Executive Summary

Arsenic is a toxic metalloid element, and no amount of it is considered safe. Low-dose chronic exposure to arsenic is a well-known cause of skin, lung, and bladder cancer, and is associated with cancers of the kidneys, liver, and prostate. Each year scientists are learning more and more about the potential noncancer health effects of chronic arsenic exposure, such as diabetes, heart disease, and immunological effects.

Arsenics can be grouped into two main categories (chemical types): inorganic and organic (not to be confused with "organic" as defined by the Department of Agriculture—"organic arsenic" is a chemistry term). The inorganic forms of arsenic are considered to be the most harmful; some organic forms are considered to be slightly less harmful; and one organic form, arsenobetaine (the main type found in fish), is believed to be relatively nontoxic. The main routes of exposure to the most harmful types of inorganic arsenic are through food and water. One of the foods with the generally highest levels of inorganic arsenic is rice.

Though arsenic is a naturally occurring compound, humans have caused more arsenic to be released into the environment than Mother Nature. They continue to recycle arsenic in the food supply through the use of arsenic-based pesticides, drugs, and rice byproducts in agricultural production.

In the current study Consumer Reports sought to determine whether some types of rices were lower in arsenic than others, whether alternative grains such as quinoa were lower in arsenic than rice, and to revise and expand our analysis of arsenic in rice-containing processed foods. In conducting this analysis we tested 128 samples of basmati, jasmine, and sushi rice, and combined that data with the data from our 2012 test, as well as the Food and Drug Administration's (FDA) data, to create a data set of 697 total rice samples (see table below for details). We also tested 114 samples of alternative grains and analyzed FDA data of 656 foods containing rice. This is what we found based on our analysis:

- Basmati rice from India, Pakistan, or California, and sushi rice from the U.S. had the lowest levels of total inorganic arsenic compared with other types of rice. Those are the best choices for consumers to reduce exposure to arsenic from rice.

- Because of the significantly lower levels of total inorganic arsenic, we have revised our recommendations for consumption of basmati and sushi rices. Consumers can eat about 4.5 weekly servings, more than twice as much rice per week as we previously recommended of basmati rice from India, Pakistan, or California, or sushi rice, and not increase lifetime population cancer risk. For other types of rice we still recommend two servings per

week for adults and 1 1/4 servings per week for children. A serving size of rice is approximately 45 grams (1/4 cup) uncooked.

- In general, rice labeled as from the U.S. or from Arkansas, Louisiana, or Texas tended to have the highest levels of total inorganic arsenic compared with rice from elsewhere.

- Brown rice of a particular type always had higher levels of inorganic arsenic than white rice of the *same type*. But the origin of rice can also affect arsenic levels in addition to type. Brown basmati rices from India, Pakistan, or California are better choices for brown rice. Those brown rices have lower levels of inorganic arsenic than other brown rices from all other parts of the U.S.

- Alternative grains to rice such as amaranth, millet, and quinoa all have significantly less inorganic arsenic than rice.

- Based on our analysis of the rice-containing foods in the FDA data set, we have revised some of our previous advice on ways to limit exposure to arsenic from foods by slightly limiting servings per week. Consumers who eat a lot of rice and rice products, such as those on a gluten-free diet, can reduce their exposure to arsenic by limiting consumption of those products and incorporating more non-rice-based, non-gluten-based grains.

- We created a point system for rice-containing foods to help consumers reduce their exposure to arsenic from a variety of foods. In the table below, a serving of each food is equal to the number of points below the product type. We recommend that over the course of a week children and adults do not exceed more than 7 points, on average.

- Children (up to 70 pounds) should rarely eat hot rice cereals or rice pastas. Those products all had 95th percentile total inorganic arsenic levels that were above 9 micrograms per serving. (The 95th percentile is the value that 95 percent of the other observed values are below—so it is one of the highest values.)

Food	Infant Cereal	Hot Cereal	Ready-to-Eat Cereal	Rice Drinks	Rice	Rice Pasta	Savory Rice Snacks	Rice Cakes
Serving Size	15 g	40 g	30 g	240 ml	45 g	55 g	30 g	30 g
Adult Points*	NA	3 1/2	2 1/4	2	3 1/2	3	1 1/4	2 1/2
Child Points*	1 1/4	**8 1/4**	4 1/2	-	5 1/2	**7 1/4**	2 3/4	6 1/4

*Calculations are for a child up to about 12 years of age (up to about 70 pounds) and an adult weighing 176 pounds, except for Infant Cereal recommendations, which apply only to infants (up to 1

year of age). Note: Point calculations are based on the 95th percentile levels of inorganic arsenic for each product category in the FDA data set.

Food	Cake & Muffin Mix	Brownie Mix	Pie & Pizza Crust	Pudding	Cookies	Sweet Rice Snacks	Cereal & Granola Bars	Energy Bars
Serving Size	55-80 g	40 g	40-55 g	30g	30 g	30 g	40 g	40 g
Adult Points*	$1\frac{1}{2}$	$\frac{1}{2}$	1	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{1}{2}$	$1\frac{1}{4}$	$1\frac{1}{4}$
Child Points*	$3\frac{3}{4}$	$1\frac{1}{4}$	2	$1\frac{3}{4}$	$1\frac{3}{4}$	$1\frac{1}{4}$	$2\frac{3}{4}$	$2\frac{3}{4}$

*Calculations are for a child up to about 12 years of age (up to about 70 pounds) and an adult weighing 176 pounds. Note: Point calculations are based on the 95th percentile levels of inorganic arsenic for each product category in the FDA data set.

Additional Advice for Consumers

- In addition to exposure to inorganic arsenic from rice, well water represents potential for exposure. People who get their water from a private well should have it tested.

What the Government Should Do

- The FDA needs to complete its risk assessment of arsenic in rice and set a limit this year for the amount of arsenic in rice to protect consumers from the toxic element.

- Based on a review of the science, Consumers Union, the advocacy arm of Consumer Reports, believes the FDA should set a limit for total inorganic arsenic in rice of 120 parts per billion.

- The FDA should immediately address the risk for children consuming rice and commonly consumed rice-based foods, including rice cereals, pastas, and beverages, by setting standards for inorganic arsenic in those foods.

- The FDA should remove the approval for the remaining arsenic-containing animal drug nitarsone.

- The EPA should ban the use of arsenic-based pesticides for all applications.

Introduction

The Consumer Reports Food Safety and Sustainability Center is committed to ensuring that consumers have access to a fair, just, and safe food system. The center works in many domains, and one of its core goals is to eliminate toxins from the food supply. Heavy metals, especially arsenic, and their continued cycling through our food are a major concern. Since the publication of our first report on "Arsenic in Apple Juice" in January 2012 and "Arsenic in Your Food" in November 2012, the center has continued to investigate the presence of arsenic in our food and work with stakeholders to reduce it. In the current investigation we have attempted to respond to consumer questions regarding the presence of arsenic in additional types of rice, rice products, and other grains by conducting additional testing and analysis.

