Playing Chicken

Avoiding Arsenic in Your Meat

20 years

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About this publication

Playing Chicken: Avoiding Arsenic in Your Meat

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Executive summary

Arsenic causes cancer even at the low levels currently found in our environment. Arsenic also contributes to other diseases, including heart disease, diabetes and declines in intellectual function, the evidence suggests. Some human exposure to arsenic stems directly from its natural occurrence in the earth's crust. Other arsenic is mined and then used intentionally, for commercial purposes.

Drinking water, rice, playground equipment—Americans' daily exposure to cancer-causing arsenic comes from a variety of sources. Regulatory action has reduced some of that daily exposure. As advised by multiple bodies of scientific experts, the Environmental Protection Agency (EPA) finally lowered its long-outdated drinking water standard in 2001, dropping by five-fold the amount of arsenic legally allowed in tap water, for example.

Arsenic also contaminates many of your favorite foods, including fish, rice and chicken. Some food contamination stems from intentional uses of arsenic. In this report we clearly connect arsenic residues in chicken meat to the decades-old practice of intentionally putting arsenic into chicken feed. Of the 8.7 billion American broiler chickens produced each year, estimates are that at least 70 percent have been fed arsenic. Some of that arsenic stays in chicken meat.

We show in Chapter 1 of this report how and why arsenic is routinely fed to most of America's chickens. In Chapter 2, we review some of the latest science on how arsenic impacts our health, and who is at greatest risk. In short, there are many science-based reasons to avoid ingesting arsenic, whatever its form.

Our arsenic testing of the chicken meat that people eat—the most extensive ever—shows that much of it contains arsenic. Our testing also indicates that some of America's largest chicken producers already successfully raise chickens in ways that contaminate it with little or no arsenic. See Chapter 3 for more details.

Even if our testing hadn't found arsenic in many of America's most popular brands of chicken products, there would still be compelling reasons for producers to stop feeding arsenic to chickens.

One way or another, putting arsenic in chicken feed means exposing more people to more arsenic. We estimate from 1.7 to 2.2 million pounds of roxarsone, a single arsenic feed additive, are given each year to chickens. Arsenic is an element—it doesn't degrade or disappear. Arsenic subsequently contaminates much of the 26-55 billion pounds of litter or waste generated each year by the U.S. broiler chicken industry, likely also contaminating the communities where that waste is generated or dispersed. In the chicken-producing town of Prairie Grove, Ark., house dust in every one of 31 homes examined was found to contain at least two kinds of arsenic also found in chicken litter.

Giving arsenic to chickens further adds to an already significant arsenic burden in our environment from other intentional, now-banned uses. For example, American-grown rice contains 1.4 to 5 times more arsenic on average than does rice from Europe, India and Bangladesh—scientists think the likely culprit is the American practice of growing rice on former cotton fields contaminated with long-banned arsenic pesticides. For decades, Americans also were exposed intentionally to arsenic from the use of lumber "pressure-treated" with chromated copper arsenate (CCA), a pesticide mixture that is 22 percent arsenic by weight. This contaminated lumber, much of it still in use, carries a familiar greenish hue. The EPA finally ended the manufacture and sale of CCA-treated lumber in 2004. At that time, more than 90 percent of all outdoor wood decks, playground sets and other wooden structures in the U.S. were made of arsenic-treated wood.

Why this study?

It has been claimed that none—or at least very little—of the arsenic put into chicken feed makes its way into the meat.

But arsenic levels in chicken meat are a lot higher than previously acknowledged. That was the conclusion of U.S. Department of Agriculture (USDA) scientists, writing in 2004 in *Environmental Health Perspectives*, a journal of the National Institutes of Health.

So, we set out to do something the federal government had never done. We tested for arsenic in the chicken meat that people mostly eat. Ours also is the first study to successfully test for arsenic in brand-name chicken products and tell the public the results.

We tested brands of chicken bought in both supermarkets and at fast food outlets. From Minnesota and California supermarkets, we bought 151 packages of raw chicken—chicken breasts, thighs or legs, whole chickens and

Table 1. Number of samples of purchased raw chicken breasts, thighs, livers and whole chickens from conventional and premium brands tested for total arsenic

	Breasts	Thighs	Livers	Whole chickens	All
Conventional brands*	38	32	10	0	80
Detect	23	26	10	0	59
Non-detect	15	6	0	0	21
Premium brands†	35	30	5	5	75
Detect	11	11	0	4	26
Non-detect	24	19	5	1	49
All brands	73	62	15	5	155
Detect	34	37	10	4	85
Non-detect	39	25	5	1	70

Table 2. Prevalence of detectable arsenic in purchased raw chicken breasts, thighs, livers and whole chickens, from conventional and premium brands (limit of detection down to 2 parts per billion)

	Breasts	Thighs	Livers	Whole chickens	All
Conventional brands*					
Detect	61%	81%	100%	0%	74%
Non-detect	39%	19%	0%	0%	26%
Premium brands†					
Detect	31%	37%	0%	80%	35%
Non-detect	69%	63%	100%	20%	65%
All brands					
Detect	47%	60%	67%	80%	55%
Non-detect	53%	40%	33%	20%	45%

* We consider "conventional" brands to include Farm Harvest, Foster Farms, Gold'n Plump, Smart Chicken (non-organic), Spring River Farms, and Tyson.

† We consider "premium" brands to include the certified organic Rosie Chicken and Smart Chicken (organic), as well as chicken not certified as organic and sold under the Gerber's Amish, Kadejan, Raised Right, Rocky Jr. and Trader Joe's brands.

livers—raised under the labels of some of the nation's largest chicken-producing companies, along with "premium" chicken products, including certified-organic and kosher. (For comparison, the USDA's testing program has looked for arsenic just in chicken livers from about 1,200 birds per year. It doesn't identify brands.)

We also bought and tested 90 orders of fried chicken, chicken burgers, strips and nuggets from most of the fast food chains offering chicken products, including McDonald's, Wendy's, Arby's, Hardee's, Jack in the Box, Carl's Jr. and Subway, as well as KFC, Church's and Popeyes.

By identifying the specific brands of chicken tested, we arguably provide consumers with better data than does the USDA to make healthier, more informed decisions when purchasing chicken.

On the other hand, our results aren't definitive. Testing is expensive so we tested no more than five samples of any one product. We never set out to do the kind of comprehensive testing and statistical analysis that American consumers deserve. What we have done, however, represents the most thorough testing to date of the chicken that people actually eat.

What we found

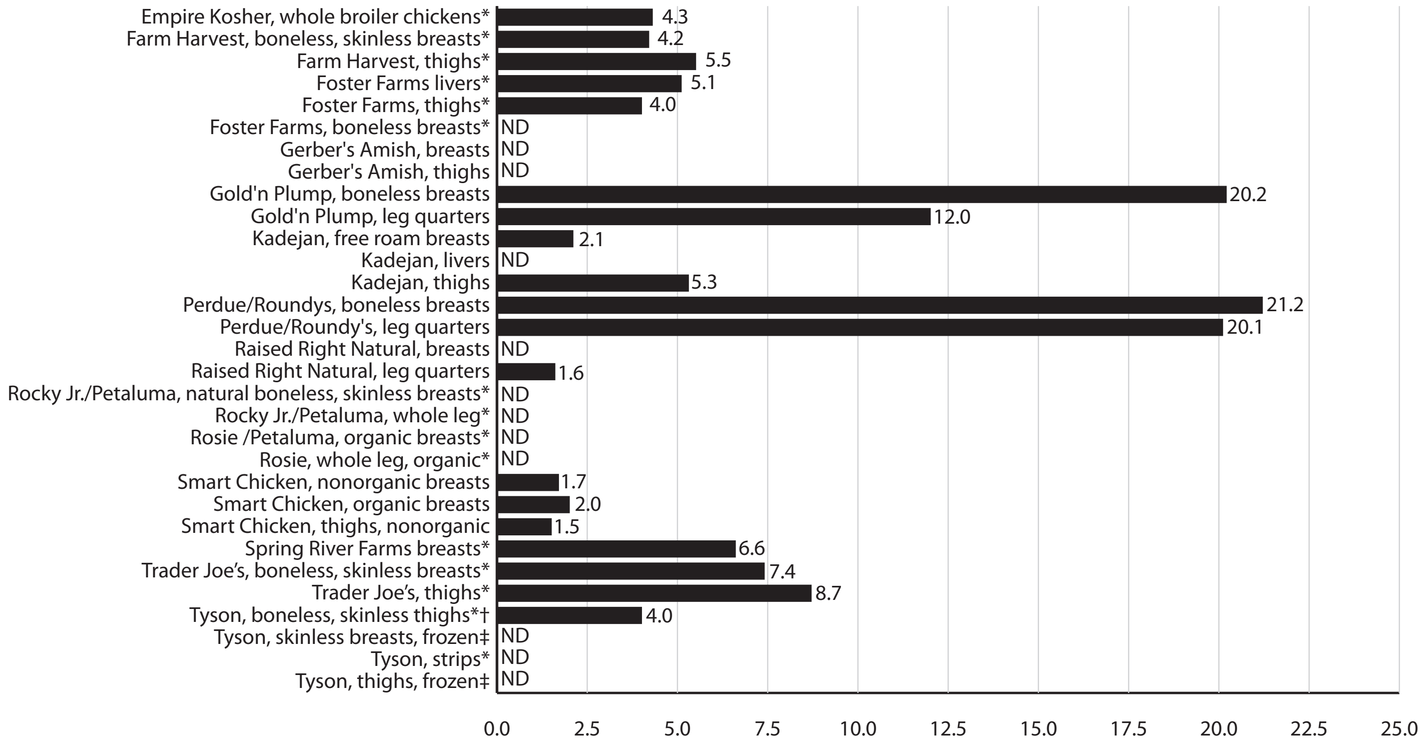
Most uncooked chicken products we purchased from supermarkets (55 percent) contained detectable arsenic. Average levels of arsenic varied substantially (Figure A). Our most contaminated raw chicken products had ten-fold higher average arsenic levels than did the least contaminated. Plenty of the supermarket chicken tested carried no arsenic, however. Of our 155 samples, 45 percent had no arsenic or arsenic below the limit of detection. Clearly, arsenic in chicken is not a "natural" or industry-wide problem.

On the other hand, your choices as a chicken shopper and consumer will directly bear on how much arsenic you will ingest, our results suggest. Nearly three-quarters of the raw chicken breasts, thighs and livers from conventional producers that we tested carried detectable levels of arsenic. Of certified organic or other "premium" chicken parts or whole chickens, just one-third had detectable arsenic. Use of arsenic in chicken feed is prohibited under organic standards.

While we tested no more than five packages of a specific product from any one brand, results were somewhat

Figure A. Average total arsenic in uncooked chicken products (parts per billion)

Averaged over five packages, unless indicated (†, ‡)



** Purchased in California*
† Averaged over four packages
‡ Averaged over three samples from a single, multipound package

consistent within individual brands. None of the Rosie Organic Chicken breast, for example, had detectable arsenic. Arsenic also was absent or near the limit of our laboratory's ability to detect it from several non-organic premium chicken brands, including Smart Chicken as well as Raised Right Natural, Gerber's Amish and Rocky Jr. Natural Chicken.

Premium brands did not test uniformly superior in terms of arsenic, however. Four of five whole chickens from the single kosher/halal brand we tested, Empire Kosher, had detectable arsenic, with an average level of about 4 parts per billion. We also found detectable levels of arsenic—albeit very close to the limit of detection—in 4 of 5 samples of Smart Chicken organic chicken breasts, purchased in Minnesota.

