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# Mercury Concentrations in Louisiana and Chinese Crayfish

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Crayfish reside in a niche of the ecosystem where they have the potential to contact and bioaccumulate water-borne, sediment-borne, and dietary-borne contaminants, such as trace metals (Anderson et al. 1978). Researchers have shown that crayfish accumulate metals in their tissues (Stinson and Eaton 1983; Bagatto and Alikhan 1987; Rincon-Leon et al. 1988). Mercury has been found to accumulate primarily in the tail meat of the crayfish which is the principle edible component consumed by man (Potter et al. 1975; Sheffy 1978; Stinson and Eaton 1983). To reduce the possibility of mercury poisoning in humans, the Food and Drug Administration (FDA) and the U.S. Environmental Protection Agency (EPA) have both established action limits, 1.0 mg Hg/g and 0.5 mg Hg/g respectively, for mercury concentrations in fish and shellfish, including crayfish. The FDA's action limit applies to fish and shellfish transported through interstate commerce, while the EPA's action level applies to fish and shellfish taken from bodies of water where recreational and subsistence fishing may be occurring.

There are two primary forms in which crayfish may reach a consumer, fresh or commercially processed. A fresh crayfish is one that is bought live and prepared for immediate consumption by an individual. The commercial process involves peeling, partial cooking and packaging of the tail meat of the crayfish (Moody 1994). Only 15% of Louisiana's crayfish are processed into tail meat, and the large majority of that is distributed only in the State of Louisiana and adjacent areas due to concerns about the freshness of the product. Chinese crayfish are not placed under these same regional strictures, as the exported crayfish are frozen. For this reason, Chinese crayfish are shipped throughout the United States, and are the principle crayfish products sold in most restaurants. Since 1993, the Chinese share of the processed crayfish market has risen from 24.6% to 80%, primarily due to price and availability (USITC 1996).

The purpose of this study was to determine if there are measurable differences in the total mercury concentration of commercially processed Chinese and Louisiana crayfish tail meat, as well as fresh Louisiana crayfish. In addition,

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the mercury concentrations of the different types of crayfish were used to determine the amount of crayfish that could be consumed without exceeding a safe dose of mercury.

## MATERIALS AND METHODS

Total mercury concentrations in crayfish were determined by analyzing samples of crayfish purchased from area supermarkets and restaurants. Four samples of Louisiana and Chinese processed crayfish were purchased and placed in a freezer until analysis. Two sets of live samples were taken from restaurants and analyzed immediately upon return to the laboratory. Sample preparation involved rinsing with distilled water and dissection into approximately one gram tissue samples.

One gram tissue samples were placed directly into individual digestion flasks, and ultra-pure grade $HNO_3$ and $H_2SO_4$ was added to each flask. The samples were then digested following methods similar to Kiavlo et al. (1974). Mercury concentrations were determined by cold vapor atomic absorption spectrometry (CVAAS) using a Bacharach MAS-50B Mercury Analyzer. Samples registering as "non-detect" were assigned values of 0.010 mg Hg/kg and spike recovery ranged from 99.26-l 02.1%.

## RESULTS AND DISCUSSION

There is a statistically significant difference ($\alpha$=0.05) between mercury concentrations in Louisiana and Chinese crayfish. Chinese crayfish were found to have approximately twice the concentration of mercury as Louisiana crayfish. The mean concentration for Chinese crayfish is 0.054 mg Hg/kg (Table 1), and the mean concentrations for the Louisiana processed and fresh are 0.025 mg Hg/kg and 0.021 mg Hg/kg, respectively (Tables 2 and 3). Practically all mercury in shellfish tissue is in the form of methylmercury, which is toxic to humans. Because of the higher cost of methylmercury analysis, the EPA recommends that total mercury be determined and the conservative assumption be made that all mercury is present as methylmercury in order to be most protective of human health (USEPA 1993).