Background

For thousands of years the deadly consequences of high arsenic exposure have been known and helped to make that tasteless and odorless metalloid element a popular choice for poisoners.[1] The relatively high amounts required for a lethal dose have been understood since ancient times, but it is only in the past several decades that scientists have begun to appreciate the effects of low-dose chronic arsenic exposure on human health.[2]

Arsenic can be found in two principal chemical forms: inorganic and organic. (Those are chemical terms and have nothing to do with organic agriculture practices.) Inorganic forms of arsenic are generally considered to be most toxic. Organic forms are also toxic but are considered to be less so. The organic and inorganic forms of arsenic can interconvert, though, so organic arsenic can be transformed into inorganic forms. Arsenobetaine, the organic form of arsenic found in seafood, is generally considered to be relatively nontoxic.[3]

Arsenic is one of the World Health Organization's (WHO) top ten chemicals of public health concern[4] and is well recognized by numerous governments and international bodies as a human carcinogen. The International Agency for Research on Cancer (IARC), part of the WHO, states that arsenic and inorganic arsenic are "Carcinogenic to Humans" (Group 1),[5] the United States National Toxicology Program (NTP) places arsenic and inorganic arsenic compounds on its list of substances "known to be human carcinogens,"[6] and the Environmental Protection Agency (EPA) has classified arsenic in its most definitive category as a human carcinogen.[7] Arsenic is known to cause skin, lung, and bladder cancer; is associated with cancers of the liver, kidneys, and prostate;[8] and may be quite potent. In fact, in a 2010 draft assessment, the EPA determined that arsenic's cancer potency was 17 times greater than a previous assessment, which would have made it the second-most-potent carcinogen that the EPA has evaluated.[9] But because of political pressure, that risk assessment never made it past the draft stage. The EPA was forced to start over on its assessment in 2013 after Congress included report language in the agency's budget requiring the

reboot.[10] The process is expected to take at least three years, and until then regulatory actions will probably be based on the older, outdated assessments.

In addition to inorganic arsenic being a carcinogen, chronic exposure to relatively low doses of it is also associated with the development of a variety of conditions, including diabetes, heart disease, and immune-system changes.[11,12,13]

In many places around the world and some places within the U.S., water is the main source of arsenic exposure, but for most in the U.S., food is usually the primary source.[14] After fish (which contains mostly arsenobetaine, generally regarded as a safe form of organic arsenic), rice appears to be one of the greatest contributors of arsenic (mostly inorganic) in the diet.[14,15,16]

Inorganic Arsenic in Rice: Common Questions and Answers

Why does rice have inorganic arsenic in it?

Rice plants like to take up arsenic from the soil, and that arsenic can accumulate in the rice grain. There are many factors that can affect how much arsenic the plant takes up, including the variety of rice and the conditions in which it is grown. For example, rice is commonly grown in flooded fields, and flooding the fields can promote the uptake of arsenic.[17] Soils and water in different locations can have varying levels of arsenic[42] that could effect how much of it ends up in rice planted there, so where you plant may make an important difference. There are also likely to be many other currently unknown factors that influence arsenic levels.

Where does the arsenic come from? Isn't it just part of nature?

Arsenic is a naturally occurring element and can be found at naturally widely varying levels in the soil and water in different locations throughout the globe and even the U.S.[42] That being said, human beings have a long history of using arsenic in pesticides and in animal feed, as well as in other products (such as paint, wallpaper, and cosmetics!), and human interventions have led to the release of far more arsenic in the environment than have natural sources.[18] Even today we still have many agricultural practices that lead to the cycling of arsenic in our food supply. For example, rice bran, which tends to be high in arsenic, is often used in animal feed[19,20,21] and bedding,[21] then the animal manure is used as a fertilizer for things such as rice.[22,23]

Did you say that arsenic is used as an animal feed?

Arsenic has been a component of drugs fed to chickens and swine to promote growth, pigment muscle, and prevent disease for many decades.[24,25] Chicken manure is a fertilizer that can be used in rice fields[22,23] and is sometimes fed to other animals.[26] The type of arsenic used in animal drugs is an organic form, but scientists have found that organic forms of arsenic can be converted to inorganic forms in

animals as well as in the soil.[27,28] In 2011 the FDA published a study of chickens fed an arsenical drug called roxarsone and found that the birds that received the drug had higher levels of inorganic arsenic in their livers than birds that did not receive the drug.[29] As a result of that study, roxarsone manufacturer Pfizer voluntarily withdrew the drug from the market.[30] In 2013 the FDA removed approvals for roxarsone as well as two other arsenical drugs.[31] There is still one arsenic drug approved for use in chickens and turkeys, called nitarsone.[32] It is very similar in structure to roxarsone. There is no data on how much of the drug is fed to birds, but Consumers Union believes that this remaining arsenical drug should also be banned.

Arsenic-based pesticides aren't actually used anymore, are they?

Yes, they are. Organic-arsenic-based pesticides are still permitted to be used in the U.S. on golf courses, highway medians, and sod farms.[33] Their use was supposed to have been phased out in 2013, but that still has not occurred.[32] Though those pesticides may contain an organic form of arsenic, organic arsenic can be converted to inorganic forms in the soil.[34]

Inorganic-arsenic-based pesticides were in use for almost a century before their use was banned in the U.S. in 1988.[35,36] Those pesticides were used on many agricultural crops, including cotton and apples.[37,38] Because of arsenic's metallic nature, it does not simply go away when the pesticide use has stopped. Cotton was a common crop in the south-central U.S., and that area is now also a popular rice-producing region.[38]

Consumers Union believes the use of all arsenic-containing pesticides for all uses should be banned.

I've heard brown rice has more arsenic in it than white rice. Why is that?

Arsenic accumulates in different parts of the rice plant, especially the outer parts of the grain. To make white rice, the outer layers of the rice grain are polished off, and with them goes some of the arsenic. Because more of the fibrous outer layers of the grain are left in brown rice, the brown varieties tend to have higher levels of arsenic than white rice of the same type. That doesn't mean you should skip brown and eat only white rice. Brown rice may have other nutritional benefits that white rice doesn't have, so if you follow our advice of limiting consumption of most rice to two servings per week, you can eat either brown or white.[17]

People in Asia eat a lot of rice, don't they? Do they have higher rates of lung and bladder cancer as a result?

There is no evidence that people who eat a lot of rice have higher rates of lung and bladder cancer than people who don't. Good studies looking at that have yet to be conducted, though. It seems like it would be easy just to compare the populations from two countries or regions to answer that question, but it is actually not so straightforward, and carefully designed studies on that subject need to be done. This

past year a study was published that demonstrated that people who frequently ate rice with relatively high levels of arsenic were more likely to have cells in their bladders that had damage to chromosomes that could be associated with cancer.[48]

Are there any limits for arsenic in rice or any other foods?

Though there are U.S. regulatory for limits for the amount of arsenic permitted in water (10 ppb), there are no limits for arsenic in food.[17] Recently the FDA proposed an action level for arsenic in apple juice at 10 ppb, which is still pending finalization.[39] Consumers Union believes that this level is too high and that based on the science, it should be set at 3 ppb.

At the international level, the Codex Alimentarius Commission, which was established by the Food and Agriculture Organization of the United Nations (FAO) and the WHO, and sets international standards for foods, recently adopted a maximum level for inorganic arsenic in rice of 0.2 milligrams per kilogram (200 ppb).[40] That is an important first step in establishing a limit for arsenic in rice, though Consumers Union believes the public would be better served by an inorganic-arsenic limit of 120 ppb.

I eat a lot of rice. Should I get tested for arsenic?