When we tested chicken breasts or strips (although not necessarily chicken thighs) from Tyson and Foster Farms, the largest and eighth largest broiler chicken producers in the U.S. respectively, we detected no arsenic on average.

Arsenic was absent from thigh or leg meat tested under the Rosie Organic, Rocky Jr. and Gerber's Amish labels.

Among the three kinds of chicken liver tested, the premium Kadejan brand was the only one found to be free of arsenic. Five packages of Gold'n Plump livers contained an average of nearly 222 ppb arsenic, the highest of all our chicken samples—albeit still below the 2,000 ppb arsenic maximum allowed in liver under law.

Arsenic also varied greatly among fast food chicken products that we tested (Figure B). All such products carried some detectable arsenic. But on average chicken thighs from Church's had 20 times the arsenic on average of thighs purchased from KFC; on average, chicken sandwiches from Jack In The Box registered more than five times the arsenic of those from Subway. The source of this variation is unclear, however.

Making sense

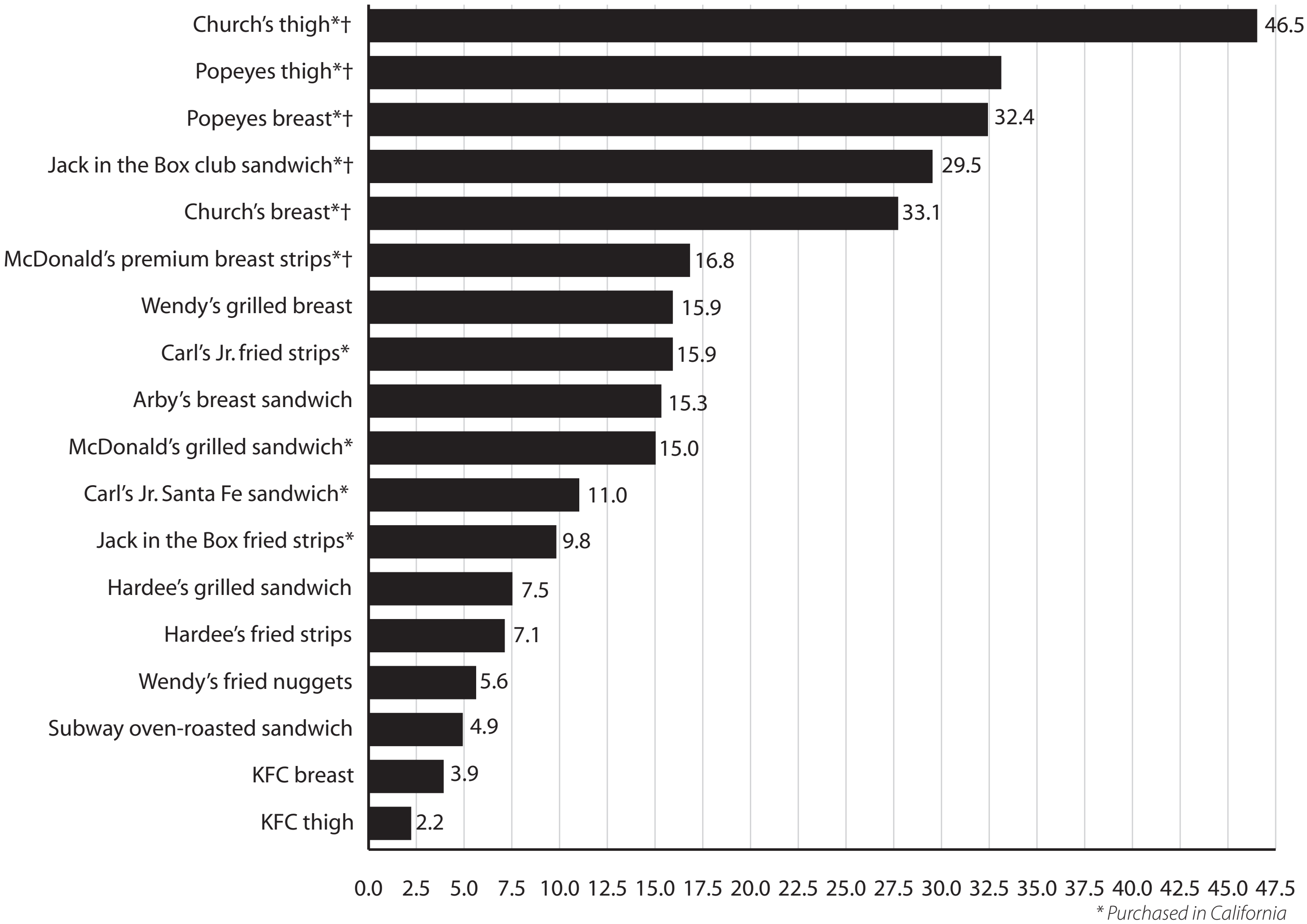
Arsenic levels previously found in chicken generally have been lower than federal standards, as are ours. That is, they don't appear to routinely violate the "tolerance levels" for arsenic in meat set by the Food and Drug Administration—in a process we describe in Chapter 2, and below which consumption is deemed to be "safe."

But that misses a more important point. This is arsenic added intentionally to chicken. Why put more arsenic in the food chain in the first place?

Some in the poultry industry claim arsenic in feed is needed to raise healthy birds. Not true. Arsenic use in chicken is unnecessary, pure and simple. Europe has banned arsenic in animal feeds. Based on our limited sampling, many organic and other U.S. chicken producers also appear to use no or

Figure B. Average total arsenic in select fast food chicken products (parts per billion)

Limit of detection = 2 ppb, 10 ppb if indicated (†)



very little arsenic. We found little or no arsenic in chicken products from Tyson, the world's largest producer, for example. (Our samples are too limited in number for us to comfortably draw conclusions about Tyson's arsenic use for its entire global production.)

The poultry industry also has claimed the kinds of arsenic fed to these birds is harmless. That's because arsenic comes in various forms, both inorganic and organic. The kinds of arsenic directly added to chicken feed are "organic" arsenics, most often one called roxarsone. (Organic in this case means a molecule containing carbon atoms as well as arsenic). Until recently, conventional wisdom had it that organic arsenic wasn't as poisonous as inorganic arsenic, the kind most closely linked to cancer thus far.

But again, this claim misses the point. All arsenic should be considered toxic. Organic and inorganic forms of arsenic convert to one another, in the body and in the environment. In fact, some organic arsenic appears to be transformed *within the chicken* to inorganic arsenic; the EPA estimates 65 percent of arsenic in chicken meat is inorganic arsenic.

Further, the latest science is overturning conventional wisdom: some organic forms of arsenic created by the body's metabolism now appear to be more toxic than inorganic arsenic.

All of this suggests that the best arsenic, in chicken meat or chicken feed, is no arsenic at all.

Finally, the poultry industry may claim the amount of arsenic in chicken is simply too low to worry about. But even low exposures to something known to cause cancer generally is presumed to be risky, and therefore to be avoided. Further, the USDA and FDA have avoided testing for arsenic in the chicken that people mostly eat, namely muscle tissue. People may be getting a lot more arsenic exposure through eating chicken than previously was acknowledged. This is especially true for "chicken lovers," people who eat more chicken than average.

Children who eat chicken also may face greater arsenic risks than we previously knew. That's because the latest science shows that some arsenic exerts its poisonous effects in ways that food regulators haven't necessarily taken into account in setting "safe" levels, such as by disrupting hormone function. Hormones are essential for the body's function, as well as for normal development of a child's brain, gonads and other organs. Because nature intends for hormones in the body to function at very, very low levels, even tiny exposures to a hormone-disrupting chemical may be sufficient to throw normal hormone function off course.

Conclusion and recommendations

Putting arsenic in chicken feed increases arsenic in chicken meat, and adds to the arsenic in our environment.

As a society, why should we accept this practice when it's unnecessary for raising chickens? We shouldn't.

And, why buy chicken raised with arsenic when you don't have to? Again, there is no good reason. We therefore make the following recommendations:

1. Squeamish about eating arsenic with your chicken? Consumers can simply buy one of many kinds of chicken raised without arsenic.

The good news is that some poultry producers appear to be working hard to raise chickens in a healthier way, without arsenic. The Eat Well Guide (eatwellguide.org) carries state-by-state listings of producers who claim to use no artificial feed additives, including antibiotics or arsenic. The guide also lists restaurants and other places to buy these products.

The bad news is that it's not always easy to distinguish producers who use arsenic from those who don't. Buying USDA-certified organic chicken is one good approach, since producers using this label are legally prohibited from using arsenic.

Unfortunately, the federal government doesn't verify many private claims. If in doubt, ask your grocer to verify that they only sell chicken raised without arsenic. Or, better yet, call your favorite chicken company and ask them directly if they use arsenic in their chicken feed. Below are the phone numbers for the brands that we tested.

2. Poultry companies should follow the example of responsible organic producers as well as European chicken producers, and simply opt to raise birds without arsenic. Four of the top ten U.S. poultry companies, Tyson Foods, Gold Kist, Perdue Farms and Foster Farms, have been moving to raise birds without adding antibiotics to their feed routinely, a practice which contributes to the human burden of antibiotic-resistant disease. Why not make American poultry even healthier by avoiding the use of arsenic as well?

3. Restaurants, hospitals and schools also should ask poultry suppliers if they use arsenic to raise their chickens. If they do, find a new supplier; or demand they stop the practice, as has been done in Europe where arsenic is banned from animal feed. On menus, restaurants serving chicken from birds raised without arsenic should make note of it.

Students are captive eaters when it comes to food choices. These customers, too, ought to be offered poultry raised without arsenic—especially given recent science suggesting children may be more vulnerable to the toxic effects of different forms of arsenic.

4. Federal and state regulators must act. Given the expanding array of health impacts linked by science to low-level arsenic exposure, as well as heightened concern about organic forms of arsenic in particular, the FDA ought to follow Europe's lead and withdraw its approval for meat and poultry producers to add arsenic to our food chain and the environment.

Regulators also should prepare and release to the public estimates of how much arsenic Americans are exposed to cumulatively, from all sources—including from chicken and other dietary sources, from contaminated drinking water, from soils contaminated with arsenical pesticides, and from decks and playground equipment treated with arsenic (CCA) preservatives. Cumulated arsenic exposure should be calculated for children and others who may be "above average" in their arsenic exposures.

To our knowledge, no one has ever tried to cumulate all of our risks from arsenic. Why not? The reality of Americans' cumulative exposure to arsenic, combined with our ignorance about the magnitude of this exposure, should make us question even more the prudence of allowing any intentional and unnecessary uses of arsenic.

Poultry companies' contact information

Brand	Telephone	Brand	Telephone
Tyson Foods Inc.	(800) 424-4253	Gold'n Plump Poultry, Inc.	(320) 251-3570
Gold Kist Inc.	(770) 393-5000	MBA Poultry (Smart Chicken)	(402) 335-2501
Perdue Farms Inc.	(800) 473-7383	Empire Kosher Poultry	(717) 436-5921
Foster Farms	(800) 255-7227	Kadejan	(320) 634-3561
OK Foods, Inc. (Spring River Farms)	(800) 635-9441	Gerber's Amish Chicken	(800) 362-7381
Petaluma Poultry (Rosie, Rocky Jr.)	(800) 556-6789	Cambridge Packing Co. (Raised Right Natural)	(800) 722-6726
Farm Harvest	*Unavailable*		

1. The modern American chicken: Arsenic use in context

Average Americans eat a lot more chicken than they used to. From 1966 to 2000, annual chicken consumption rose 253 percent, from 32.1 to 81.2 pounds per person.[1] In 2004, the U.S. produced 8.7 billion broiler chickens, about a 65 percent increase over the previous 14 years.[2,3] Broilers are the young adult chickens that Americans overwhelmingly eat.

