mono-unsaturated fatty acid; PCB, polychlorinated biphenyls; POPs, persistent organic pollutants; PTWI, provisional tolerable weekly intake; RDI, recommended daily intake; RfD, reference dose; SFA, saturated fatty acid; TDI, tolerance daily intake; TC, total cholesterol; TG, triglyceride; WHO, World Health Organization.

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(POPs), such as polychlorinated biphenyl (PCB) (Sidhu, 2003; Smith and Sahyoun, 2005). There are numerous studies which describe the teratogenic and carcinogenic effects of heavy metals and POPs (Battershill, 1994; Borchers et al., 2010; Irigaray et al., 2007; Weyandt et al., 2008), and evidence also indicates that environmental contaminants impair cardiac function by disrupting the role of thyroid hormones (U.S.EPA, 1997) and are associated with atherosclerotic and cardiomyopathic processes (Jokinen et al., 2003; Toborek et al., 1995). Furthermore, a correlation has been established between POPs in fish oil and insulin resistance as the basal sign of metabolic syndromes (Ruzzin et al., 2010). High doses of contaminants, such as mercury, have been shown to counteract the beneficial effects of fish in CVD prevention (Rissanen et al., 2000; Salonen et al., 1995). Fillets from oily fish contain considerably higher levels of organic contaminants than lean fish, therefore, increasing fish, especially oily fish consumption increases consumer exposure to these contaminants and represents a potential health risk.

Based on the fact that the high nutritional–toxicological conflict existing in fish has led to severe confusion in mind of general populations, a number of studies focusing on risk–beneficial evaluation of fish have been carried out by measuring the contaminant and nutrient contents in bulk of fish products, in order to provide more scientific and practical advices of fish consumption (Bethune et al., 2006; Ginsberg and Toal, 2009; Loring et al., 2010; McKelvey et al., 2010; Urban et al., 2009). Maximum limits have been established globally by the Codex Alimentarius Commission, and in Europe by the Commission, Council and Parliament for several contaminants in different types of food including fish. Surveillance programs show that the contaminants levels in the majority of fish products in the markets of western developed countries are below the maximum limit. Based on the high n-3 PUFA content and relatively low contaminants, some fish species, mainly oily fish, such as salmon, trout, sardines and herring are highly recommended. However, the relatively higher contaminants content in other fish, such as tuna, swordfish and marlin, has led to consumption advisories of these fish for specific populations, such as children and pregnant women, in some countries (Smith and Sahyoun, 2005).

In contemporary China, with the rapid economic development and lifestyle changes, as in western developed countries, CVD has become the main cause of mortality and morbidity among adult people (Ministry of Health, P.R.C., 2010). Despite the advanced medical therapies which improve clinical symptoms and slow the progression, CVD continues to cause disability and mortality in China. Therefore, disease prevention initiatives are being encouraged including nutritional approaches of consuming healthy food, such as marine oily fish containing high n-3 PUFA. Recently, two human intervention trials have been performed in China using marine oily fish, and the conclusion of these studies was that dietary inclusion of marine oily fish could significantly reduce CVD risk markers, particularly serum triglycerides, in dyslipidemic adult men and women (Zhang et al., 2010, in press). However, data from the Chinese Nutrition and Health Survey indicated that, from 1992 to 2002, the amount of pork and beef consumption increased about 33.9% while there was only 7.1% increase for aquatic food (Zhai and Yang, 2006). In some large cities such as Beijing, the mean aquatic food intake per capita was 25.3 g/day, even lower than the level in 1992 (27.7 g/day) (Liu, 2006). One possible reason for the limited consumption of seafood may be attributed to the severe coastal pollution which causes a large number of Chinese to refrain from eating more marine oily fish which contain more pollutants compared to lean freshwater fish. This has been partly verified by a few studies showing the high levels of pollutants in some coastal fish species and their potential health risk to consumers (Monirith et al., 2003; Yatawara et al., 2009; Yuan et al., 2001). However, the limitations of these studies were 1) the fish in these studies were mostly wild fish, not farmed fish; 2) the authors mainly focused on the risk aspects, whereas the benefits of seafood were not fully considered. Of note, most of the fish consumed by Chinese, particularly the residents in large cities, are from aquaculture and are mainly fed with commercially formulated fish diets, which limit the pollutant exposure compared to the natural food chain. However, the information for risk–benefit evaluation of fish from markets of Chinese cities is currently lacking, and this has limited the Chinese health agency to provide dietary advisories for fish consumers.

The present study investigated the contents of contaminants and nutrients in 24 fish species, which are commonly seen in Chinese markets, in five cities with populations more than six million. The tolerable intakes for contaminants set by JECFA and maximum limits for contaminants and nutrient recommendations set by Chinese authorities, WHO and EFSA were used to evaluate the potential risk and beneficial effects of consumption of these fish. Moreover, these data were associated with the results of our recent human dietary intervention trials to make a comprehensive risk–benefit evaluation for marine oily fish. To the best of our knowledge, this is the first risk–benefit evaluation study of market fish facing general urban population in China.

2. Materials and methods

2.1. Ethics statement

This study didn't contain human materials and it was not performed in living animals. Most of the data were from the chemical measurements of fish which were purchased in Chinese markets. The related human data used for health assessment were from our previously published paper.

2.2. Sample collection and preparation

Fish samples were collected during March–May of 2007. They were randomly purchased from large modern supermarkets and traditional open markets in five big Chinese cities, with populations of at least six million, located in coastal provinces, from north to south including Dalian, Beijing, Nanjing, Shanghai and Guangzhou. The geographical locations and populations of these cities are shown in Fig. 1. More than 400 individual fish were collected, and among them 24 species were identified, each fish species contained least 12 individual samples. The common names and corresponding Latin names are: silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idellus*), bluntnose black bream (*Megalobrama amblycephala*), common carp (*Cyprinus carpio*), crucian carp (*Carassius auratus*), tilapia (*Oreochromis niloticus*), barracuda (*Mugil soiuy*), Chinese perch (*Siniperca chuatsi*), black bass (*Micropterus salmoides*), snakehead fish (*Channa argus*), yellow catfish (*Pelteobagrus fulvidraco*), ricefield eel (*Monopterus albus*), besugo (*Nemipterus virgatus*), Japanese sea bass (*Lateolabrax japonicus*), pacific fluke (*Paralichthys olivaceus*), belt fish (*Trichiurus haumela*), small yellow croaker (*Pseudosciaena polyactis*), bluegill Sunfish (*Lepomis macroehius*), silvery pomfret (*Pampus argenteus*), pacific mackerel (*Scomberomorus niphonius*), large yellow croaker (*Pseudosciaena crocea*), pompano (*Trachinotus ovatus*), herring (*Clupea harengus*), and salmon (*Salmo salar*). Most of these fish were locally farmed and had a long history of consumption in China, except the salmon (*S. salar*) and herring (*C. harengus*) which were imported from Norway during recent years. All of the fish species included in the study were commonly consumed in these cities, thus the results of the present investigation could represent the average levels of nutrient intake and contaminant exposure to the residents from consuming fish. After collection, the samples which belong to the same fish species were fillet and skinned and homogenized as a pooled sample. The 24 pooled samples were freeze-dried and stored at −80 °C for further analyses.