Just because you eat a lot of rice doesn't mean you should rush out and test your urine for arsenic. But if you are in one of the 15 million[41] American households that drinks water from a private well, you should have your well tested if you haven't already. Arsenic concentrations in ground water vary greatly across the country. Concentrations can be especially high in water in the New England states as well as parts of California, Texas, Michigan, Washington, Arizona, and Idaho.[42] In Maine and New Hampshire it's estimated that about 30 percent of wells produce water with arsenic levels above the EPA limit.[43] For information on how to get your water tested, contact your local health department or check out Dartmouth College's Arsenic in Well Water web page.[44]

In your article "Arsenic in Your Food," from 2012, you suggested that rice from California, India, and Thailand as a group had lower levels of arsenic than rice from the south-central U.S. Do you have any more advice about which rices have the lowest amount of arsenic?

Questions like this led us to do some additional analysis and testing. You will find the answer to this question and more below.

Consumer Reports and Arsenic in Rice & Rice Products

In the November 2012 edition of Consumer Reports magazine, we published our analysis of 223 samples of various rice and rice products, including white and brown rice, rice drinks, rice pasta, rice cereals, and infant rice cereals. We found varying levels of arsenic in the products we tested and noted that rice from Arkansas, Louisiana, Missouri, and Texas, which account for the majority of rice produced in the U.S., generally had higher levels of inorganic arsenic than rice from elsewhere. There was insufficient data to make any further determinations about origin and types of rice. But all of the levels we found in all types of rice and rice products we tested were concerning, so we created a table (below) to provide guidance for consumers on how to reduce their exposure to inorganic arsenic from rice and rice products.

Limit your exposure

Rice product	Infant cereal	Hot cereal	Ready-to-eat cereal	Rice drink	Rice	Rice pasta	Rice crackers	Rice cakes
Approximate serving size uncooked	¼ cup	¼ cup	1 cup	1 cup	¼ cup	2 oz.	16-18 crackers	1-3 cakes
Children	1 serving/day	1¾ servings/week	1½ servings/week	–	1¼ servings/week	1½ servings/week	½ serving/day	1 serving/week
Adult	NA	2½ servings/week	3 servings/week	½ serving/day	2 servings/week	3 servings/week	1 serving/day	2½ servings/week

CR 2012 table: Currently out of date—see new table for current recommendations.

In addition, Consumer Reports recommended that Consumers diversify their grains and experiment with other grains such as quinoa, millet, and amaranth, though they had not been studied extensively. Consumers Union, the advocacy arm of Consumer Reports, also called on the Food and Drug Administration to set limits on the amount of arsenic permitted in rice to protect consumers.

As a result of our investigation—and the same day our report was published online— the FDA released results from 200 samples of rice and rice products that it had tested.[45] Its results were from part of a larger sample that the FDA was analyzing, and the levels of arsenic were similar to what we had found. Then on Sept. 6, 2013, the FDA released the test results from the remainder of its samples, an additional 1,100 analytical results.[46] The FDA is using those results to conduct a risk assessment and to determine what actions it will take.

Consumer Reports analyzed that larger data set in the beginning of 2014 and found that among types of white rice, the parboiled version tended to have the highest levels of inorganic arsenic, instant rice had the lowest, and medium-grain rice from California tended to have lower levels of inorganic arsenic than rice originating from other areas of the U.S. Again, there was insufficient data to make any additional

determinations about the relationship between arsenic levels and other rice types or origins.[47]

Consumers have continued to ask Consumer Reports whether any types of rice were lower in arsenic than others, and until now we have not been able to give them any more definitive answers than the above. Because our 2012 data suggested that imported basmati and jasmine rice might have lower average levels of arsenic than other types, we decided to test additional imported basmati and jasmine rice as well as domestic sushi rice, for which little data existed in our data set or the FDA's. In addition, we decided to test some of the alternative grains that we had recommended but for which little research was available in the U.S. As a result of that expanded testing and combining our results with the FDA's, we are now able to make clearer distinctions between rice types and give consumers useful advice. Using the FDA data set we also have updated and expanded our analysis of rice products to provide enhanced advice on how to reduce the risk from exposure to arsenic in rice and rice products.

Consumer Reports Latest Tests

What We Did

From April to May of 2014 we purchased 128 packages (samples) of basmati, jasmine, and sushi rice in the New York, Atlanta, and Los Angeles metro areas from a variety of brands. In some cases we purchased multiple varieties from the same brands. In addition, we purchased 114 packages (samples) of alternative grains including amaranth, barley, buckwheat, bulgur, farro, millet, polenta/grits, and quinoa from a variety of brands.

Our sample pool for Jasmine and Basmati rices represents the majority of the market for these products. Additional brands of rice, sushi rice, and other grains were selected by visiting multiple supermarkets and identifying brands with wide availability.

For each product identified and found, we purchased and tested between one and three lots as available in the markets. Tables 1 and 2 below contain information on how many individual packages and models of each were purchased and tested for this project. (A model is a single product from a single brand.)

Table 1

Rice CR2014			
	Basmati/Texmati	Jasmine	Sushi
Models (Domestic)	9	0	9
Models (Imported)	18	13	0
Total Models	27	13	9
Packages (Domestic)	27	0	24

Packages (Imported)	43	34	0
Total Packages	70	34	24

Table 2

Alternative Grains CR2014								
	Amaranth	Barley	Buckwheat	Bulgur	Farro	Millet	Polenta/Grits	Quinoa
Models	4	6	2	5	3	5	7	18
Packages	9	15	5	10	7	10	13	45

For our statistical analysis of the rice data we created a data set with 697 samples by combining the current data set (referred to as CR2014) with our 2012 data set (referred to as CR2012) and with the FDA's complete data set. Our new large data set contained samples with the following characteristics:

Table 3

	FDA data		**CR 2012**		**CR2014**		
	Brown	**White**	**Brown**	**White**	**Brown**	**White**	**TOTAL**
Basmati/Texmati, Domestic	7	9	3	9	14	13	55
Basmati, Imported	4	24	0	9	4	39	80
Sushi, Domestic	0	3	0	0	0	24	27
Jasmine, Domestic	0	3	0	0	0	0	3
Jasmine, Imported	2	8	0	9	3	31	53
Generic Long-Grain, Domestic	0	149	0	30	0	0	179
Generic Medium-Grain, Domestic	0	89	0	0	0	0	89
Generic Short-Grain, Domestic	0	22	0	0	0	0	22
Brown Nonaromatic, Domestic	98	0	22	0	0	0	120
Parboiled (all)	1	36	3	6	0	0	46
Quick Cook (all)	1	14	0	0	0	8	23
TOTAL	113	360	31	66	21	115	**697**

Using this new data set we conducted a statistical analysis to look for the types and origins of rice with the lowest levels of arsenic. The results of that analysis are in the "What We Found" section below.

Analysis of Rice-Containing Products

We conducted a separate analysis on the FDA's 1,300-sample data set (FDA data only) of rice-containing products. That data set contains information on a variety of processed foods, including products from food categories such as pastas, bars, cookies, and cereals. We identified the products in the FDA database that were gluten-free and conducted an analysis to determine the levels of inorganic arsenic per serving in those foods. We also conducted a cancer risk assessment to access the risk of excess cases of cancer in the adult population as a result of consumption of inorganic arsenic in foods over a lifetime. To calculate maximum excess cancer risk

we used a cancer slope factor (CSF) of 25.7 milligrams per kilogram of body weight per day for the combined risk of inorganic arsenic for skin, bladder, and lung cancer as derived in the EPA IRIS 2010 draft reassessment of the arsenic CSF. We determined the maximum amount of arsenic per capita per day that a population would need to consume over a lifetime to not exceed a very lenient risk tolerance. Though an ideal risk tolerance would be less than one excess cancer case in 1 million people, we chose to use a tolerance of about one excess case of cancer in 1,000 people.