Our increasing appetite for chicken isn't the only dramatic change. Almost all broiler chickens are now raised indoors. But a modern broiler house is no chicken coop. Typically it is a single-story facility, approximately 40 feet wide by 400-500 feet long that holds 25,000 to 30,000 birds. A modern broiler "farm" generally has 2-6 such houses, with up to 150,000 birds or more.[4]

Broiler production today is nearly completely under the control of "vertically integrated" poultry companies. Vertical integration arose for economic reasons, as producers realized that clustering hatchery, feed, grow-out and processing facilities in close proximity would improve coordination, reduce transportation costs and increase profits.[5]

Broiler production: Ownership and geographic concentration

Vertically integrated companies dominate broiler production. They either directly own broiler facilities, or more commonly contract with farms that account for more than 80 percent of the nation's broiler production. A vertically integrated "complex" typically consists of a centralized feed mill, hatchery and processing plant, surrounded by contract or other grow-out farms within a 50-mile radius of the plant. The very largest broiler facilities—those containing more than 90,000 birds—account for about half of all broilers produced, even though these "farms" represent just 11 percent of broiler operations. While ownership of broiler production is concentrated, the vertically integrated model also concentrates production geographically. The top four states—Georgia, Arkansas, Mississippi and North Carolina—account for 48 percent of the 8.7 billion broilers produced annually; the next four states add an additional 16 percent.

Sources

1. National Academy of Sciences/National Research Council (2003), Air Emissions from Animal Feeding Operations: Current Knowledge, Future Needs. National Academies Press: Washington, DC. page 38.

2. EPA (2001), Development Document for the Proposed Revisions to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Feeding Operations. EPA-821-R-01-003. p. 4-41.

Feed costs comprise nearly 70 percent of the total cost of producing broilers. By moving birds indoors where feed can be controlled, and by optimizing feed mixtures, vertically integrated producers found another means to reduce costs and increase profits. The indoor birds are raised on diets of corn and soybean-meal for protein and calories, mixed with vitamins, minerals and other feed additives.[6] Feed is formulated to try and match the birds' nutritional requirements at specific stages of development.[7] As a result, today's broiler on a per-pound basis requires just 42 percent of the feed to reach market weight as did a bird 50 years ago.[8]

Combined with selective breeding, feed changes have also made it possible for integrated producers to raise chicks to market size in much less time, even as the average broiler has become substantially larger. In 1957, a 4-pound broiler was raised to market weight in 103-105 days. To reach market weight in 2001 took about half as long, even for broilers that weigh up to 50 percent more.[9,10,11] In what is deemed "all-in, all-out" production, each broiler house now raises a flock of day-old broiler chickens to market weight in 42 to 56 days,[12,13] 5.5 to 6 flocks per year.[14]

How feed additives are used in broiler production

The relentless drive to produce more animals in less time at lower cost is what lies behind the routine addition to animal feeds of antimicrobial drugs—including arsenicals, antibiotics, and other compounds.[15] The Institute of Medicine cites industry estimates, for example, that 88 percent of antibiotics used in cattle, swine and poultry in 1985 were given to animals (typically in feed) at lower-than-therapeutic concentrations.[16,17]

In broilers, at least nine different antibiotics and three arsenic-containing compounds are approved for use as feed additives (Table 3).[18,19,20]

Again, most poultry feed additives are not used to treat sickness. Rather, they are given to healthy birds to promote faster growth on less feed (growth promotion/feed efficiency), or to prevent disease among flocks that are now raised typically under indoor, crowded, stress-inducing conditions that promote it.[21,22]

Table 3. FDA-approved arsenic compounds in animal feeds

Common name	Technical name	Intended use in
Roxarsone	3-nitro-4-hydroxyphenylarsonic acid	Chickens, turkeys
Arsanilic acid	p-arsanilic acid, or p-ASA	Chickens, turkeys, swine
Nitarsone	4-nitrophenylarsonic acid	Chickens, turkeys
Carbarsone	p-ureidophenylarsonic acid	Turkeys

Source: U.S. Food and Drug Administration, Center for Veterinary Medicine, 2004 Online Green Book accessed 01/15/05 at http://www.fda.gov/cvm/greenbook/elecgbook.html.

In terms of arsenic feed additives or "arsenicals," specifically, distinguishing the intent behind any particular use would be difficult. That's because the FDA-approved labels are so broadly worded, with most of them including usage "For increased rate of weight gain, improved feed efficiency, and improved pigmentation."[23] In many cases, the same arsenic additives also are labeled "as an aid in the prevention of coccidiosis." Coccidiosis is an intestinal infestation causes by a parasite. Another reason it would be difficult is because regardless of intent, arsenical feed additives generally are given to broilers at the same dosage, in the same manner.

Third, arsenic, like other antimicrobials, is added to poultry feed without a prescription. As with other antimicrobials, therefore, there are no public data to help quantify the amount of arsenic compounds being given to poultry, let alone the purpose of their use.[24] In contrast to the lack of public usage data there is, apparently, a proprietary database that stores data collected monthly from companies representing 90 percent of U.S. broiler production on their use of antibiotics and arsenicals.[25]

Most broilers receive multiple drugs in their feed or drinking water. For the first phase of their lives, broilers typically are fed pre-starter and starter feeds containing up to three drug components: an antibiotic to promote growth, an organic arsenic and an anti-parasite drug called a coccidiostat (Table 4).[26,27] About half of surveyed broiler operations appear to use all three.[28]

Table 4. Antimicrobial feed additives at various stages of broiler production

Feed period	Duration in a 6-week cycle	Total amount of feed required	Typical drug additives
Starter	~19 days	2-3 lbs.	Coccidiostat (prophylaxis) Antibiotic (growth promotion) Organic arsenical (growth promotion and prophylaxis)
Grower	~8-12 days	5 to 7 lbs. for grower/finisher stages combined	Coccidiostat (prophylaxis) Antibiotic (growth promotion) Organic arsenical (growth promotion and prophylaxis)
Finisher	~5-9 days		Antibiotic (growth promotion) Organic arsenical (in the initial withdrawal period only)

Sources: Compiled from NRC 1999. page 34; also, feed requirement data from Mississippi State University, 1998.

"Nutritional notes: Nutrient and feeding requirements." Department of Poultry. July. Accessed August 2005 at http://msstate.edu/dept/poultry/nutnote3.htm.

During the next 8–12 days, broilers are given "grower" feeds, again often including an arsenical, a coccidiostat, and an antibiotic. Among surveyed broiler operations, about one-third appear to use all three.[29] During the initial part of the remainder of their 6-week lifespan, broilers may again be given "finisher" feeds containing an arsenical and an antibiotic, although arsenicals are prohibited for the final 5-day "withdrawal" period, just before slaughter.[30]

It is little known that under modern production broiler chickens are intentionally exposed to multiple compounds in feed that are biologically active in the human body, and that are specifically intended to act in concert with one another. Many FDA-approved poultry feed additives are in fact combination products, with the arsenic component co-existing with one or multiple antibiotics, as seen in Appendix A. These drugs are intended to act synergistically, which manufacturers advertise.[31] On approving their individual use in chicken feed, regulators almost certainly haven't considered the impact on human health of the concurrent use of these multiple drugs, as we note in Chapter 3.

Arsenical feed additives in isolation

The vast majority of the 8.7 billion broiler chickens produced annually in the U.S. are given feed containing arsenic compounds at some point in their brief lives. Most commonly this is an arsenical called roxarsone, but could include arsanilic acid or nitarsone as well.[32] An estimated 70 percent of broiler chickens on starter rations and approximately 74 percent of those on grower rations in the United States are receiving roxarsone.[33]

Roxarsone, arsanilic acid, nitarsone and a fourth arsenical called carbarsone[34] are FDA-approved as feed additives for turkeys, as well. Arsanilic acid also is approved for use in swine feed, although arsenical uses other than for broiler chickens are not a focus of this report.

Using the U.S. Food and Drug Administration's online "Green Book," we identified 93 FDA-approved arsenic products for broiler chickens—94 percent containing roxarsone (Appendix A).[35] Five products contain arsanilic acid and one, nitarsone.

One company, Alpharma, accounts for over half of these roxarsone products, while just six companies are responsible for a combined 93 percent (Table 5).

Table 5. FDA-approved animal products containing roxarsone, by company

Company	Number of FDA-approved products	Percent of total
Alpharma	47	54%
Elanco Animal Health, A Division of Eli Lilly & Co.	4	5%
Fort Dodge Animal Health, Division of Wyeth	3	3%
Intervet, Inc.	15	17%
Merial Ltd.	6	7%
Phibro Animal Health, Inc.	6	7%
Other: Planalquimica Industrial Ltda., Pennfield Oil Co., Pharmacia & Upjohn Co., Schering-Plough Animal Health Corp., Swisher Feed Division	6	7%
	87	**100%**

Source: U.S. Food and Drug Administration, Center for Veterinary Medicine, 2004 Online Green Book, at www.fda.gov/cvm/greenbook/elecgbook.html

Estimating how much arsenic is given to U.S. broiler chickens

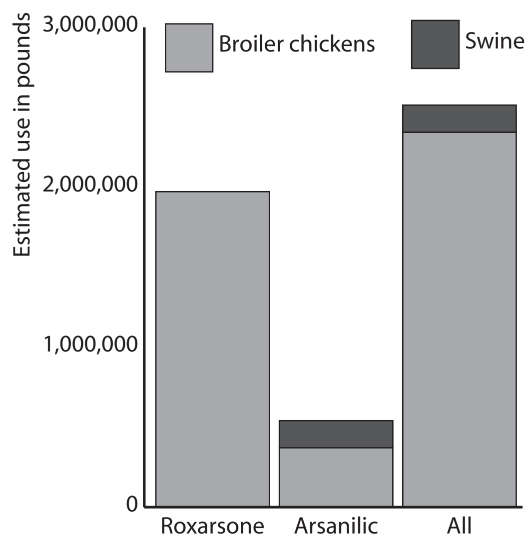
As previously stated, there's no public mechanism for quantifying *exactly* how much arsenic is given to U.S. food animals each year in their feed. However the Union of Concerned Scientists (UCS), using the best publicly available data plus some reasonable assumptions, estimates nearly 2 million pounds of roxarsone alone are given annually to U.S. chickens, based on 1998 production of 7.8 billion broilers (Figure C).

Adjusting the UCS estimates to today's broiler production levels, other assumptions remaining the same, would yield an estimate closer to 2.2 million pounds of roxarsone given to chickens annually.

Another basis for estimation is Alpharma's claim that a U.S. broiler on roxarsone-containing feed will get 3.5 mg of roxarsone daily for its six-week lifespan (minus the 5-day withdrawal period).[36] If we assume 70 percent of all broilers are on arsenical feed additives, this translates to around 1.7 million pounds of roxarsone fed to broilers annually—within 25 percent of the adjusted UCS estimate of 2.2 million pounds.

Therefore, industry and other estimates roughly agree that at least 1.7 to 2.2 million pounds of arsenic compounds (roxarsone)—almost 1,000 tons—are given to American broiler chickens each year.

Figure C. Estimated use of arsenic compounds in feed additives in broiler chickens



	Roxarsone	Arsanilic	All
Swine	0	169,440	169,440
Broiler chickens	1,972,443	371,435	2,343,878

Source: Union of Concerned Scientists (2001), *Hogging It.*

2. Concerns with adding arsenic routinely to chicken feed

> "Fifty years of use guarantees the safety of 3-Nitro (roxarsone) for animals, humans, as well as the environment, when used in accordance with the instructions."

