Dietary Manganese Exposure from the consumption of wheat—Probabilistic Health Risks to Children and Teen Populations in Las Vegas

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Overview

In this study, concentrations of Manganese (Mn) and other potentially toxic elements were determined for commonly consumed wheat flour and berries in Las Vegas, using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). In addition, Monte Carlo Simulation (MCS) technique was employed to evaluate non-carcinogenic risk in four life stages (2-4 years, 5-8 years, 9-13 years, and 14-18 years). Wheat intake and body weight data from What We Eat in America, National Health and Nutrition Examination Survey, and National Center for Health Statistics weight for age charts, respectively, were used in the MCS model.

Methods

ICP-MS Analysis (EPA Method 3050B)

1. Samples weighed out in Triplicate to 0.25 grams
2. Samples digested with Nitric Acid via Hot Block
3. Hydrogen Peroxide added and digested again
4. After digestion is complete, deionized water is added to make 50mL solution
5. Samples filtered with syringe filter using 0.45µm pore filter
6. 10x samples created using 5mL of original solution and 45mL of Nitric Acid
7. Samples analyzed using the Inductively Coupled Plasma Mass Spectrometry (ICP-MS)

Target hazard quotient (THQ)

- The THQ is a ratio of determined dose of an element to a reference dose level provided by the Centers for Disease Control at 0.14 mg/kg/day of Mn. If the ratio is less than 1, the exposed population is unlikely to experience obvious adverse effects.
- The method to estimate THQ was provided in the USEPA Region III Risk-Based Concentration Table (USEPA, 2010):

$$THQ = Cn * I * EFr * ED/RfD * Bw * AT$$

Monte Carlo Simulation (Health risk assessment)

- Monte Carlo simulation (MCS) is one of the most broadly used methods for probabilistic risk assessment (PRA) modeling and was employed using Target hazard quotient (THQ) estimations.
- Can assess the variability and uncertainty in the several parameters of the human health risk assessment procedure (Fakhri et al., 2018).
- In the present study, the non-carcinogenic risks of Mn from the consumption of wheat were estimated using MCS (Oracle Crystal Ball software, version 11.1.5072.0, USA).

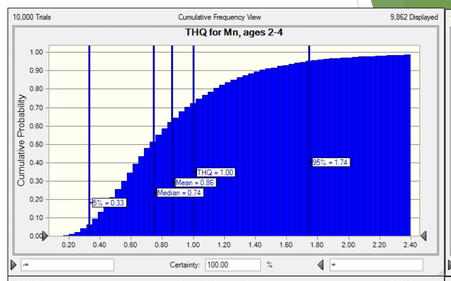
Introduction

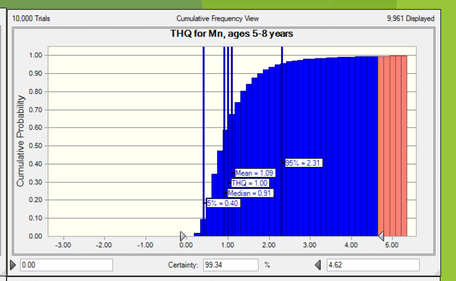
Wheat, produced in different regions or over different seasons, is the third largest U.S. crop in terms of both value and acreage. Wheat flour and grains, which are used to produce a variety of food items, such as bread, noodles, pasta, cakes, biscuits, and cookies, can be major contributors of dietary intake of potentially toxic elements including Manganese (Mn). This could be more pronounced for imported wheat flour, especially from countries where food safety framework is relatively weak. The main sources of Mn in soil and wheat are linked to several natural and anthropogenic activities including industrial activities, and indiscriminate use of chemical inputs (Sachse et al., 2019). Our study was partly aimed at estimating the probabilistic health risk for dietary Mn exposure from wheat consumption in Las Vegas.

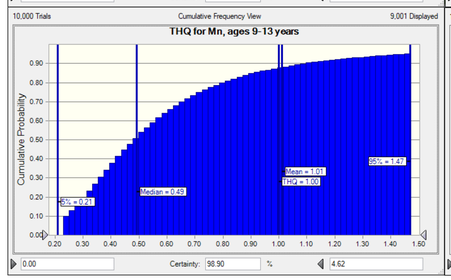
Results

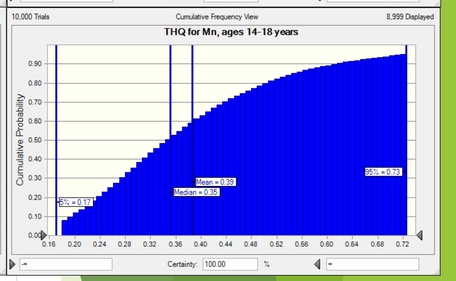
- Ages 2 – 4:
  - Mean THQ = 0.86
  - Probability to exceed threshold – 28%
- Ages 5 – 8:
  - Mean THQ = 1.09
  - Probability to exceed threshold – 32%
- Ages 9 – 13:
  - Mean THQ = 1.01
  - Probability to exceed threshold – 16%
- Ages 14 – 18:
  - Mean THQ = 0.39
  - Probability to exceed threshold – 0%

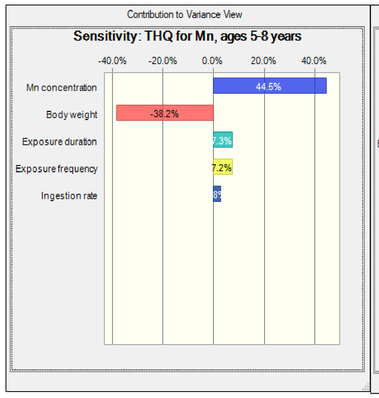
****THQ > 1 signifies possibility of obvious adverse health effects****

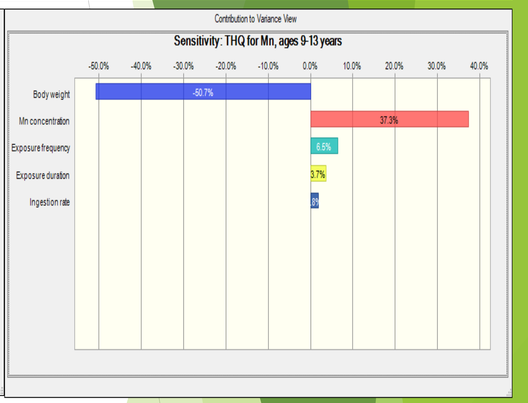












Conclusion

✓The MCS THQ graphs suggests that children aged between 5 and 8 years may have a higher potential Mn-related health risks

✓THQ sensitivity graphs suggest:

- THQ and Body weight are inversely proportional and that an increase in body weight, as a child ages, lowers the risk of adverse effect from Mn.
- Concentration of Mn had the strongest positive impact on THQ estimations, increasing the possibility of health risks
- Exposure frequency and exposure duration also had a positive impact on the risk outcomes across the four life stages

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