After we derived this maximum arsenic exposure value, we assigned it a point value by dividing it by the 95th percentile value of inorganic arsenic per serving we found in the gluten-free foods in the FDA database. We recommend that consumers try to eat no more than 1 point per day, but because this is lifetime risk, it can be averaged over the course of a week or more. For example, in a week we would recommend that a consumer eat no more than 1 point times seven days, or 7 points per week on average.

To derive our recommendations for childhood consumption, we took a life-stage approach to analyzing lifetime cancer risk. We calculated the excess cancer risk for six age groups by varying serving size so that the lifetime risk would not exceed the lenient risk tolerance of about one case per 1,000 people. For the adult age group we used the daily intake that we arrived at by the method described above, then determined the daily consumption that could be eaten without exceeding a risk tolerance of about one in 10,000 excess cases of cancer for any childhood life stage (about ages 1 to 12 or up to about 70 pounds). The weekly consumption (servings per week) was calculated by multiplying the daily consumption rate by seven, then seven days were divided by the weekly consumption we calculated to determine the number of points each item was worth for consumers to eat no more than 1 point per day.

How We Did Our Testing

The purchased rice and other grain products were shipped overnight to an independent, accredited analytical lab. To determine the total arsenic level, a known mass of each sample was weighed into a polypropylene vial and digested with HNO_3 and H_2O_2 in accordance with EPA Method 3050B. The resulting digests were analyzed for total arsenic via inductively coupled plasma dynamic reaction cell mass spectrometry (ICP-DRC-MS) according to a performance and quality control standard set in EPA 200.8. All samples then underwent speciation analysis to determine the type of arsenic species present. To do that, a known mass of each sample was placed into a polypropylene vial, digested with trifluoroacetic acid (TFA) digestion, followed by centrifugation and filtration to prepare the sample extracts for further analysis. All sample extracts were analyzed for levels of arsenite,

arsenate, monomethylarsonic acid (MMAs), and dimethylarsinic acid (DMAs) by ion chromatography inductively coupled plasma collision reaction cell mass spectrometry (IC-ICP-CRC-MS) in accordance with quality-control standards set in FDA methods for arsenic speciation of rice, Section 4.11 of the FDA Elemental Analysis Manual.

What We Found

White Rice

We analyzed data from 541 samples of white rice and looked to see whether there was a difference in arsenic levels among types for all origins (Table 4). We found that the different types of rice appeared to have different average levels of total inorganic arsenic, but those results are deceiving. Based on the results of Table 1, one might conclude that basmati rice is always the best choice, because it appears to have the lowest levels of inorganic arsenic, but the averages are for all origins combined, and depending on where that rice comes from, it can have very different levels.

Table 4: Inorganic Arsenic in All White Rice Types (all origins)

Rice Type	Mean Total Inorganic Arsenic		Min-Max Total Inorganic Arsenic	
	ppb	mcg/serving	ppb	mcg/serving
Basmati/Texmati	57.4	2.6	21.2-144	1.0-6.5
Sushi	61.9	2.8	30.4-94.5	1.4-4.3
Jasmine	75.9	3.4	34.0-110.0	1.5-5.0
Short (Nonaromatic)	80.1	3.6	52.0-102.0	2.3-4.6
Medium (Nonaromatic)	81.0	3.7	39.0-174.0	1.8-7.8
Long (Nonaromatic)	101.2	4.6	23.0-196.0	1.0-8.8

When we stratified basmati rice in our data set by origin, we found that basmati rice imported from India or Pakistan or grown in California had the lowest average levels of inorganic arsenic. We also found that those levels were significantly lower than levels in basmati grown in the south-central U.S. (Arkansas and/or Texas) or basmati that did not have any more specific origin information than U.S. (Table 5). Based on our analysis, basmati rice from India, Pakistan, or California is a good choice for those who are looking for rice with the lowest amounts of arsenic.

Table 5: Basmati/Texmati White Rice by Origin

Origin	Mean Total Inorganic Arsenic		Min-Max Total Inorganic Arsenic	
	ppb	mcg/serving	ppb	mcg/serving
California	43.1*	1.9*	27.0-56.0	1.2-2.5
India/Pakistan	52.9*	2.4*	21.2-144.0	1.0-6.5

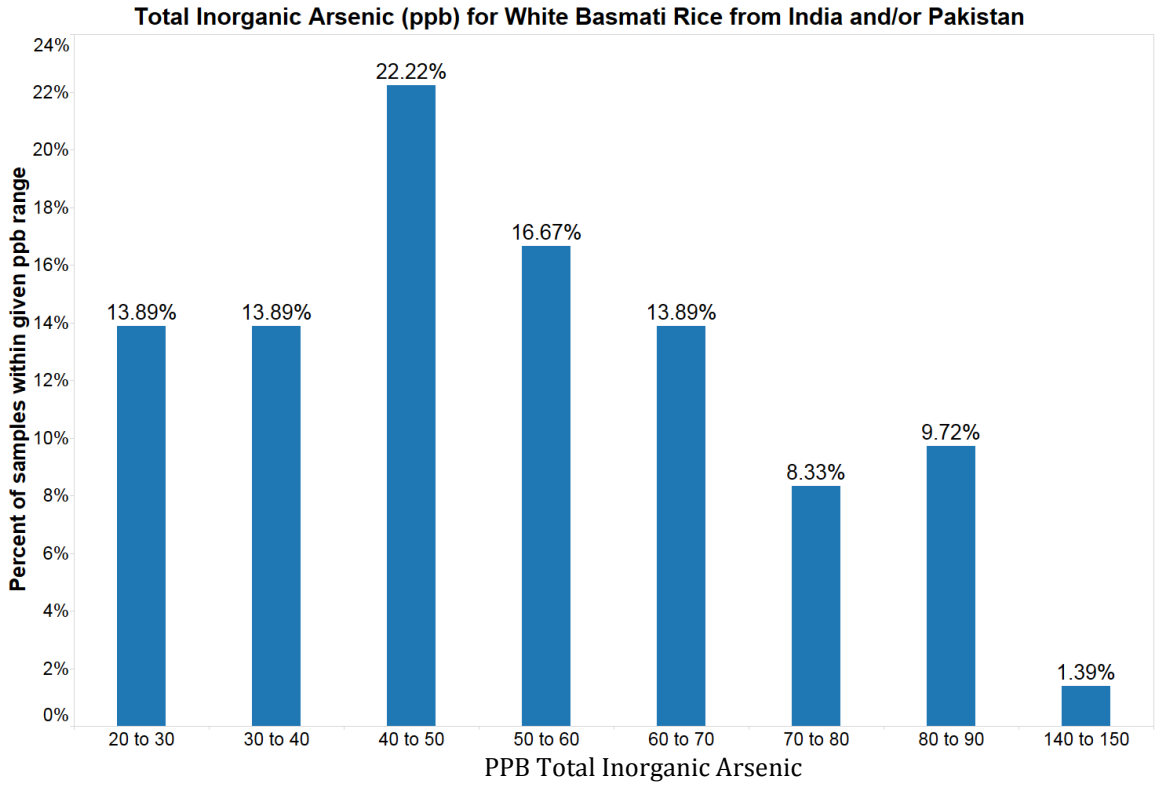
U.S.	79.3	3.6	40.9-107.0	1.8-4.8
Arkansas/Texas	94.3	4.2	77.0-112.4	3.5-5.1

*These values are significantly different from the rest $p<0.001$.