Source: Alpharma Animal Health, www.alpharma.com/ahd/index.html

We don't share Alpharma's nonchalance over the last half-century or so of routine arsenic use in raising broiler chickens.

Instead, when Dr. Tamar Lasky and colleagues at the USDA reported in early 2004 that the public's intake of arsenic in chicken likely was higher than previously thought, we were worried. Let's explain why.

Health risks from eating or drinking arsenic

Arsenic has been known since ancient times. Its name comes from the Greek word meaning "potent."[37]

Arsenic exists in various forms, both organic and inorganic. Arsenic that naturally occurs in groundwater, for example, is comprised mostly of inorganic species called arsenate, As(V), and arsenite, As(III). Roxarsone and other organic arsenic feed additives also potentially can contaminate groundwater—obviously, they are not naturally occurring. Inorganic arsenic is one of the few substances studied well enough in people to be considered a "known" cause of human cancer. Inorganic arsenic also is linked to serious health effects apart from cancer. Long-term arsenic, depending on the level of exposure, can cause hyperpigmented skin, skin nodules, vessel disease, and appears to heighten the risk of death from high blood pressure and heart disease. Diabetes risk also is increased.[38,39] Among children drinking contaminated water, arsenic has been associated with worse intellectual function.[40] On these grounds alone, arsenic contamination of U.S. groundwater is a major public health problem.

The arsenic present in food is a mixture of inorganic and organic forms. The National Research Council has found no evidence "that arsenic is an essential element in humans or that it is required for any essential biochemical process."[41] Conventional wisdom used to be that ingesting *organic* arsenics, like those added to animal feed, carried fewer health concerns than ingesting the *inorganic* forms sometimes found in tap water. Limited study of roxarsone's toxicity, for example, had suggested it was not all that toxic.[42]

Arsenic and cancer

Arsenic ingested in drinking water causes skin, bladder and lung cancer, and is "associated with" other kinds of cancer.[43,44] According to the EPA, about 12 million Americans drink water containing arsenic at or exceeding its safety standard of 10 ppb arsenic. (Three times as many consume water containing over 3 ppb arsenic.)[45]

Men and women who daily drink water contaminated with arsenic at this 10 ppb level, have a greater than 1-in-300 risk of developing cancer during their lifetime, according to the National Academies of Science.[46,47] If the 12 million Americans who in 2001 drank water contaminated with arsenic at or above this risk level were to continue doing so, we could expect at least an additional 40,000 cases of cancer. The EPA doesn't tolerate this much exposure to other cancer-causing agents in drinking water. Generally, it regulates them such that the lifetime cancer risk is around 30 times lower, or 1-in-10,000.

Arsenic risks need to be considered on top of those acquired from other cancer-causing agents in the environment, such as tobacco smoke, diesel exhaust, and carcinogenic industrial chemicals, for example. A person's individual risk from developing environmentally induced cancer therefore could be much higher than 1-in-300.

Recent science calls into question the presumption that organic forms of arsenic are less toxic. Organic and inorganic forms of arsenic generally convert to one another, in the human body, in the environment, and likely in chickens as well. Strong evidence now suggests that within the chicken the organic arsenic compound, roxarsone, is converted into the inorganic forms of arsenic thought to date to pose the greatest health risks to humans.[48,49]

In addition, when people ingest inorganic arsenic, such as in contaminated tap water, the body converts most of it to organic forms of arsenic via a process called methylation—the attachment of carbon atoms to arsenic. Methylation used to be thought of solely as a process of detoxification. That assumption was wrong. It's now clear that in the process of converting and eliminating arsenic, the body creates some organic arsenic species more toxic than their inorganic parent compounds.[50,51,52] (Bacteria living in water or soil also can convert inorganic arsenic to organic arsenic via methylation—as well as convert organic arsenic into inorganic forms).

One additional study bears special mention. Xie et al. (2004) fed laboratory animals both organic and inorganic arsenic and looked at changes to the liver, an important organ for detoxification.[53] What they found was surprising. Arsenic accumulated in the liver regardless of whether it was organic or inorganic arsenic being fed to animals. In addition, *all forms of arsenic altered how liver cells interpret or "express" the genetic information* contained in those cells, even if the specific expression of these genes differed somewhat between organic and inorganic arsenic.

Scientists continue to discover new health impacts from arsenic exposure, effects not previously considered. Arsenic now appears to be a potent disruptor of hormone function, altering at extremely low levels the way in which hormones transmit information between cells.[54,55,56] Arsenic's ability to disrupt the function of some hormones has been observed among cells from mammals exposed to arsenic concentrations lower than those allowed in public drinking water systems by the EPA's new 10 ppb standard.[57]

Arsenic isn't poisonous to everyone to the same degree. Adults vary in how their body metabolizes arsenic, depending on their individual genetic make-up. However, children, infants and the human fetus now appear to be among those potentially most vulnerable to arsenic's toxic effects, in part due to differences in arsenic metabolism very early in life; arsenic and its organic metabolites easily pass the placenta, for example.[58,59] And yet, there has been little concerted effort until recently to study the toxic effects of arsenic exposure on early child development. Nevertheless, some studies in animals suggest that arsenic causes birth defects and some human studies link arsenic in drinking water to increases in miscarriage, stillbirth, and preterm birth.[60]

In short, the science-based reasons to avoid ingesting arsenic—whatever the form—are many.

Other arsenic risks

Beyond the direct hazards of ingesting arsenic, there are good reasons to question the intentional addition of arsenic to chicken feed.

The more than 8.7 billion U.S. broiler chickens raised each year generate 26 to 55 *billion* pounds of poultry litter or waste,[61] creating a huge disposal problem concentrated in relatively few geographic areas.[62] Around 90 percent currently is applied to fields and cropland as "fertilizer."[63,64,65] Poultry litter containing arsenic also is fed to beef cattle. (In January 2004, the FDA had proposed banning the practice; however, the agency reversed course in October 2005 and decided to continue allowing it after all.[66,67]) The rising volume of chicken waste, as well as its geographic concentration, means that larger broiler chicken factories now produce far more waste than they can safely get rid of through land application.

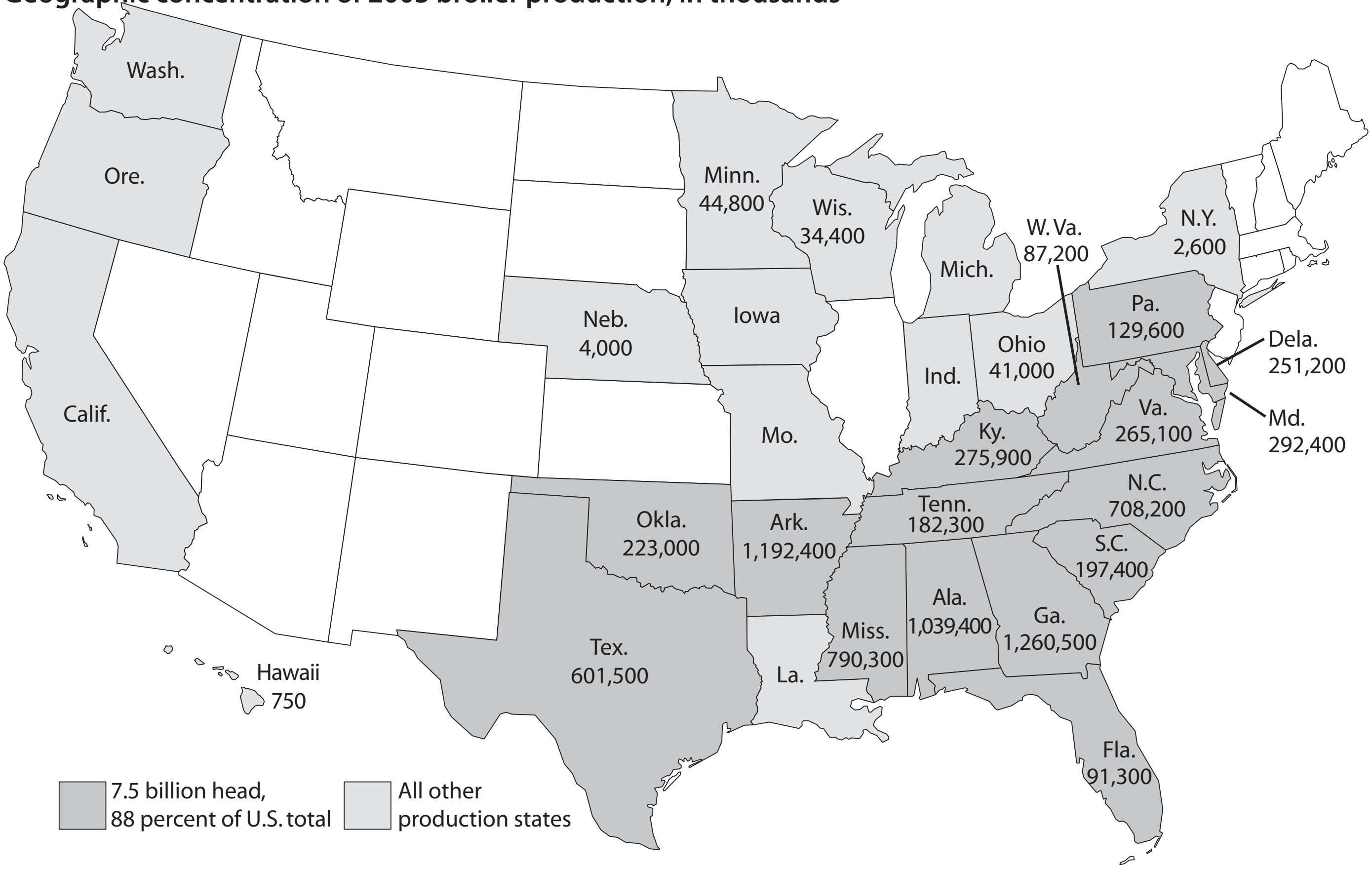
One major hurdle to safer management of all this waste is the routine addition of arsenic to chicken feed. Of the 2 million pounds or so of roxarsone fed to chickens each year, up to three-quarters will pass unchanged into poultry waste. Once there, roxarsone rapidly breaks down into other organic and inorganic forms of arsenic during waste storage and composting, after land application,[68,69,70] and in the water leaching from litter-applied fields.[71,72,73] Both inorganic and organic breakdown products carry recognized health risks.

