Reducing Arsenic In Rice
Scientists search for ways to lower levels of the toxic element in the widely eaten grain

By Britt E. Erickson

Department: Government & Policy
Keywords: rice, arsenic, food

Billions of people around the world depend on rice as a major source of nutrition. Half of the world’s population eats this grain every day. So alarm and confusion spread after magazine reported late last year that hundreds of rice-based products sold in the U.S. contain inorganic arsenic at levels that put infants and children at risk of getting cancer, heart disease, and type 2 diabetes later in life.

It wasn't the first time Consumer Reports raised concerns about the presence of arsenic in rice. The magazine first highlighted the issue in 2012. The following year, the Food & Drug Administration released the results of its own investigation. The agency analyzed about 1,300 samples of rice and rice products. Average levels of inorganic arsenic in the products ranged from 0.1 to 7.2 µg per serving.

For an average serving size of 45 g, that equates to 0.002 to 0.16 mg of arsenic per kg of rice. Agency scientists concluded “the amount of detectable arsenic is too low in the rice and rice product samples to cause any immediate or short-term adverse health effects.”

Currently there are no legal limits for arsenic content in food sold in the U.S. and the European Union. Last year, however, the World Health Organization (WHO) recommended a maximum level of 0.2 mg/kg rice.

The European Commission, the executive arm of the EU government, has proposed a limit of 0.2 mg/kg for white rice, 0.25 mg/kg for brown rice, 0.3 mg/kg for polished rice, and 0.1 mg/kg for rice products intended for children. The new limits are likely to take effect next year.

The European rice industry backs the proposed rule, saying it will provide clarity to consumers by setting clear regulatory limits on the element. Rice sold in the EU is already in compliance with the proposal, says the Federation of European Rice Millers, an industry group. During the past 18 months, routine industry testing of about 700 samples of rice grown in and outside of the EU showed 99% conformed to the proposed EU arsenic limits, the group notes.

In the U.S., FDA is assessing the long-term risks of consuming low levels of arsenic in rice. Chronic exposure to high levels of arsenic is associated with skin, bladder, and lung cancers and heart disease. FDA is investigating how much arsenic is typically consumed from rice and rice products and whether there are variations in health effects within segments of the U.S. population.

Scientists are also examining the health effects of exposure to arsenic at levels typically consumed in a Western-style diet. At Dartmouth College, one group is investigating the role arsenic plays in respiratory diseases and disruption of the fetal immune system. Another Dartmouth team is studying whether arsenic exposure can influence cardiovascular disease risk factors—such as glucose metabolism, blood pressure, and markers of inflammation—in pregnant women.

Other researchers are looking for ways to lower the amount of arsenic in rice and rice-based foods. A third team of scientists at Dartmouth is screening different cultivars of rice looking for ones that accumulate the lowest amounts of arsenic. Meanwhile, a group in Northern Ireland at Queen’s University Belfast is developing ways to cook rice that lower the amount of arsenic in the finished food that people eat.

Arsenic levels vary depending on the type of rice and where it is grown. Some arsenic in rice originates from natural sources in soil and groundwater. But some of it also stems from pesticides that were formerly applied to rice fields.

Inorganic arsenic, which is more toxic than organic forms of the metalloid, exists in the environment as arsenite (AsO\textsubscript{3}\textsuperscript{3-}) and arsenate (AsO\textsubscript{4}\textsuperscript{2-}). Under anaerobic conditions such as those found in flooded rice paddies, arsenite predominates. “That is bad, because rice can’t
distinguish between arsenite and silicic acid,” says Mary Lou Guerinot, associate director of the Toxic Metals Superfund Research Program at Dartmouth.

“Rice takes up silicon because it is very beneficial for the rice plant,” Guerinot explains, noting that silicon strengthens the rice plant’s stem and protects against pathogens. Rice can accumulate 10 times more silicon than other grasses, and that means it can accumulate 10 times more arsenic, she adds.

Under more aerobic soil conditions, arsenate is the major form of inorganic arsenic. Rice plants can’t distinguish arsenate from the nutrient phosphate, Guerinot says. Thus, the plants take up arsenate the same way as they do phosphate.