Looking at the distribution of the values for total inorganic arsenic samples from California and those that were imported, one can see that the basmati rice from

California tends to be relatively tightly distributed around the mean, and those from India or Pakistan are slightly more spread out (see Figure 1).

Figure 1



The 95th percentile value for inorganic arsenic in imported basmati rice was 86.0 ppb (3.9 mcg per serving), and only one single sample was over 90.0 pbb, at 144.0 ppb.

U.S. sushi rice appears to be another rice with relatively lower levels of inorganic arsenic. In our 2012 study we did not test sushi rice and were not able to make any comments on it. In our new data set we have 27 samples of sushi rice—all from the U.S. Sushi rice is similar in total inorganic arsenic levels to imported and California basmati rice. Although the samples in our pool from Texas had slightly lower levels of total inorganic arsenic than those from California, there does not appear to be a statistically significant difference in origin (Table 6). For sushi rice the 95th percentile total inorganic arsenic for California was 94.5 ppb (4.25 mcg per serving); that was also that maximum value for all sushi rice.

Table 6: Sushi White Rice

Origin	Mean Total Inorganic Arsenic		Min-Max Total Inorganic Arsenic	
	ppb	mcg/serving	ppb	mcg/serving
Texas	54.0	2.4	30.4-89.5	1.4-4.0
California	64.6	2.9	41.6-94.5	1.9-4.3

Serving Recommendations Revisited

Because basmati rice from California, India, or Pakistan, and sushi rice had significantly lower levels of inorganic arsenic than other rice types, we decided to re-evaluate our recommendations for consumption of those rice types. Based on the finding in this study and assuming no other arsenic consumption, consumers could potentially eat a little more than twice as many servings of rice per week as we previously recommended if they ate only basmati rice from California, India, or Pakistan, or sushi rice. That means that the population of adults could eat about 4.5 servings of those rice types per week, and children about 2.75 servings per week, without incurring any additional population lifetime cancer risk as a result.

White Rice Origin

Origin independent of type appears to have an important effect on the average levels of inorganic arsenic in rice. When we look at all types of rice, we find a similar relationship for origin that we noted in our 2012 report. Those with origins in the south-central U.S. tend to have higher levels of arsenic than those from elsewhere, and those simply noted to be from the U.S. (which we expect to be a mixture of rice from the U.S.) have the highest levels (Table 7).

Table 7. All White Rice Types by Origin

Origin	Mean Total Inorganic Arsenic		Min-Max Total Inorganic Arsenic	
	ppb	mcg/serving	ppb	mcg/serving
India or Pakistan	52.9*	2.4*	21.2-144.0	1.0-6.5
California	62.6*	2.8*	23.0-102.0	1.0-4.6
Thailand	77.1*	3.5*	56.3-110.0	2.5-5.0
Arkansas/Louisiana/Texas	91.6*	4.1*	30.4-174.0	1.4-7.8
U.S.	113.9*	5.1*	40.9-196.0	1.8-8.8

*All values are statistically different from others $p<0.001$.

Jasmine Rice

In our first study it appeared that jasmine rice from Thailand might be a better low-arsenic choice than some other types of rice. Based on the analysis of the current data set, it appears that jasmine rice from Thailand has a moderate average level of inorganic arsenic, 77.1 ppb (3.5 mcg per serving), and a 95th percentile value of 96.2 ppb (4.3 mcg per serving). It was not statistically significantly different from most other rice, except for generic long-grain rice from the U.S. (124.9 ppb, 5.6 mcg per serving).

Parboiled and Quick-Cook White Rice

As we previously reported, processing rice appears to have an effect on the inorganic arsenic content. Rice that is prepped for quick or instant cooking tends to have relatively low levels of inorganic arsenic; rice that is parboiled tends to have relatively high levels of inorganic arsenic.

Table 8: All Types of White Rice

Origin	Mean Total Inorganic Arsenic		Min-Max Total Inorganic Arsenic	
	ppb	mcg/serving	ppb	mcg/serving
Quick-Cooking/Instant (India/Pakistan/Arkansas/ Texas)	40.5*	1.8*	23.3-56.0	1.0-2.5
Parboiled (Arkansas/Texas)	109.1	4.9	87.0-154.0	3.9-6.9
Parboiled (U.S.)	133.9	6.0	91.4-182.0	4.1-8.2
*This value is significantly different from the rest p<0.001.				

Brown Rice vs. White Rice

Because brown rice contains more of the outer layers of the rice grain than white rice, it tends to have higher levels of inorganic arsenic than white. Looking across all types of rice and origins in our sample pool, there is a significant difference between the inorganic arsenic levels in brown and white rice (Table 9).

Table 9: Brown Rice vs. White Rice (all types, all origins)

Origin	Total Inorganic Arsenic		Min-Max Total Inorganic Arsenic	
	ppb	mcg/serving	ppb	mcg/serving
Brown	146.4*	6.6*	34.0-249.0	1.5-11.2
White	81.8*	3.7*	21.2-196.0	1.0-8.8
*Values are statistically different p<0.001.				

For a given type of rice the brown version always had more total inorganic arsenic than the white version, with the brown rice having on average about 80 percent more arsenic than white. Just because brown rice has more arsenic than white rice doesn't mean consumers should switch entirely to white rice. Brown rice has other nutritional benefits over white rice, and there are some brown types that may have relatively lower levels of inorganic arsenic.

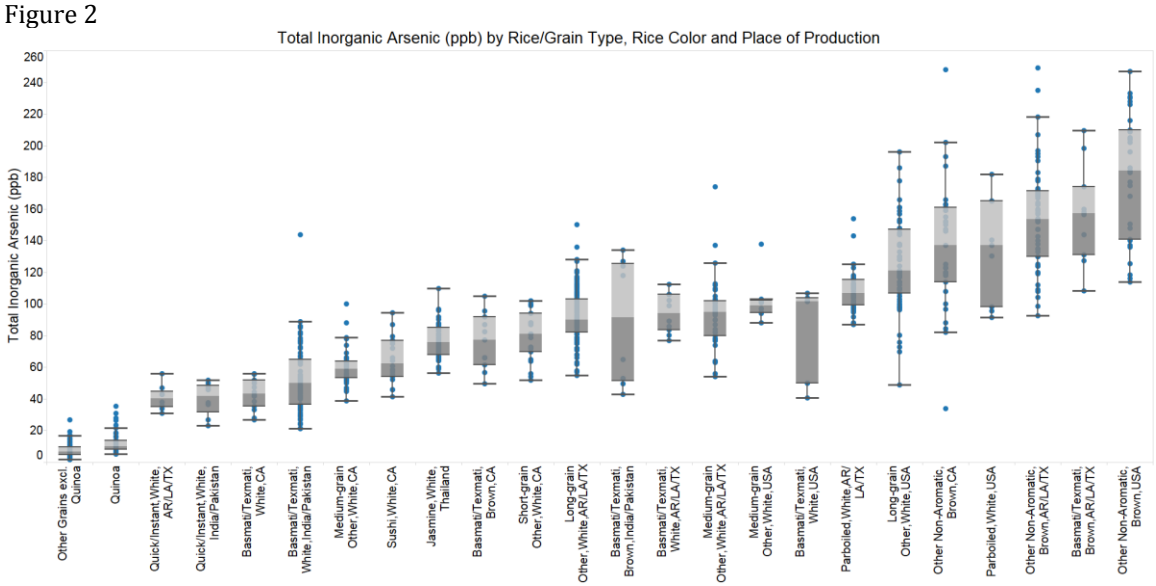
Brown Rice

Brown rice of a particular type always had more total inorganic arsenic in our sample than white rice of the same type, but there were some brown rices with relatively lower levels of arsenic. Eleven samples of brown basmati rice from

California had an average total inorganic arsenic of 76.3 ppb (3.4 mcg per serving) and a 95th percentile of 105.0 ppb (4.7 mcg per serving). Some types of brown rice had even lower levels than some types of white (see Figure 2).