As much as half of the roxarsone in poultry litter converts, for example, to very toxic inorganic arsenate, As(V), in a process accelerated by the presence of water.[74,75] If the EPA made it possible to classify animal waste as hazardous waste—which it doesn't—then land application of poultry waste would be prohibited "based solely on its concentrations of leachable arsenic."[76,77,78]

Poultry litter disposed of on nearby agricultural fields therefore may disperse from a half million to 2.6 million pounds of roxarsone and its degradation products into the environment annually, according to various estimates.[79,80,81] This environmental arsenic must necessarily be concentrated—like the birds themselves—in a few areas of high-density poultry production, like the Delmarva peninsula of Delaware, Maryland and Virginia; the Ozark plateau of Arkansas, Missouri and Oklahoma; and certain sections of Georgia, eastern Texas and the Carolinas.[82]

The relatively new practice of converting poultry litter into fertilizer pellets, to be sold for commercial use on

Geographic concentration of 2003 broiler production, in thousands



Source: National Agricultural Statistics Service, at http://usda.mannlib.cornell.edu/reports/nassr/poultry/pbh-bbp/plva0405.pdf

crops, as well as for home landscaping, gardening and on golf courses, opens up entirely new avenues of arsenic exposure; arsenic levels in these pellets are reportedly similar to those found in unprocessed poultry waste.[83]

In late 2002, Minnesota also permitted the first U.S. incinerator for the purpose of burning poultry litter for electricity generation.[84] While neither pelletization nor incineration can destroy or detoxify arsenic, both would further disperse it into the human environment.[85]

Applying poultry litter to fields can expose farmers and workers directly to the arsenic therein. Of course, the airborne drift of poultry litter dust as well as subsequent groundwater contamination, also can expose neighbors to these operations, and indirectly to arsenic. Around 70-90 percent of arsenic in poultry litter becomes water soluble, enhancing its migration through soils and into underlying groundwater.[86,87] The routine use of roxarsone in chicken feed therefore quite likely adds to already large public health problems with arsenic-contaminated groundwater.[88,89]

In Prairie Grove, Ark., an intensive poultry production area, O'Connor et al. recently sampled 31 homes and detected roxarsone in house dust of 30 of them (97 percent). All the house dust samples contained two or more of the arsenic species known to be in litter from broiler chickens. In 97 percent of samples an inorganic arsenic, As(V), accounted for 90 percent or more of the total arsenic detected, a profile consistent with studies of roxarsone's degradation in the environment.[90] Prairie Grove residents have filed suit against Alpharma and Alpharma Animal Health, as well as poultry producers Cal-Maine Farms, Cargill, George's, Peterson, Simmons and Tyson Foods, seeking an injunction against the use of roxarsone-containing feed additives as being "a continuing health hazard."[91]

Poultry farms and poultry manure waste are replete with bacteria as well as residues of arsenic and antibiotics. Some microbiology experts warn that arsenic routinely added to chicken feed, and thus to chicken litter, therefore may also help to create drug-resistant "superbugs."

We know that adding antibiotics routinely to chicken feed exposes bacteria to them, and can quickly make the bacteria resistant to these medicines. Upon eating the meat, or handling the birds, these resistant bacteria can be transmitted to people and cause infections, like salmonella food poisoning, that are resistant to treatment with antibiotics. An estimated 90 percent of antibiotic-resistant salmonella comes from this use of antibiotics in food animals.[92,93]

Pieces of DNA that account for a bacterium's resistance to individual antibiotics also can be physically linked on a longer piece of genetic material, called a plasmid, that carries resistance to multiple drugs. These plasmids are transmitted easily among bacteria. Thus, exposing the bacteria in a farm environment to just one antibiotic feed additive may actually pressure them to become resistant not only to this specific drug, but also to every other antibiotic represented on that gene-carrying plasmid.

What's all this have to do with arsenic? As it turns out, bacteria also can acquire genes making them resistant to heavy metals, like arsenic. Plasmids can carry these arsenic resistance genes, along with antibiotic resistance genes. Exposing chickens routinely to arsenic therefore may spur the creation of bacteria in those chickens that are resistant to multiple antibiotics, in addition to the arsenic; the fact that producers simultaneously feed chickens both antibiotics and arsenic compounds only heightens this concern.[94,95]

Finally, chicken isn't our only source of arsenic. In addition to arsenic in drinking water, scientists recently reported from a survey of global rice that U.S. rice carries arsenic levels from 40 percent to 5-times higher than does rice from Europe, India or Bangladesh. Some Americans are further exposed to arsenic leaching from decks and or playground equipment made with arsenic-treated wood—now banned. Neighbors of the many superfund sites contaminated with the residues of now-banned arsenic pesticides experience additional potential exposures.

Contrasting approaches to regulating arsenic in food and animal feeds

Foods can and often do contain chemical residues.[96] Residues can occur from the intentional use of animal drugs, as well as from use of food additives and pesticides. Chemical food contamination also may derive from environmentally dispersed pollutants, such as mercury, perchlorate or outdated pesticides (including arsenic pesticides) no longer used but still lurking in agricultural soils.

The U.S. approach, generally, does not aim to keep chemical contaminants completely out of the food sup-

Food chemicals: What's "safe"?

The U.S. government's explicit aim is not to try and prevent human exposure to all of a particular chemical in food—even for a human carcinogen like arsenic. Instead, the way that federal agencies address chemical food contamination works like this:

Manufacturers of food-use chemicals must receive federal approval before their products legally can be used;

The appropriate agency establishes a "tolerance," the maximum level of a toxic chemical legally allowed to contaminate poultry, meat and egg products;

Federal agencies then sample and test food products to ensure their "safety," i.e., to ensure that chemical residues don't exceed the tolerance levels;

Agencies hypothetically can take action to remove from the market foods that have been sampled and found to be contaminated with chemical residues above tolerance levels, although in practice that is rarely done.

The roles of specific federal agencies are determined by law. Animal drugs are initially approved for use by the FDA, as are food additives; food-use pesticides are approved by the EPA. These federal agencies also set and enforce the tolerances for these respective classes of chemicals. For environmental pollutants found to contaminate foods, (e.g., perchlorate, an ingredient in rocket fuel) or canceled pesticides, like DDT, the EPA also may recommend to the FDA and the USDA an appropriate "action level" for the contaminant(s) in question.

In 1994, the General Accounting Office (GAO) identified several problems with the U.S. food safety approach. With primary responsibility for monitoring chemical contamination of food split between the FDA, USDA and EPA, the GAO called federal efforts to monitor for and respond to chemical food contamination "fragmented" and fundamentally weak. Other problems include:

▷ **Lack of federal monitoring.** Despite more than 80,000 industrial (non-food use) chemicals approved for use in the U.S.—some chemicals certainly entering the food chain as contaminants—no food safety law actually requires federal officials to monitor the food supply for these environmental contaminants;

▷ **Failure to fund adequate testing.** As of 1994, responsible federal agencies spent just $150 million to monitor chemicals in food. In 2001, the USDA's Food Safety Inspection Service analyzed for arsenic in just 1,207 of the 8.6 billion or so young chickens produced, finding three of them to be violative, i.e., exceeding the tolerance.

▷ **Failure to base standards on science.** Science evolves. Yet federal law generally does not require agencies to periodically review the safety of chemicals previously approved for use in or on foods, using the most up-to-date science and standards; this virtually ensures that legal tolerances will always lag behind what is scientifically known about the actual safety of such residues.

ply (see box)—even for cancer-causing arsenic. In fact, U.S. efforts to monitor for and respond to chemical food contamination have been found fundamentally weak and "fragmented," with primary responsibility split between the USDA, the FDA and the EPA.[97]

Rather, the aim of U.S. regulators is to determine the maximum exposure to that chemical deemed to be "safe," and then to legally allow contamination of a particular food product up to the level of consumption that will result in that maximum "safe" exposure. Safety in this context is a relative term. It doesn't mean the food product is free of contaminants or hazard; it simply means the possible hazard posed by ingestion of the amount of contaminant allowed is deemed acceptable by regulators—and therefore "safe" by their own definition.

The USDA's Food Safety Inspection Service, or FSIS, enforces "tolerances" or legal standards for chemical residues in food resulting from use of approved drugs or chemicals, as well as "action levels" for canceled pesticides and environmental contaminants that have no tolerance. The cornerstone of FSIS' effort is the National Residue Program, which since 1970 has monitored chemical residues in food—more specifically, in both domestically produced and imported meat, poultry, and egg products.[98]

The FDA has set tolerances for arsenic in various foods (see Table 6). It's notable that FDA's tolerances allow four times as much arsenic in chicken livers as in chicken breasts, thighs or other muscle tissues. FDA's tolerances are for total arsenic—inorganic and organic species combined.

Some arsenic in some foods may derive from naturally occurring sources. It's likely that the intentional use of arsenic as a feed additive, as well as the prior use of now-outdated arsenical pesticides, also accounts for some of the total arsenic found in various foods. (At this time, for any particular food there's no way of knowing the ultimate source of the arsenic found therein. Until recently, it was technically difficult and expensive to determine from a food sample how much arsenic was inorganic, how much organic, and which organic and inorganic arsenic species were present. The USDA's sampling of chicken in its FSIS program has not attempted to do so.)

Table 6. U.S. tolerances for total residues of combined arsenic in food

In eggs and in edible tissues of **chickens** and turkeys:	500 parts per billion (ppb) in uncooked **muscle tissue**. 2,000 ppb in uncooked edible by-products (**liver, kidney**) 500 ppb in eggs
In edible tissues of swine:	2,000 ppb in uncooked liver and kidney. 500 ppb in uncooked muscle tissue and by-products other than liver and kidney.

Source: 21 Code of Federal Regulations Part 556.60. http://dil.vetmed.vt.edu/cfr/Display.cfm?Directory=556&Chapter=60.txt

Europe's approach. Veterinary drugs in the European Union also must be approved by regulators prior to use in food animals, same as they are in the U.S. The European Medicines Agency (EMEA) determines the maximum amount of any particular drug allowed in meat from those animals, called an MRL (maximum residue limit).[99] But the EMEA does so only if it can assure the public that food residues below that level pose *no* health hazard. This is where the European approach differs from that in the U.S. Again, regulators in the U.S. allow health hazards, even from carcinogens, as long as the food residues fall below a level they have determined to be acceptable.

In Europe, no arsenic is added to animal feed.[100] For roxarsone, the EMEA determined early in 2004 that it could not meet its health standard, and so it established no maximum residue limit. European authorities, in other words, found they lacked the science to be able to assure consumers that eating any arsenic residues in meat would be "safe."[101] Europe's refusal to set a "safe" level for arsenic residues in food reflects the real health risks from eating arsenic-contaminated meat.

What the Lasky study found

By contrast, the routine addition of arsenic to animal feed in the U.S. dates back decades.

Surprisingly, this practice received little public health attention until Dr. Lasky and other USDA scientists published their estimates in *Environmental Health Perspectives*, an NIH-published journal, that young broiler chickens have an average (mean) total arsenic concentration of 0.39 parts per million—three- to four-fold higher than that found in other types of meat. Estimates were derived using the USDA's own data, from more than 5,000 chicken samples collected by the FSIS program between 1993 and 2000.[102]

On average, Americans now eat 250 percent more chicken than they did 40 years ago, while some people eat six to ten times more chicken per day than does the "average" person. Combining their estimates of average arsenic in chicken with consumption data on how much chicken Americans actually eat, Lasky et al. further estimated the amount of total arsenic ingested by different categories of Americans. They found an average adult, for example, eating about 2 ounces of chicken per day, would ingest from 5.6 to 8.1 micrograms of total arsenic daily—depending on one's assumptions about how much arsenic accumulates in chicken muscle vs. liver.

Lasky's estimates represent a significant chunk of total arsenic intake in the diet, which various studies estimate for the "average" person in the U.S., Canada and UK to be between 53 and 63 micrograms per day.[103] Moreover, our exposure to arsenic in chicken appears to be an easily preventable component of our overall exposure.

"The higher than previously recognized concentrations of arsenic in chicken combined with the increasing levels of chicken consumption may indicate a need to review assumptions regarding overall ingested arsenic intake," [104] Lasky concluded.

The Lasky study raised a number of other worthy questions as well:

1. Why are consumers left in the dark about how much arsenic is in chicken they eat?

Lasky brought attention to the fact that even though the USDA had collected and tested more than 5,000 samples from broiler chickens between 1993 and 2000, the public was told only how many samples tested above the limit of detection for arsenic and how many of these violated the legal tolerance. Until Lasky's study, any indication of the range or average levels of arsenic found were lost to public view. By 2004, FSIS began to report more information about the actual levels of arsenic being found in young chickens.

The Lasky article pointed out another, perhaps even more fundamental issue.

To estimate concentrations of arsenic in chicken muscle, these USDA scientists were forced to use the only USDA arsenic data available—from chicken *livers*. Since the vast majority of Americans eat chicken muscle—chicken breasts, thighs and leg meat—one has to wonder why the USDA never tested for arsenic in the meat that people eat?

