BROOKS RAND LABS
MEANINGFUL METALS DATA®

Analysis of Methylmercury Contamination in U.S. Market Rice: A Health Risk to Consumers?

Annie Carter, Michelle Briscoe, Becky Thorsness, Joel Creswell
Brooks Rand Labs, Seattle WA USA

Introduction

Rice is a staple food for vast numbers of people worldwide. With more than 470 million metric tons produced per year, rice is a major source of calories for around half of the world's population, particularly in Asian countries. As contaminants in foods become more of a concern, monitoring of the rice supply for toxic heavy metals and organo-metallic compounds becomes vital for ensuring food safety. There have been few studies published to date pertaining to the methylmercury content of rice at low concentrations.

For this research, we analyzed approximately twenty different ground rice samples for total mercury and methylmercury. The samples include white rice, brown rice, and rice-based children's cereal, all commercially available in the US. We validated our method and results by analyzing the NIST 1568a Standard Reference Material and multiple matrix spikes. We compare our results to the mercury consumption guidelines recommended by the U.S. Environmental Protection Agency, the World Health Organization, the U.S. Food and Drug Administration, and the EU Directorate General for Health and Consumers. We speculate, based on average diet statistics for different groups in the U.S., whether rice purchased on the U.S. market could pose a health risk to consumers due to mercury contamination.

Results

Twenty-two rice samples were tested for both THg and MeHg. The samples were all purchased at grocery stores in the US and were a variety of rice types and source countries. The THg concentrations ranged from 0.84 ng/g to 6.77 ng/g with an average of 2.57 ng/g. The The MeHg concentrations ranged from approximately 0.94 ng/g to 4.86 ng/g with an average of 2.05 ng/g. (Figure 1)

Figure 2. The percentage of mercury present in the rice samples as MeHg ranged from 54% to 112% with an average of 84%. The five samples that had MeHg results higher than the THg results all had RPDs within the acceptance criteria of duplicate precision for this method and it indicates that all mercury present in those samples is in the form of MeHg.

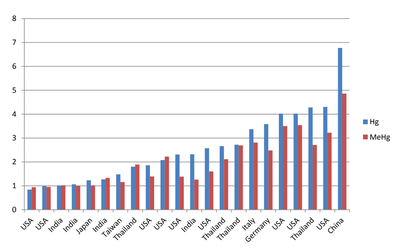

Figure 1

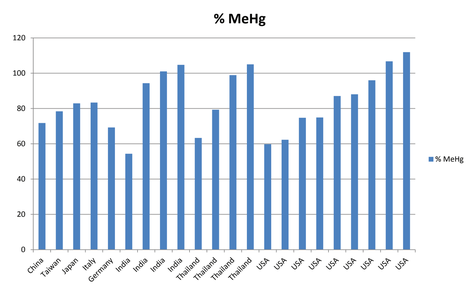

Figure 2

Figure 3. Four of the rice samples were prepped in duplicate (Dup) and had matrix spikes (MS) and matrix spike duplicates (MSD) performed on them. The duplicates were evaluated by calculating the relative percent difference (RPD) between the native sample and the duplicate. The highest RPD was 11% and the lowest was 1%. The MS/MSDs for both THg and MeHg were spiked with approximately 15 ng/g of the analyte of interest. The average spike recovery for THg was 98% with a range of 85% to 107%. The average spike recovery for MeHg was 107% with a range of 84% to 121%.

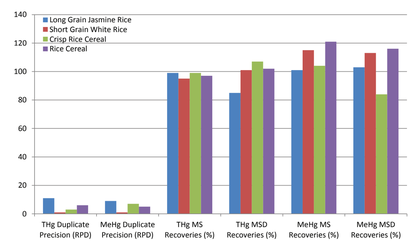

Figure 3

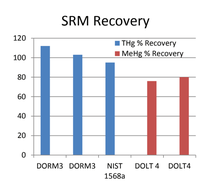

Figure 4

Figure 4. Standard reference materials (SRM) were prepared with the samples. For THg, two different SRMs were prepared: DORM3 (fish tissue) and NIST 1568a (rice flour). For MeHg, DOLT4 (dogfish liver) was prepared. Though the rice flour SRM would have been more relevant, it does not have a certified MeHg value. All SRM recoveries were within the method acceptance criteria.