The mercury concentrations of Louisiana and Chinese crayfish are both below the action levels established by the EPA and the FDA. However, it is important to consider how much fish, and therefore how much mercury, is being consumed in an average serving size of crayfish. To determine this, a mercury reference dose is used. The reference dose (RfD) is an estimation of the amount of mercury an individual can consume on a daily basis that is unlikely to cause deleterious effects during a lifetime (USEPA 1995). A RfD of $3 \times 10^{-4}$ is used for adults while a RfD of $6 \times 10^{-5}$ is used for women of childbearing age, which also includes children. Using the concentrations of

**Table 1.** Mean mercury concentrations of Chinese crayfish in mg/kg.

| Chinese Processed Crayfish | Mean mg Hg/kg (wet wt) | Standard Deviation | n |
|---|---|---|---|
| **Brand 1** | **0.044** | **0.011** | **12** |
| **Brand 2** | **0.050** | **0.034** | **12** |
| **Brand 3** | **0.034** | **0.013** | **12** |
| **Brand 4** | **0.086** | **0.025** | **12** |
| **Overall Mean** | **0.054** | **0.030** | **48** |

**Table 2.** Mean mercury concentration of Louisiana processed crayfish in mg/kg.

| Louisiana Processed Crayfish | Mean mg Hg/kg (wet wt) | Standard Deviation | n |
|---|---|---|---|
| **Brand 1** | **0.025** | **0.011** | **12** |
| **Brand 2** | **0.016** | **0.004** | **12** |
| **Brand 3** | **0.024** | **0.016** | **12** |
| **Brand 4** | **0.039** | **0.010** | **12** |
| **Overall Mean** | **0.025** | **0.014** | **48** |

**Table 3.** Mean mercury concentration of Louisiana fresh crayfish in mg/kg.

| Louisiana Fresh Crayfish | Mean mg Hg/kg (wet wt) | Standard Deviation | n |
|---|---|---|---|
| **Restaurant 1** | **0.022** | **0.019** | **12** |
| **Restaurant 2** | **0.019** | **0.008** | **12** |
| **Overall Mean** | **0.021** | **0.015** | **24** |

mercury measured in the fresh and processed Louisiana crayfish and the processed Chinese crayfish, the RfDs were applied to determine a safe daily consumption limit (or serving size) for both men and women (Table 4).

**Table 4.** Maximum serving size (kg) of crayfish that can be consumed without exceeding the RfD. Serving size varies with the body weight, age, and sex of the individual.

| Product | RfD=3×10-4 Adult | | RfD=6×10-5 Women of child bearing age | |
|---|---|---|---|---|
| | 70 kg body weight | 54 kg body weight | 70 kg body weight | 54 kg body weight |
| Chinese(Processed) | 0.389 | 0.300 | 0.078 | 0.060 |
| Louisiana(Processed) | 0.811 | 0.623 | 0.162 | 0.125 |
| Louisiana(Fresh) | 1.000 | 0.771 | 0.200 | 0.154 |

The consumption rate is calculated by the following equation:

$$Cr_{lim} = (RfD \times BW)/C_m$$

where: $Cr_{lim}$ = maximum allowable consumption rate of crayfish per day (kg/d)

RfD = reference dose (mg Hg/kg body wt·d)

BW = body weight (kg)

$C_m$ = concentration of mercury in crayfish (mg Hg/kg)

When the usual serving sizes of Louisiana and Chinese crayfish are compared to the maximum serving size calculated using the RfD, the disparity in mercury concentrations becomes apparent. The general serving size for a prepared meal (jambalaya, etouffee, stew, etc.) of crayfish ranges from approximately 0.056 kg to 0.112 kg and an average serving size of fresh boiled crayfish is approximately 0.273 kg of tail meat. Processed Louisiana crayfish can be safely consumed by adults and women of childbearing age, even under the assumption that more than one serving size may be consumed per person. Fresh Louisiana crayfish can be safely consumed by adults while women of childbearing age should consume less than one serving size to stay within the reference dose. Chinese crayfish may be safely consumed by men (3.5 serving sizes); however, women must consume less than one serving of Chinese crayfish to remain within safe limits.

The mercury concentrations of fresh Louisiana crayfish were not statistically different ($\alpha$=0.05) from processed Louisiana crayfish. There is very little indication from our research that the processing facilities contribute significant amounts of mercury to the final measured concentrations.

Processing procedures in the United States and China are equivalent to one another (USITC 1996). This indicates that there should be no significant

difference between fresh and processed Chinese crayfish. If this is the case, then the possibility arises that the mercury concentrations of Chinese crayfish are of environmental origin. Reports dealing with the environment of China state that over one quarter of the freshwater systems are considered to be highly polluted, and that the environmental policies in place are not strictly enforced (Boxer 1994). This study indicates that processed Chinese crayfish present an increased risk of mercury poisoning.

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