Neither form of arsenic appears to harm the plant. But rice takes up this arsenic at the expense of valuable silicon or phosphate.

Guerinot’s team has analyzed the arsenic content of nearly 2,000 different types of rice. Many varieties, particularly unpolished brown rice, have levels higher than that recommended by WHO, Guerinot says. “If we find low arsenic-accumulating cultivars, they could go immediately into arsenic-rich soils and they could be used as stock for breeding programs.”

But there is a trade-off, Guerinot says. Rice plants that take up less arsenic will also take up less silicon. As a result, they will not be as sturdy and may fall over and be damaged in heavy winds. In addition, rice plants that take up less silicon are more susceptible to diseases, she says.

In the short term, a simpler way to remove arsenic from rice may be to change the way it is cooked. Andy Meharg, professor of plant and soil sciences at the Queen’s University Institute for Global Food Security, and colleagues have shown that using excess water to cook rice and pouring off the extra water decreases the amount of arsenic in cooked rice.

Cooking with a water-to-rice ratio of 12:1 by volume, Meharg and colleagues found, can remove nearly 60% of the arsenic from the grain. The researchers discovered that even more arsenic—up to 85%—can be removed from rice using an off-the-shelf coffee percolator. The scientists published their results last month in the journal PLOS One (2015, DOI: 10.1371/journal.pone.0131608).

“We rethought the method of rice cooking to optimize the removal of inorganic arsenic,” Meharg says. “We discovered that by using percolating technology, where cooking water is continually passed through rice in a constant flow, we could maximize removal of arsenic.” The researchers have applied for a patent on their percolating rice cooker. They are hoping the technology will soon end up in kitchens around the world.

In the meantime, Dartmouth researchers are working to quantify the amount and form of arsenic in gluten-free products such as cookies and crackers, which are typically made with rice flour instead of wheat flour. They are also developing a website highlighting the risks of arsenic in food and water to help educate consumers and policy-makers.

Consumer advocacy groups are putting heat on FDA to finalize its risk assessment of arsenic in rice. This pressure has already led regulators to look for ways to decrease the amount of arsenic in the environment and the human diet.

FDA, for example, in 2013 proposed a guideline of 10 ppb for arsenic in apple juice, the same level set by the Environmental Protection Agency for arsenic in drinking water. The move came two years after test results released by the television program “The Dr. Oz Show” and Consumer Reports raised red flags about arsenic in apple juice. FDA was unable to reproduce their test results, but the agency established a limit “to provide guidance for industry.”

During the past few years, FDA has also encouraged drugmakers to remove more than 100 arsenic-based veterinary drugs from the market. Such drugs were once routinely given to poultry to prevent disease. FDA announced in April that manufacturer Zoetis will stop selling nitarsone—the only arsenic-containing animal drug in the U.S. still approved for preventing disease in food animals—later this year.

“Because poultry won’t be fed arsenic, a known carcinogen, the spread of arsenic into the food supply will be curtailed,” says Urvashi Rangan, executive director of Consumer Reports’ Food Safety & Sustainability Center. “Poultry manure used for fertilizer will contain less arsenic and won’t contribute to contamination of crops and the environment,” she says. The group is now urging EPA to phase out the use of arsenic in pesticides.

Rep. Rosa DeLauro (D-Conn.) is also putting pressure on FDA to act. The congresswoman introduced legislation (H.R. 2529) in May that would limit the amount of inorganic arsenic permitted in rice and rice-based foods sold in the U.S. The bill, the proposed R.I.C.E. (Reducing Food-based Inorganic Compounds Exposure) Act, would require FDA to set a maximum permissible level of inorganic arsenic in rice. The bill is unlikely to be taken up this year, as Congress has a full agenda.

Rice industry groups maintain that the grain provides health benefits that outweigh the potential risks of exposure to low levels of arsenic. They also point out that arsenic concentrations in nearly all rice samples tested by regulators and industry officials since
2012 have been below WHO-recommended limits. Nonetheless, the industry groups say, pressure from advocacy groups and lawmakers will likely continue, along with consumer confusion, until U.S. and EU regulators set a limit for arsenic in rice.