Eight samples of basmati rice from India or Pakistan had an average total inorganic arsenic level of 89.2 ppb (4.0 mcg per serving) and a 95th percentile of 134.0 ppb (6.0 mcg per serving). Those represent better choices than some of the nonaromatic-type brown rice (from all regions of the U.S.), which had average total inorganic arsenic levels that ranged from 136.7 ppb (6.2 mcg per serving) to 180.6 ppb (8.1 mcg per serving) and went as high as 249.0 ppb (11.2 mcg per serving).

Figure 2



Alternative Grains

In addition to looking at inorganic arsenic in rice, we also looked at the levels of total inorganic arsenic in alternative grains. Quinoa and the other grains we tested combined all had significantly less arsenic than rice and represent good alternatives to rice for those looking to reduce exposure to arsenic.

Table 10: Alternative Grains

Type	Mean Total Inorganic Arsenic		Min-Max Total Inorganic Arsenic	
	ppb	mcg/serving	ppb	mcg/serving
Amaranth[GF]	6.2	0.28	3.8-11.3	0.17-0.51
Barley	10.4	0.47	1.9-20.8	0.09-0.94

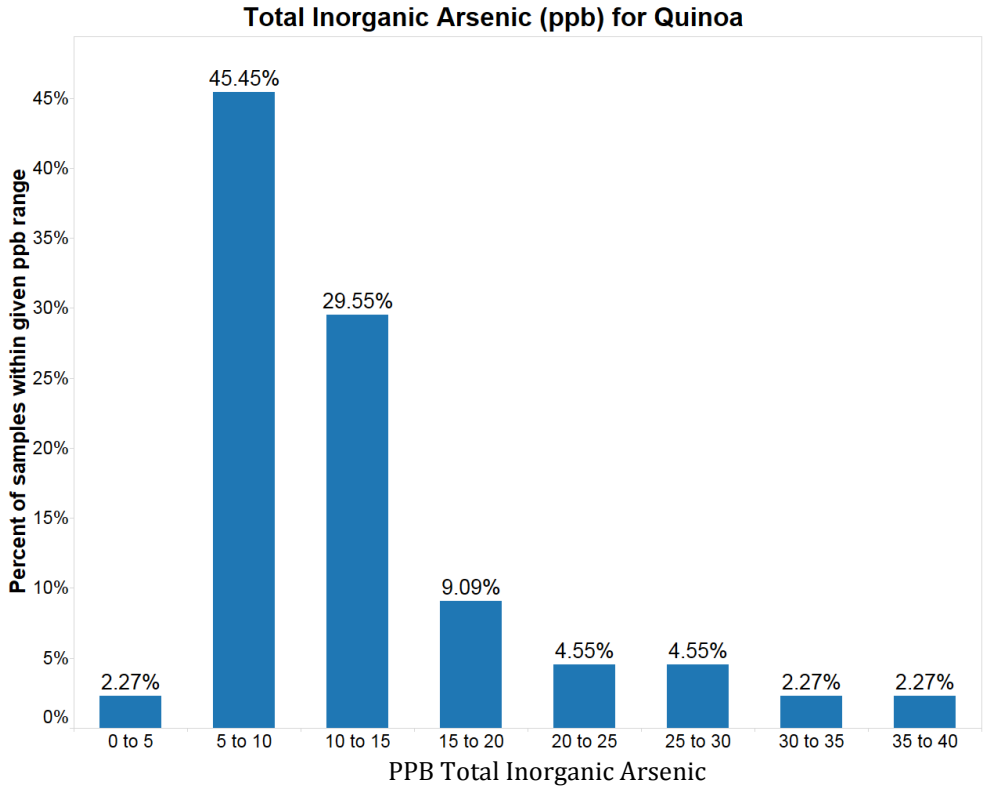
Buckwheat[GF]	5.6	0.25	3.8-7.4	0.17-0.33
Bulgar	8.4	0.38	4.8-16.7	0.22-0.75
Farro	7.3	0.33	2.0-10.1	0.09-0.45
Millet[GF]	12.1	0.54	6.4-26.8	0.29-1.21
Polenta/Grits[GF]	4.2	0.19	1.9-5.4	0.09-0.24
Quinoa[GF]	12.5	0.56	2.6-35.5	0.12-1.60

[GF]Gluten-Free.

The type of alternative grain with the largest sample in our test was quinoa. We noted that there were some samples with relatively higher levels of inorganic arsenic compared with the others (see Figure 3).

Though the vast majority of samples had total inorganic arsenic levels of between 5.0 ppb (0.23 mcg per serving) and 15.0 pbb (0.68 mcg per serving), a few samples had levels in the range of 30.0 (1.4 mcg per serving) to 40.0 (1.8 mcg per serving). That is still well below the vast majority of the levels in rice, though it illustrates the value of not eating too much of any one type of grain and diversifying your diet.

Figure 3



Rice Containing Foods

Rice is in a wide variety of foods we eat. Individuals on a gluten-free diet may consume even more rice than people not avoiding gluten because rice is a gluten-free food. In the FDA's 1,300-sample data set of rice and rice products, it tested a

wide variety of processed products that contain rice, including pastas, bars, cookies, and cereals. We conducted an analysis on those products to determine the distribution of inorganic arsenic per serving in rice-containing foods (Table 11).

Table 11: Total Inorganic Arsenic in Rice-Containing Foods From FDA Database

		Total inorganic arsenic microgram/serving		
	Samples	Min-Max	Mean	95th Percentile
Brownies	5	0.8-1.6	1.3	1.6
Cakes/Muffins	24	0.04-5.0	3.0	4.9
Cereal/Granola Bars	86	0.2-5.1	1.7	3.9
Cookies	43	0.5-3.1	1.6	2.4
Hot Cereal	7	1.6-11.0	5.7	11.0
Infant Cereal	69	0.6-3.8	1.8	3.1
Meal-Replacement/Energy Bars	29	0.2-3.9	2.0	3.7
Rice Drinks	61	0.7-11.0	3.2	5.8
Rice Pasta	23	3.6-11.0	6.6	9.6
Pie/Pizza Crust	3	1.8-2.9	2.5	2.9
Pudding	4	0.02-2.4	0.8	2.4
Ready-to-Eat Cereal	102	0.6-10.0	2.8	6.9
Rice Cakes	59	0.7-8.2	4.4	8.0
Savory Rice Snacks	119	0.4-5.2	2.2	4.0
Sweet Rice Snacks	22	0.02-2.0	0.9	1.8

From Table 11 you can see that the highest average levels of inorganic arsenic are in hot cereals and rice pastas, but some ready-to-eat cereals and rice cakes can also have some relatively high values for total inorganic arsenic per serving. One of the highest-arsenic cereal products (not included in the data above) was a rice-bran cereal that had 30 micrograms of inorganic arsenic per serving.