Conclusions

Based on results of the duplicates, matrix spikes, and reference materials, the methods for both total mercury and methylmercury were acceptable. Additionally, the detection limits for both methods were adequately low for rice testing.

Based on even the most stringent RfD guidelines from the EPA, all 22 of the rice samples tested were low enough that it is not likely that they pose a significant risk to human health.

The percentage of mercury present in the rice as methylmercury averaged 84% in the rice we tested. Though the rice we tested was relatively low, in areas where rice is found to have higher concentrations of mercury, this could be a significant factor in the health safety.

Putting it into Perspective

Though mercury is not a mineral that is necessary for any body functions, humans are able to tolerate some level of mercury exposure. The FDA, EPA, EU, and WHO have all established different reference dose (RfD) guidelines for mercury and/or methylmercury consumption.

	THg µg /kg bw/day	MeHg µg /kg bw/day
EU	0.7	0.2
FDA	0.4	
EPA	0.1	

Figure 5. Reference dose guidelines in micrograms of mercury/methylmercury per kilogram of bodyweight per day.

Based on the results of our research and the most stringent RfD (the EPA's RfD of 0.1 µg/kg bw/day), three different scenarios are depicted in the pie charts below.

Figure 6. Worst Case: The pie chart above shows the portion of mercury for a 100 lb person that eats 1 serving of rice per day of the highest level of rice tested (6.77 ng/g) compared to the EPA's reference dose of 0.1 µg/kg bw/d.

Figure 7. Average: The pie chart above shows the portion of mercury for a person of average weight (166 lbs) that eats the average American consumption of rice per day (34 grams) of the average level of rice tested (2.57 ng/g) compared to the EPA's reference dose of 0.1 µg/kg bw/d.

Figure 8. Baby: The pie chart above shows the portion of mercury for an infant of average weight at 6 months old (16.5 lbs) that eats 3 serving of rice cereal per day of the level of rice cereal tested (3.58 ng/g) compared to the EPA's reference dose of 0.1 µg/kg bw/d.

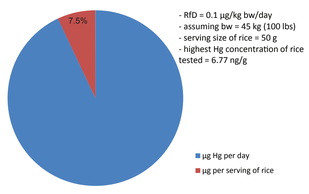

Figure 6

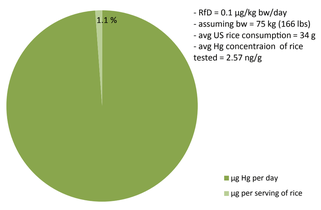

Figure 7

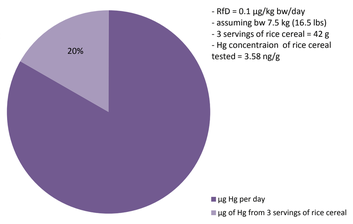

Figure 8

Methods

An aliquot of each rice sample was removed directly from the bag and homogenized in a Magic Bullet blender for approximately 20 seconds until powdered. Aliquots of the ground rice samples were then prepared for total mercury (THg) and methylmercury (MeHg). Standard Reference Materials (SRM), sample duplicates, matrix spikes, and matrix spike duplicates were prepared to validate the analytical and extraction procedures.

Total Mercury Sample Prep

Approximately 0.5 grams of homogenized rice was weighed out into a 40 mL borosilicate glass vial with a Teflon lined lid. To that, 3 mL concentrated sulfuric acid was added and allowed to react for approximately 30 minutes. 7 mL concentrated nitric was then added slowly and the vial was loosely capped and allowed to react overnight. The sample was not heated but a considerable amount of heat was generated when the acids were added. 0.5 mL 2N BrCl was added and the sample was brought up to 40 mL with deionized water. A maximum volume of 1 mL of the sample preparation was analyzed. All analysis was done on a Brooks Rand Instruments MERX-T following EPA Method 1631 Appendix E. The detection limit was 0.2 ng/g.

Methylmercury Sample Prep

Approximately 100 milligrams of homogenized rice was weighed out into a 5 mL solid Teflon vial. To that, 1 mL of a 25% KOH in methanol solution was added. The sample was then vortexed to ensure complete mixing then heated to 65 °C for 4 hours. After cooling, the sample was brought to 2.5 mL with methanol. A maximum of 0.030 mL of the sample preparation was analyzed. All analysis was done on a Brooks Rand Instruments MERX-M following EPA Method 1630. The detection limit was 1.0 ng/g.