

Investigation on Background Content of Boron in Major Aquatic Products in China (Overview)

Boron is a kind of non-metallic element that is widely distributed in nature. Biologically, boron is an element with a nutritional function. However, health damage can also occur when large amounts of boron are ingested in a short period of time. The World Health Organization (WHO) suggests that the average intake of boron for adults is 1 to 13 mg/d. In the natural state, the boron content in food is low (in the form of borate and boric acid). However, when boron compounds (usually borax or boric acid) are artificially added to food, the boron content is significantly increased. In 2008, the former Ministry of Health included borax and boric acid in the "List of Non-edible Substances That May Be Illegally Added to Food (the first list)". Boron is of great concern mainly because of the conversion of low concentrations of borax to boric acid in the presence of stomach acid. Boric acid and borax have been used as additives in different foods for a long time. Since boric acid and borax can effectively inhibit yeast, and slightly inhibit mold and bacteria, they can be used to prevent food spoilage. In addition, these two additives also make the food more elastic and crunchy and prevent shrimp from turning black. However, it is difficult to judge whether the boron detected in food is a natural background or artificially, which brings challenges to defining illegal additions and determining regulatory measures.

In 2010, the National Experts Committee for Food Safety Risk Assessment conducted a boron background survey in cereals, meat and fruits and obtained the background level of boron in these foods, which provided a scientific basis for scientific supervision. In recent years, the authorities found that there may be artificial addition of boric acid in aquatic products. Thus, it is recommended to carry out a

background investigation of boron in aquatic products. To provide a basis for determining this potential food adulteration, the National Experts Committee for Food Safety Risk Assessment proposed to conduct a background boron level survey in aquatic products.

This project collected fresh aquatic products (fish, crustaceans and mollusks) without any additives in the fishing process and used inductively coupled plasma mass spectrometry (ICP-MS method) for boron content detection. Statistical analysis was conducted on the available data, combined with the principle of background value derivation, to propose the recommended value of background content of boron in major aquatic products in China.

1. Boron Content in Aquatic Products

In this project, 956 aquatic products of 47 species of fish, crustaceans and mollusks in the Bohai Sea, Yellow Sea, East China Sea and other marine areas and inland were collected and analyzed. It was found that the overall detection rate of boron in aquatic products was 99.79%, the average content was 1.01 mg/kg, the median was 0.55 mg/kg and the maximum was 5.92 mg/kg, with a non-abnormal distribution. In terms of mean boron content, the highest was the molluscs (2.34 mg/kg), followed by crustaceans (1.14 mg/kg), and the lowest was fish (0.47 mg/kg). The detection rate of boron in fish was 100.00%, and the average value of boron content in various fish was 0.27-1.02 mg/kg. The boron content in freshwater fish was lower than that in marine fish. Among freshwater fish, the highest average boron content was found in Japanese sea bass (0.62 mg/kg), followed by rice eel (0.37 mg/kg), and the lowest boron content was found in carp, catfish and pond loach (0.27 mg/kg). Among marine fish, the highest boron content was found in barracuda (1.02

mg/kg), followed by black skirt tetra (0.94 mg/kg), and the lowest boron content was found in arrowhead fish (0.33 mg/kg). The detection rate of boron in crustaceans was 99.47%, and the average value of boron content in various crustaceans was 0.22-1.25 mg/kg. Among freshwater crustaceans, the highest boron content was found in red swamp crayfish (0.45 mg/kg), followed by river shrimp and lake shrimp (0.30 mg/kg), and the lowest boron content was found in hairy crab (0.22 mg/kg). Among the marine crustaceans, the boron contents of sea crabs and sea shrimps were basically similar, at 1.25 mg/kg and 1.16 mg/kg, respectively. The detection rate of boron in mollusks was 100.00%, and the average boron content in various mollusks ranged from 0.28 to 3.92 mg/kg. Among freshwater mollusks, the boron content of mussels and snails was 0.32 mg/kg and 0.28 mg/kg, respectively; among marine mollusks, the highest boron content was found in scallops (3.92 mg/kg), followed by oysters (3.72 mg/kg), and the lowest was in razor shells (0.74 mg/kg).

2. Analysis of Factors Affecting Boron Content in Aquatic Products

The Wilcoxon rank sum test was used to conduct a single factor analysis of the factors influencing the boron content in aquatic products, including the nature of waters, types of aquatic products, sampling areas, and production methods. The results showed that the content of boron in aquatic products from different waters of different nature varied, with the average content of boron in marine aquatic products being more than three times that of freshwater aquatic products. The content of boron in different types of aquatic products varied, with mollusks showing the highest, followed by crustaceans, and fish showing the lowest. There were also differences in the boron content of marine products in different sampling areas, with slightly higher boron content in marine products in Shandong than in other areas. In addition, the

boron content in aquatic products varied between production modes, with higher boron content in captured aquatic products than in farmed aquatic products. Based on the results of univariate analysis, multiple regression analysis was used to screen four factors, namely, nature of waters, type of aquatic products, sampling area and production mode, and the results showed that the four factors were all of importance in influencing the boron content in aquatic products.

3. Estimation of Boron Background Content in Aquatic Products

The 95% confidence interval of P99 for boron content in aquatic products was 5.11 (4.97, 5.36), calculated by applying the generalized Pareto distribution to the 95% confidence interval of the 99% quantile of all boron content data obtained from the special survey. Therefore, the highest background content of boron in aquatic products reached 5.36 mg/kg based on existing data in combination with statistical methods and the derivation principle of background contents.

4. Risk Assessment

The risk assessment results showed that the daily intake of boron through cereals, beans, meat, eggs, fruits, vegetables, nuts and mushrooms was 0.009 mg/kg BW, and, based on the conservative estimate with the background value of 5.36 mg/kg for aquatic products, the daily intake of boron through aquatic products was 0.002 mg/kg BW for Chinese residents. In addition to food, the boron is also widely found in seawater, surface water and groundwater. In China, the limit value of boron in drinking water is set to be 0.5 mg/L. If an adults drink 2 L of water per day, the daily intake of boron through drinking water does not exceed 0.015 mg/kg BW. Since food and drinking water are the main boron, the daily intake of boron for Chinese residents is about 0.026 mg/kg BW. This value represents 16.3% of the ADI value for boron

(0.16 mg/kg BW) for adults recently proposed by the European Food Safety Authority. Therefore, without considering the illegal addition of boron in food, the background dietary intake of boron is in a safe range in China.

5. Conclusions and Recommendations

(1) Boron could be commonly detected in most aquatic products (detection rate was 99.79%), but the average content was low (mean value 1.01 mg/kg, standard deviation 1.13 mg/kg). The results of the multiple regression analysis showed that the nature of the waters, the type of aquatic products, the sampling area and the production mode were all important factors affecting the boron content in aquatic products.

(2) The maximum range of boron background value in aquatic products is between 4.97-5.36 mg/kg. Based on the upper limit of this range and the food consumption data of Chinese residents, the intake of boron is in the safe range in China if no illegal addition of boron in food.

(3) This investigation fully considered and excluded the key factors affecting the background of boron in aquatic products, but still cannot exclude the existence of individual abnormally high background due to geological factors or local water pollution. Therefore, the background value higher than that suggested by this investigation does not necessarily indicate the existence of anthropogenic additive behavior, and it is recommended to consider the source of boron in food for comprehensive analysis.