No amount of exposure to arsenic is considered safe. To reduce exposure to arsenic from rice products, consumers may want to consider limiting their intake. We did not analyze gluten-free products specifically, but our recommendations should also help people on a gluten-free diet who are eating a significant amount of rice and rice-containing products.

The table below provides advice based on our calculations using standard estimates of weight and consumption over a lifetime, as well as the 95th percentile value for total inorganic arsenic per serving found in our analysis for all rice-containing foods. Our advice is that on average consumers eat foods that total less than 1 point per day. That can be averaged over the course of a week, two weeks, three weeks, etc. Over the course of a week we would recommend that consumers limit consumption to an average of 7 points. A consumer can add up the points for each serving of what they eat per week to calculate the total. Some of the levels we found in the larger FDA database exceeded the levels we found in our previous tests of rice products in

2012. As a result of our new analysis we have updated the recommendations for consumption of some foods that we previously tested, and you can see the difference by comparing the point values in Table 12 to those in Table 13. Most regular rice is still recommended at no more than two servings per week for adults (3.5 points for one serving). Basmati rice from California, India, or Pakistan, and sushi rice are worth 1.5 points for one serving.

Table 12: Adult and Child Points Based on Recommendations from CR2012 for 1 serving

Food	Infant Cereal	Hot Cereal	RTE-Cereal	Rice Drinks	Rice	Rice Pasta	Rice Crackers	Rice Cakes
Adult Points	NA	$2^{3}/_{4}$	$2^{1}/_{4}$	2	$3^{1}/_{2}$	$2^{1}/_{4}$	1	3
Child Points	1	4	$4^{1}/_{2}$	-	$5^{1}/_{2}$	$4^{1}/_{2}$	2	7

Table 13: Adult and Child Points for 1 serving, 2014

Food	Infant Cereal	Hot Cereal	RTE-Cereal	Rice Drinks	Rice[#]	Rice Pasta	Savory Rice Snacks	Rice Cakes
Serving Size	15 g	40 g	30 g	240 ml	45 g	55 g	30 g	30 g
Adult Points*	NA	$3^{1}/_{2}$	$2^{1}/_{4}$	2	$3^{1}/_{2}$	3	$1^{1}/_{4}$	$2^{1}/_{2}$
Child Points*	$1^{1}/_{4}$	**$8^{1}/_{4}$**	$4^{1}/_{2}$	-	$5^{1}/_{2}$	**$7^{1}/_{4}$**	$2^{3}/_{4}$	$6^{1}/_{4}$

*This is for all rice types/colors other than white basmati or sushi. These recommendations are from CR2012 and were not recalculated for this report.

Table 13: Adult and Child Points for 1 serving, 2014 (continued)

Food	Cake & Muffin Mix	Brownie Mix	Pie & Pizza Crust	Pudding	Cookies	Sweet Rice Snacks	Cereal & Granola Bars	Energy Bars
Serving Size	55-80 g	40 g	40-55 g	30g	30 g	30 g	40 g	40 g
Adult Points*	$1^{1}/_{2}$	$^{1}/_{2}$	1	$^{3}/_{4}$	$^{3}/_{4}$	$^{1}/_{2}$	$1^{1}/_{4}$	$1^{1}/_{4}$
Child Points*	$3^{3}/_{4}$	$1^{1}/_{4}$	2	$1^{3}/_{4}$	$1^{3}/_{4}$	$1^{1}/_{4}$	$2^{3}/_{4}$	$2^{3}/_{4}$

*Calculations are based on a child of up to about 12 years of age (up to about 70 pounds) and an adult weighing 176 pounds, except for infant-cereal recommendations, which apply only to infants (up to 1 year of age). Note: Point calculations are based on the 95th percentile levels of inorganic arsenic for each product category in the FDA data set.

Table 13: Adult and Child Points for 1 serving, 2014 (continued)

Food	Basmati Rice From India, Pakistan, or California	Sushi Rice
Serving Size*	45 g	45 g

Adult Points*	$1^1/_2$	$1^1/_2$
Child Points*	$2^1/_2$	$2^1/_2$

*Calculations are based on a child of up to about 12 years of age (up to about 70 pounds) and an adult weighing 176 pounds. Note: The calculations are based on the 95th percentile levels of inorganic arsenic for these rices from our combined data set that includes data from CR2012, CR2014, and FDA data.

Note that there are some important changes in our recommendations from our 2012 report for rice products. The difference between adult recommendations and child recommendations is also different in this report for some products compared to the 2012 report because of the differences in inorganic arsenic levels in our 2012 study and the current analysis of FDA data.

The major differences are for hot cereal and rice pasta, where our recommended servings per week decreased dramatically. That is because the 95th percentile for those categories of foods was significantly higher than the maximum we found in our 2012 testing. That was also the case for the category that includes rice crackers, referred to here as savory rice snacks. For rice cakes the 95th percentile from the FDA data was actually slightly lower than the maximum value we found in our test, so rice cakes received fewer points than they would have based on the 2012 CR results. We still recommend that children don't drink rice drinks regularly or as substitute for milk.

In terms of the rest of our recommendations for children, the point values for foods tend to be two to three times higher than for adults. That is because children weigh less than adults, so the dose of arsenic they receive is higher. Based on our analysis of the FDA data, we are recommending that children rarely eat hot rice cereals or rice pastas. Those products had more than 7 points because the 95th percentile values for total inorganic arsenic were greater than 9 micrograms per serving. Also, as we previously recommended, children should not eat much more than one serving of rice cakes per week. The 95th percentile level of total inorganic arsenic in rice cakes was more than 8 in this most recent analysis and in 2012. We used the 95th percentile of arsenic in the products in this analysis to protect consumers who might buy those products with very high levels of inorganic arsenic. The FDA did not release the names of the products it tested, so we are unable to provide that information to consumers.

Conclusions

In the present report we present our findings from analyzing the total inorganic arsenic in almost 700 rice types available in the U.S. We created the new data set by combining our 2012 test results, the FDA's 2013 data, and our most recent 2014 testing. As a result of this analysis we found that:

Basmati rice from India, Pakistan, or California, and sushi rice from the U.S. had the lowest levels of total inorganic arsenic compared with other types of rice. Because of those significantly lower levels of total inorganic arsenic, we recalculated how much of those particular types of rice consumers can eat without exceeding the risk tolerances we previously used. Based on the 95th percentile level of total inorganic arsenic we found in this analysis, consumers can eat about twice as much rice per week as we previously recommended and not increase lifetime population cancer risk if they eat basmati rice from India, Pakistan, or California, or sushi rice. That is equivalent to about 4.5 servings per week.

Our current analysis also substantiated what we had noted in our 2012 study: In general rice labeled as from the U.S. or from Arkansas, Louisiana, or Texas tended to have the highest levels of total inorganic arsenic compared with rice from elsewhere.

Also in this analysis, brown rice of a particular type always had higher levels of inorganic arsenic than white rice of the same type. But this time we were able make an important distinction: Origin and type make a difference. Brown basmati rice from India, Pakistan, or California has lower levels of inorganic arsenic than brown rice from all other parts of the U.S., making it a good choice for brown rice with lower arsenic.