In fact, the FSIS's stated approach to testing for many toxic chemicals in domestic foods is to test only organ tissue, such as kidney or liver.[105] The practice stems from the USDA's presumption that such chemicals will reliably concentrate in organs. In effect, as long as the USDA monitors and finds chicken livers do not violate the official tolerance of 2.0 parts per million (equivalent to 2,000 parts per billion), they assume that arsenic in the untested meats that people do eat, such as in chicken breasts or thighs, will fall below the 0.5 ppm tolerance for these foods as well. (In 2001, it should be noted, the USDA tested 1207 livers from the more than 8.6 billion chickens produced and found arsenic levels to exceed the 2.0 ppm tolerance in just three of them.)

Absent real data from chicken muscle, Lasky et al. employed information supplied by Alpharma, makers of most FDA-approved roxarsone feed additives. The non-public information purportedly showed that arsenic levels in chicken liver can be 2.9 to 11 times higher than that in chicken muscle, depending on how close to slaughter the arsenic had been added to the feed. Commenting on the known science around arsenic metabolism in mammals, however, Johns Hopkins University scientist Ellen Silbergeld suggests that when animals are repeatedly exposed to arsenic (such as in their feed) their ability to excrete it may actually decrease, and therefore arsenic levels in muscle tissue may rise to surpass those in liver.[106,107]

For these and other reasons, we agree with Silbergeld that the USDA ought to be testing for arsenic (and other toxic chemicals) in the meats that people eat, and basing its food safety efforts on actual data, not untested assumptions.

2. Whose children are above average?

If anything, Lasky's study low-balled the risks to many consumers from arsenic in chicken.

Arsenic intake estimated by Lasky et al. was for a hypothetical "average" American. That is, an adult weighing an "average" weight of 154 pounds, eating just 2 ounces of chicken per day.

Table 7. Arsenic ingested by people with varying chicken consumption

Daily chicken consumption	Americans consuming at this level	Total As ingested	
		Daily (ug)	Yearly (mg)
2 oz.	As many as not (average)	5.6–8.1	2.0–3.0
12 oz. (0.75 lb.)	Chicken lovers (1 in 100)	32.5–47.1	11.9–17.2
20 oz. (1.33 lbs.)	Crazy for chicken (1 in 1000)	56.8– 82.3	20.7–30.0

Source: Adapted from data in Table 3, Lasky *et al.* 2004.

Many people are not average, however. USDA data indicate that black Americans eat about 20 percent more chicken than does the U.S. population as a whole.[108] Similarly, due to their small size, toddlers eating chicken baby food may ingest chicken at substantially higher than average levels, on a weight-adjusted basis.

For these subgroups, arsenic ingestion from contaminated chicken may be substantially higher than the "averages" estimated by Lasky et al. One in a hundred of us (let's call them "chicken lovers") now eats more than three-quarters of a pound (>350 g) of chicken per day. Using arsenic figures from Lasky et al., this person could be expected to ingest 32.50–47.07 micrograms of total arsenic per day from chicken alone. One in a thousand Americans—"crazy for chicken"—eats at least one and one-third pounds of chicken per day. For an average-sized person, this could translate into 56.8 to 82.3 micrograms of total arsenic per day, more arsenic than the average American is estimated to receive from *all* dietary sources.

3. Organic vs. inorganic: Does it matter?

Arsenic is present in all foods, at trace concentrations, occurring as a mixture of inorganic and organic forms. It's understood that the organic arsenic given to chickens is at least partially converted in the chicken to inorganic arsenic.

Table 8. Inorganic arsenic ingested by people with varying chicken consumption

Daily chicken consumption	Americans consuming at this level	Inorganic As ingested	
		Daily(ug)	Yearly (mg)
2 oz.	As many as not	3.6–5.2	1.3–1.9
12 oz. (0.75 lb.)	Chicken lovers (1 in 100)	21.1–30.6	7.7–11.2
20 oz. (1.33 lbs.)	Crazy for chicken (1 in 1000)	36.9–53.5	13.5–19.5

Source: Adapted from data in Table 3, Lasky *et al.* 2004.

Lasky et al. estimated not only the total arsenic ingested by chicken eaters, but also the fraction that is inorganic arsenic. They calculated an "average" American eats 3.6 to 5.2 micrograms of inorganic arsenic per day from chicken alone, while "chicken lovers" or those "crazy for chicken" may ingest several times that amount.

(Strangely, U.S. regulators have expended no effort to collect real data on the relative amounts of inorganic and organic arsenic in chicken, or other foods. Lasky et al. relied upon 20 year-old unpublished data collected from Canadian food samples finding that 65 percent of total arsenic in poultry (roughly two-thirds) is inorganic. Though not publicly available, these appear to be the only such data ever collected on poultry. The EPA, for instance, has also relied upon it for analyses on dietary arsenic intake done in 1988 and 1998.[109,110,111] In meat, dairy and cereal products generally, inorganic arsenic accounts 65 to 75 percent of the total arsenic burden, while in produce, fish and seafood, organic species constitute 90 percent or more of the arsenic present.[112])

To what can we compare the risk from this "average" person's daily ingestion of inorganic arsenic in chicken? An adult drinking 2 liters per day of water contaminated with arsenic at the EPA's new standard of 10 ppb would be expected to ingest around 10 micrograms of inorganic arsenic per liter per day, or 20 micrograms in total. Over a lifetime, this person's arsenic exposure would give them an additional 1-in-300 risk of developing cancer, over and above their risks for cancer due to other reasons.

For the several million Americans who currently drink water contaminated with at least this much arsenic, there would be a further cancer risk from their additional arsenic exposure from eating chicken. For "chicken lovers," their ingestion of arsenic from chicken—and therefore their heightened risk of developing cancer—could be about the same as that from drinking water contaminated with arsenic at the 10 ppb EPA standard—at least, using the estimates generated by Lasky. Americans who are simply "average" consumers of chicken, as well as of water contaminated with arsenic up to the EPA standard, could also significantly elevate their risk of cancer, but not by nearly as much as do chicken lovers.

3. What we found: Arsenic in chicken

Based on the study by Lasky and other USDA scientists, we decided to test brands of chicken products. Our report represents the first attempt to actually test for arsenic in chicken that people mostly eat—retail chicken and fast food chicken products, using up-to-date detection methods.

What we tested

We tested both retail chicken and fast food chicken sold in California and Minnesota, from December 2004 to January 2005.

Retail raw chicken products tested included thighs, breasts and livers purchased under both "conventional" and "premium" labels. We tested chicken from five of the top 25 broiler producers nationally—Tyson, Perdue, Foster Farms, OK Foods (Spring River Farms), Gold'n Plump—as well as several premium brands, such as Rosie Organic Chicken (Petaluma Poultry), Trader Joe's, Gerber's and Kadejan. We tested whole chickens from a single kosher/halal brand, Empire Kosher, as well. In total, we ran 155 arsenic tests on meat from 151 different packages of retail chicken.

Ranking of U.S. integrated poultry companies

1	Tyson Foods Inc.	21	Marshall Durbin Company
2	Pilgrim's Pride Corp.	22	Mar-Jac, Inc.
3	Gold Kist Inc.	23	Claxton Poultry Farms, Inc.
4	Perdue Farms Inc.	24	Peterson Farms, Inc.
5	Wayne Farms	25	Gold'n Plump Poultry, Inc.
6	Sanderson Farms Inc.	26	Sylvest Farms, Inc.
7	Mountaire Farms Inc.	27	Amick Farms, Inc.
8	Foster Farms	28	Harrison Poultry, Inc.
9	Cagle's Inc.	29	Golden-Rod Broilers Inc.
10	House of Raeford Farms, Inc.	30	Charoen Pokphand USA, Inc.
11	O.K. Foods, Inc.	31	Farmers Pride, Inc.
12	George's Inc.	32	B C Natural Chicken
13	Koch Foods, Inc.	33	Draper Valley Farms, Inc.
14	Fieldale Farms Corp.	34	Holmes Foods
15	Peco Foods Inc.	35	Park Farms, Inc.
16	Townsends Inc.	36	Empire Kosher Poultry Inc.
17	Allen Family Foods	37	Lady Forest Farms, Inc.
18	Simmons Foods, Inc.	38	Gentry Poultry Company, Inc.
19	Case Foods Inc.	39	MBA Poultry, LLC
20	Keystone Foods Inc.	40	College Hill Poultry, Inc.

Source: WATTPoultryUSA January 2004, accessed February 6, 2005 at http://www.ansci.umn.edu/poultry/student-resources/broilerco.htm

Fast food chicken tested was purchased from chains focused on fried chicken products (KFC, Church's, Popeyes) as well as from sandwich and burger outlets that offer chicken products in the form of sandwiches, strips and nuggets (McDonald's, Subway, Wendy's, Arby's, Jack in the Box, Hardee's and Carl's Jr.). We tested total arsenic in 90 samples of cooked fast food chicken products.

Technology to separate different kinds of arsenic from food samples is still evolving, and is expensive. We therefore asked our contract laboratory to test for total arsenic, the sum total of all organic and inorganic forms of arsenic.

As noted previously, the USDA has not tested for arsenic in muscle, the chicken meat that most people eat. In January 2005, *Consumer Reports* (*CR*) reported test results for total arsenic in 116 samples from widely sold brands of conventional and organic chicken, both muscle and liver.[113] However, its testing only carried the ability to detect arsenic down to the 50 ppb level; none of the chicken muscle *CR* tested had total arsenic greater than 50 ppb.[114] Notably, our testing on 245 raw and cooked chicken samples has been conducted by a laboratory whose limit of detection for total arsenic goes as low as 2 parts per billion.

Generally, we tested five packages of each product, bought on the same day and from the same retail market or fast food outlet.[115] Our samples obviously could not have come from the same bird, and likely not the same flock. Our sampling method was not random in that we only chose one retail market offering that product in a single city. On the other hand, this approach does provide a real-life snapshot look at total arsenic in branded chicken products that might have been purchased by consumers in those same stores on that day.

There's no telling whether the same brands today would carry the same amount of arsenic. Or whether a particular brand of chicken purchased in Minnesota or California carries the same levels of arsenic as would birds from that brand bought elsewhere in the country.

What we found

Arsenic is common in uncooked chicken products from supermarkets, we found. But arsenic in chicken is not a "natural" problem, nor one that should just be accepted. Eating chicken contaminated with arsenic is also not inevitable.

Figures D and E show that the packages of chicken breasts, thighs and legs we tested for total arsenic had average levels ranging from non-detectable to 21.2 parts per billion (at a limit of detection of 2 ppb). Our most contaminated chicken breasts or thighs, in other words, had at least 10-fold higher levels of average arsenic than did the least contaminated.

For chicken livers, average levels of arsenic varied by two orders of magnitude (Figure F).

Our figures reflect the total arsenic for each branded product averaged over the number of product packages that we tested (usually five). Where packages had no detectable arsenic, we assumed for averaging purposes that arsenic was present at 1 ppb, or half the limit of detection. That's why for some items, the average level of arsenic appears as below 2 ppb. If no arsenic was detected in any of our samples of that product, the graphs list the average total arsenic for that item as ND (non-detect).

Plenty of supermarket chicken, however—45 percent of our samples—had no detectable arsenic. This strongly suggests that different broiler chicken producers use arsenic very differently.