We tested grains that were alternatives to rice to determine their inorganic arsenic levels. All of the alterative grains we tested, such as amaranth, millet, and quinoa, have significantly less inorganic arsenic than rice. Some quinoa samples had relatively higher levels than others, and that helps emphasize the need to vary grain consumption.

In addition to analyzing the newly created rice data set, we also analyzed the FDA's data on rice products to determine the range of arsenic levels in processed foods made with rice. We found that those foods have varying levels of inorganic arsenic, some relatively high; consumers can reduce their exposure to arsenic by limiting consumption. Based on our analysis of the rice-containing foods in the FDA data set, we have revised some of our previous advice on ways to limit exposure to arsenic from foods by reducing servings per week of hot rice cereals, rice pastas, rice crackers, and infant rice cereal.

Based on this analysis we recommend that children should rarely eat hot rice cereals or rice pastas. Those products all had 95th percentile total inorganic arsenic levels that were above 9 micrograms per serving.

Arsenic in the food supply is a major public health issue, and everything possible should be done to eliminate the recycling of arsenic in our environment and food. Consumers Union is calling on the FDA to complete its risk assessment of arsenic in rice and set a limit for the amount of arsenic in rice this year, ideally at 120 ppb, to protect consumers from this toxic element. The FDA should also prioritize setting standards for rice-containing foods that present the greatest risk to children, such as rice cereals, pastas, and beverages. In addition, the FDA should remove the approval for the remaining arsenic-containing animal drug nitarsone. The EPA should ban the use of arsenic-based pesticides for all applications.

References

[1] http://www.dartmouth.edu/~toxmetal/arsenic/history.html p.1/8
[2] http://ehp.niehs.nih.gov/122-a130/ p.1-2/7
[3] http://www.atsdr.cdc.gov/toxprofiles/tp2.pdf p.63/559
[4] http://www.who.int/mediacentre/factsheets/fs372/en/ p.4/5
[5] http://monographs.iarc.fr/ENG/Classification/ClassificationsAlphaOrder.pdf p.3/34
[6] http://ntp.niehs.nih.gov/ntp/roc/twelfth/profiles/arsenic.pdf p.1/4
[7] http://www.epa.gov/iris/subst/0278.htm p.7/23
[8] http://monographs.iarc.fr/ENG/Monographs/vol100C/mono100C-6.pdf p. 45/54
[9] Compare Iris Values http://cfpub.epa.gov/ncea/iris/compare.cfm p.26/27
[10] http://insideepa.com/Superfund-Report/Superfund-Report-01/21/2013/epa-broadens-health-focus-as-it-restarts-arsenic-iris-assessment/menu-id-1094.html p.1/3
[11] http://www.ncbi.nlm.nih.gov/pubmed/18714061 p.1/2
[12] http://www.ncbi.nlm.nih.gov/pubmed/24061511 p.2/2
[13] http://www.ncbi.nlm.nih.gov/pubmed/24004508 p.1/1
[14] http://www.atsdr.cdc.gov/toxprofiles/tp2.pdf p. 24/559
[15] data from http://www.fda.gov/Food/FoodScienceResearch/TotalDietStudy/ucm184293.htm
[16] http://www.efsa.europa.eu/en/efsajournal/doc/3597.pdf p.18/68
[17] http://consumerreports.org/cro/magazine/2012/11/arsenic-in-your-food/index.htm p.3/9
[18] http://www.atsdr.cdc.gov/toxprofiles/tp2.pdf p. 333/559
[19] http://www.ricehull.com/common_uses/ p.1/2
[20] http://www.riceland.com/pages/co-products/ p.1/2
[21] http://www.usarice.com/index.php?option=com_content&view=article&id=100&Itemid=106 p.1/2
[22] http://www.lsuagcenter.com/NR/rdonlyres/AA21A447-0EDC-4B08-B47D-AC7C0536A323/64494/highrespub3139aguidetopoultrylitteruseinlariceprod.pdf p.1/4
[23] http://deltafarmpress.com/management/chicken-litter-smell-success p.1/6
[24] NAS (National Academy of Sciences). 1969. The use of drugs in animal feeds. Proceedings of a symposium. Washington, D.C.: National Academy of Sciences. p.88/425
[25] http://ehp.niehs.nih.gov/1206245/ p.1/7
[26] http://www.fda.gov/ohrms/dockets/dailys/01/Nov01/110501/ts00014.doc p.1/5
[27] http://www.fda.gov/AnimalVeterinary/SafetyHealth/ProductSafetyInformation/ucm258313.htm#studies_on_3-Nitro p.3-5/6
[28] http://www.ncbi.nlm.nih.gov/pubmed/17328188 p.1/2

[29] http://www.fda.gov/AnimalVeterinary/SafetyHealth/ProductSafetyInformation/ucm258313.htm#studies_on_3-Nitro p.5/6

[30] http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm258342.htm p.1/3

[31] http://www.nytimes.com/2013/10/02/business/fda-bans-three-arsenic-drugs-used-in-poultry-and-pig-feeds.html?_r=0 p.1/2

[32] http://www.consumerreports.org/cro/news/2014/01/fda-data-show-arsenic-in-rice-juice-and-beer/index.htm p.2/3

[33] http://www.epa.gov/oppsrrd1/reregistration/organic_arsenicals_fs.html p.1/5

[34] http://www.ncbi.nlm.nih.gov/pubmed/21272184 p.1/2

[35] http://www.deq.state.va.us/Portals/0/DEQ/Land/RemediationPrograms/Brownfields/Weaver1-195-1-PB-8r.pdf p.1/32

[36] http://nepis.epa.gov/Exe/ZyNET.exe/20011E0G.txt?ZyActionD=ZyDocument&Client=EPA&Index=1986%20Thru%201990&Docs=&Query=%28lead%20arsenate%29%20OR%20FNAME%3D%2220011E0G.txt%22%20AND%20FNAME%3D%2220011E0G.txt%22&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&UseQField=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5CZYFILES%5CINDEX%20DATA%5C86THRU90%5CTXT%5C00000015%5C20011E0G.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=p%7Cf&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x p.71/115

[37] http://www.wired.com/2012/06/arsenic-pesticides-in-our-food/ p.1,3/10

[38] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1892142/pdf/ehp0115-a00296.pdf p.1/4

[39] http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm360466.htm p.1/2

[40] http://www.fao.org/news/story/en/item/238802/icode/ p.1/3

[41] http://www.cdc.gov/healthywater/drinking/private/wells/ p.1/3

[42] http://water.usgs.gov/nawqa/trace/arsenic/ p.1/3

[43] http://w3.salemstate.edu/~dallen/NewEnglandArsenic.pdf p.1/9

[44] http://www.dartmouth.edu/~toxmetal/arsenic/wellwater.html

[45] http://www.fda.gov/newsevents/newsroom/pressannouncements/ucm319972.htm

[46] http://www.fda.gov/food/foodborneillnesscontaminants/metals/ucm319870.htm p.1/3

[47] http://www.consumerreports.org/cro/news/2014/01/fda-data-show-arsenic-in-rice-juice-and-beer/index.htm p.1/3
[48]http://www.consumerreports.org/cro/news/2014/01/fda-data-show-arsenic-in-rice-juice-and-beer/index.htm p.1-2/3