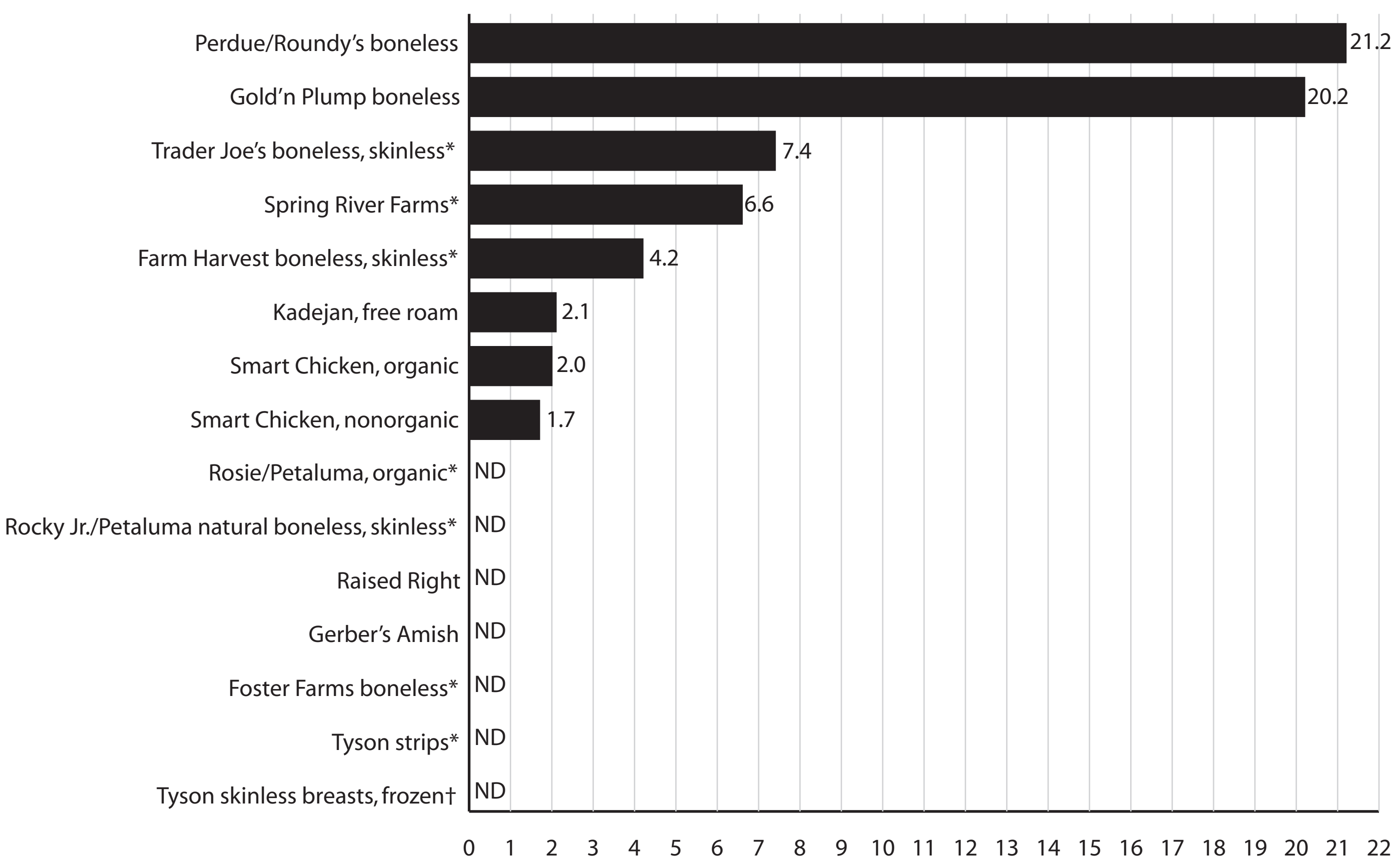
Your choices as chicken shoppers and eaters clearly has a bearing on how much arsenic you likely will ingest.

Arsenic levels tend to vary by brand, with packages of Minnesota's Gold'n Plump and Roundy's store label chicken (which the butcher described as being from Perdue, the nation's fourth largest broiler producer) carrying the highest average total arsenic among all the raw chicken breasts and thighs tested.

Several retail brands of organic, other premium and conventional chicken brands contained *no* detectable arsenic in any of the packages tested. Choosing USDA

Figure D. Average total arsenic in uncooked chicken breast products (parts per billion)

Averaged over five packages, unless indicated (†)



** Purchased in California*

† Averaged over three samples, drawn from a single, multipound package

certified organic chicken might be one effective strategy for ingesting less arsenic, since the use of arsenic feed additives are prohibited under national organic standards; Rosie Organic Chicken breasts from Petaluma Poultry in California, for instance, had no detectable arsenic in our testing. However, arsenic also was absent or near the laboratory's limit of detection in several non-organic premium brands including Smart Chicken as well as Raised Right Natural, Gerber's Amish and Rocky Jr. in California. If our results are typical of these brands, then making smart choices at the grocery counter can reduce one's total exposure to arsenic.

Not all "premium" brands are necessarily lower in arsenic than non-premium brands, however. Chicken breasts purchased in Minnesota under the organic Smart Chicken label had detectable arsenic in four of five samples—albeit very close to the 2 ppb limit of detection—while none was detected in those from the non-organic Smart Chicken label.

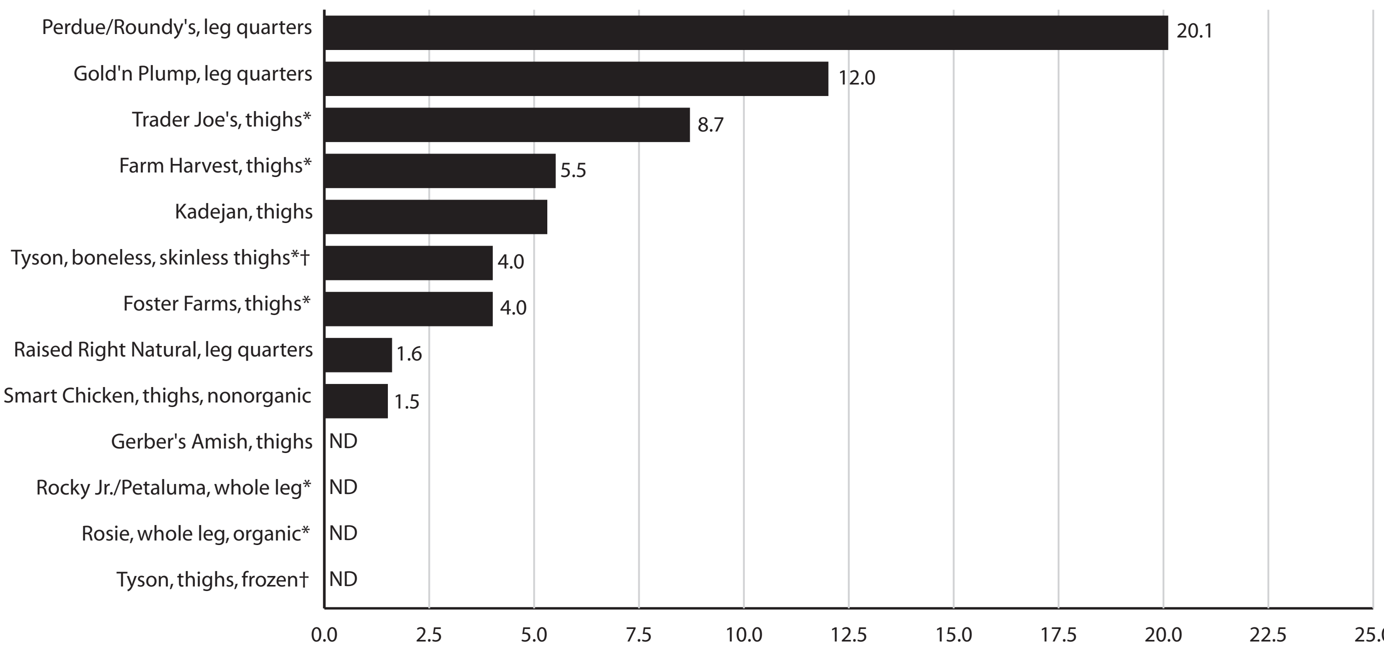
Chicken breasts from Foster Farms and breasts and chicken strips from Tyson, the eighth largest and largest broiler producers in the U.S. respectively, contained no detectable arsenic. (Not all Tyson and Foster Farms products were free of detectable arsenic, however. California-purchased chicken thighs from Tyson and Foster Farms contained average total arsenic of 4.0 parts per billion.)

We found that arsenic among fast food chicken products varied hugely as well (Figure G).

Chicken thighs that we tested from Church's on average contained 20 times the arsenic of thighs from KFC; Jack in the Box chicken sandwiches contained on average more than five times the total arsenic of Oven Roasted chicken sandwiches from Subway. While KFC

Figure E. Average total arsenic in uncooked chicken thigh, leg and leg quarter products (parts per billion)

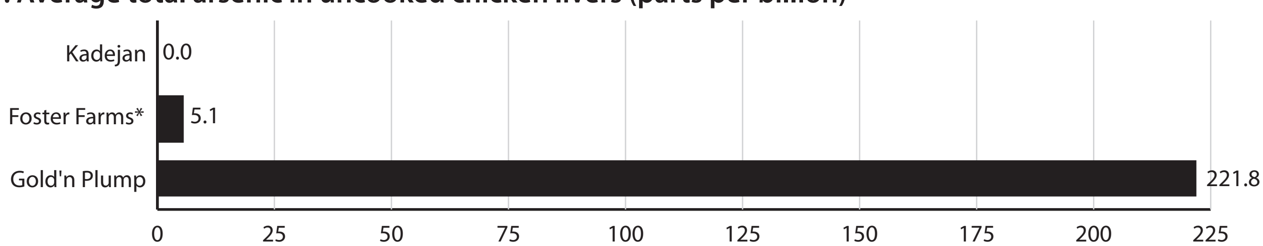
Averaged over five packages, unless indicated (†)



** Purchased in California*

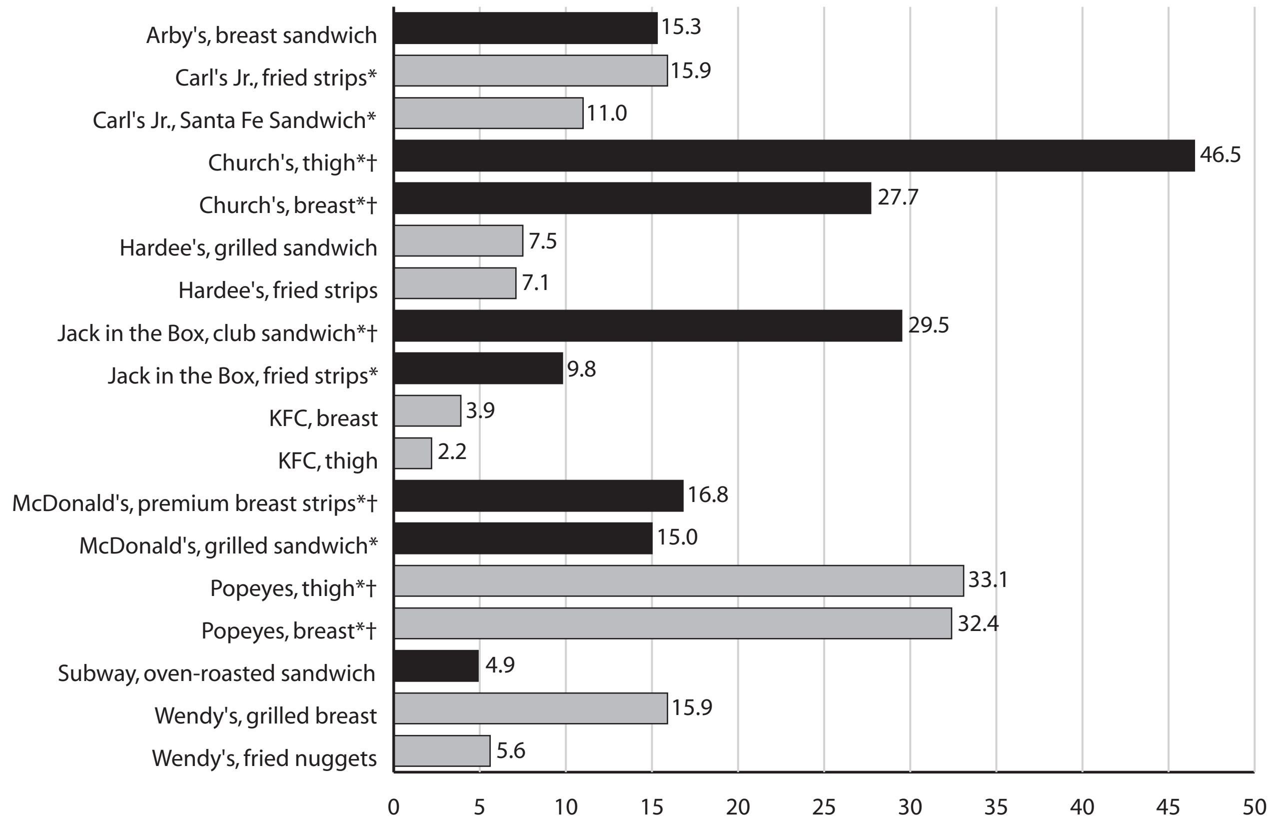
† Averaged over samples from four individual packages in California, over three samples from a single multipound package in Minnesota

Figure F. Average total arsenic in uncooked chicken livers (parts per billion)



**Purchased in California*

Figure G. Average total arsenic in select fast food chicken products (parts per billion)
Limit of detection = 2 ppb, 10 ppb if indicated (†)



** Purchased in California*

chicken products had total arsenic down close to the 2 ppb limit of detection, none of the fast food products were totally without detectable arsenic. Within individual brands, arsenic levels were fairly consistent, our limited testing suggests.

It's beyond the scope of our sampling to determine why this variation exists. One reasonable explanation is that arsenic is used in growing some of the chickens but not others. It's possible there are differences in preparation or cooking that also may play some role in the total arsenic found.

Our take home message for consumers is that fast food chicken—like raw chicken—can be produced in ways that result in low or nearly undetectable levels of arsenic. Assuming that subsequent tests of these brands would yield similar results, our findings suggest again that the choice of one fast food chain over another may significantly impact the level of arsenic ingested with fast food chicken.

Undoubtedly, more testing could and should be done. But since no federal testing exists to guide consumer choice in these matters, one could do worse than to steer your business to the fast food chains serving chicken products that tested lowest in our study.

Conclusion

We found arsenic to be widespread in the kinds of chicken people mostly eat.

While it may be true these arsenic levels are lower than federal standards—the tolerances for arsenic in meat set by the FDA, we think that simplistic observation misses a much more important point. This is an avoidable and wholly unnecessary use of arsenic that only adds to our cumulative daily load of arsenic, whatever the source.

Our testing clearly shows that chicken can be and is sometimes raised without arsenic, and that raw chicken is available without arsenic residues. The largest chicken producer in the world appears to use no or very little arsenic.

Why should chicken producers put arsenic in our meat in the first place? We can't think of any good reason.

We suggest you ask your grocer or favorite restaurant to only offer chicken from companies that can assure you they use no arsenic. Of course, there's no government effort to monitor or verify such claims.

It would surely help if companies routinely told shoppers on the label whether their chickens were raised using arsenic feed additives. Apart from USDA-certified organic products, there are no such labels.

That's why the best solution is to follow Europe's example and simply withdraw FDA-approval for the routine use of arsenic in poultry feed. If you don't want to worry about the possible impacts of eating arsenic in your chicken meal, tell your elected officials to find a way to get this done.

Appendix A. FDA-approved feed additives containing arsenic

NADA number	Trade name	Active ingredients(list separately)
005-414	Ren-O-Sal® Tablets Roxarsone	Roxarsone
006-019	Zoco Poultry Tablets; Zuco Tablets for Poultry	Roxarsone
006-081	Korum Improved Formula	Roxarsone
007-891	3-Nitro® 10, 3-Nitro® 20, 3-Nitro® 50, and 3-Nitro® 80 Type A Medicated Articles	Roxarsone
013-461	Broiler PMX No.1620	Roxarsone; Amprolium; Ethopabate
034-536	Aklomix-3; Aklomix Type A Medicated Article	Roxarsone; Aklomide
034-537	Novastat-3 Type A Medicated Article	Roxarsone; Aklomide; Sulfanitran
039-284	Swisher Super Broiler 300-108; Swisher Super Broiler	Roxarsone; Amprolium; Bacitracin Zinc; Ethopabate
039-666	Unistat-3 Type A Medicated Article	Roxarsone; Nitromide; Sulfanitran
040-264	Coyden 25® / 3-Nitro®	Roxarsone; Clopidol
040-435	3-Nitro® / Deccox®	Roxarsone; Decoquinate
041-178	Amprol Plus / Lincomix® / Roxarsone	Roxarsone; Amprolium; Ethopabate; Lincomycin Hydrochloride Monohydrate
041-500	Coban® - 1	Roxarsone; Monensin Sodium
041-541	BMD® 15 / Coyden 25®	Roxarsone; Bacitracin Methylene Disalicylate; Clopidol
041-984	Rofenaid® Plus Roxarsone	Roxarsone; Ormetoprim, Sulfadimethoxine
044-016	Coyden 25® with Roxarsone and Bacitracin Zinc	Roxarsone; Bacitracin Zinc; Clopidol
049-179	Amprol HI-E® / Roxarsone	Roxarsone; Amprolium; Ethopabate
049-180	Amprol HI-E® / BMD® / Roxarsone	Roxarsone; Amprolium; Bacitracin Methylene Disalicylate; Ethopabate
049-464	Monensin & Bacitracin & Roxarsone	Roxarsone; Bacitracin Methylene Disalicylate; Monensin
091-326	3-Nitro® / Deccox® / Albac®	Roxarsone; Bacitracin Zinc; Decoquinate
092-953	Roxarsone 10%, Roxarsone 20%, and Roxarsone 50% Type A Medicated Articles	Roxarsone
093-025	3-Nitro® Soluble; 3-Nitro® W	Roxarsone
095-546	Robenz® Plus Roxarsone	Roxarsone; Robenidine Hydrochloride
095-547	3-Nitro® / Amprol HI-E® / Flavomycin®	Roxarsone; Amprolium; Bambermycins; Ethopabate
095-548	3-Nitro® / Amprol / Flavomycin®	Roxarsone; Amprolium; Bambermycins
095-549	3-Nitro® / Amprol / Flavomycin®	Roxarsone; Amprolium; Bambermycins; Ethopabate
098-341	3-Nitro® / Coban® / Flavomycin®	Roxarsone; Bambermycins; Monensin
101-628	3-Nitro® / Flavomycin® / Zoalene	Roxarsone; Bambermycins; Zoalene
102-485	3-Nitro® / Avatec®	Roxarsone; Lasalocid
105-758	Amprol HI-E® / Baciferm® / 3-Nitro®	Roxarsone; Amprolium; Bacitracin Zinc; Ethopabate;
107-997	Medicated Broiler Feed	Roxarsone; Lincomycin Hydrochloride; Nicarbazin
108-115	Nicarbazin Roxarsone Premix	Roxarsone; Nicabazin
112-661	3-Nitro® / Avatec® / Lincomycin	Roxarsone; Lasalocid; Lincomycin Hydrochloride
112-687	3-Nitro® / Avatec® / Flavomycin®	Roxarosone; Bambermycins; Lasalocid
116-082	3-Nitro® / Avatec® / BMD®	Roxarosone; Bacitracin Methylene Disalicylate; Lasalocid
116-088	3-Nitro® / BMD® / Coban®; 3-Nitro® / Coban® / Fortracin	Roxarosone; Bacitracin Methylene Disalicylate; Monensin Sodium
120-724	3-Nitro® / Stafac® / Coban®	Roxarosone; Monensin Sodium, Virginiamycin
123-154	3-Nitro®-10 / Baciferm® / Coban® Premix	Roxarosone; Bacitracin Zinc; Monensin Sodium
126-052	3-Nitro® / Avatec® / Baciferm®	Roxarosone; Bacitracin Zinc; Lasalocid
131-894	3-Nitro® / Avatec® / Fortracin Broiler Premix	Roxarosone; Bacitracin Methylene Disalicylate; Lasalocid
132-447	Bio-Cox® / Roxarsone	Roxarosone; Salinomycin Sodium

NADA number	Trade name	Active ingredients(list separately)
134-185	3-Nitro® / Bio-Cox® / Flavomycin®	Roxarosone; Bambermycins, Salinomycin Sodium
135-321	3-Nitro® / Bio-Cox® / BMD®	Roxarosone; Bacitracin Methylene Disalicylate, Salinomycin Sodium
137-536	3-Nitro® / Albac® / Bio-Cox®	Roxarosone; Bacitracin Zinc, Salinomycin Sodium
138-703	3-Nitro® / Albac® / Coban®	Roxarosone; Bacitracin Zinc; Monensin Sodium
139-190	3-Nitro® / Bio-Cox® / Baciferm®	Roxaroson; Bacitracin Zinc, Salinomycin Sodium
140-445	Monteban® / Roxarsone	Roxarosone; Narasin
140-533	3-Nitro® / BMD® / Stenorol®	Roxarosone; Bacitracin Methylene Disalicylate; Halofuginone Hydrobromide
140-581	3-Nitro® / Bio-Cox® / Lincomix®	Roxarosone; Lincomycin Hydrochloride, Salinomycin Sodium
140-843	3-Nitro® / Flavomycin® / Monteban®	Roxarosone; Bambermycins; Narasin
140-852	3-Nitro® / BMD® / Monteban®	Roxarosone; Bacitracin Methylene Disalicylate; Narasin
140-867	Aureomycin® / Bio-Cox® / 3-Nitro®	Roxarosone; Chlortetracycline Calcium Complex, Salinomycin Sodium
141-058	3-Nitro® / Aviax™ / BMD®	Roxarosone; Bacitracin Methylene Disalicylate, Semduramicin Sodium
141-066	3-Nitro® / Aviax™	Roxarosone; Semduramicin Sodium
141-100	3-Nitro® / BMD® / Deccox®	Roxarosone; Bacitracin Methylene Disalicylate; Decoquinate
141-112	3-Nitro® / BMD® / Maxiban®	Roxarosone; Bacitracin Methylene Disalicylate; Narasin; Nicarbazin
141-113	3-Nitro® / Maxiban®	Roxarosone; Narasin; Nicarbazin
141-121	3-Nitro® / Bio-Cox® / BMD®	Roxarosone; Bacitracin Methylene Disalicylate; Salinomycin Sodium
141-135	3-Nitro® / Bio-Cox®	Roxarosone; Salinomycin Sodium
141-138	3-Nitro® / BMD® / Coban®	Roxarosone; Bacitracin Methylene Disalicylate; Monensin
141-139	3-Nitro® / Coban®	Roxarosone; Monensin
141-142	3-Nitro® / Amprol® / BMD®	Roxarosone; Amprolium; Bacitracin Methylene Disalicylate
141-155	3-Nitro® / BMD® / Robenz®	Roxarosone; Bacitracin Methylene Disalicylate; Robenidine Hydrochloride
141-157	3-Nitro® / Stenorol®	Roxarosone; Halofuginone Hydrobromide
141-190	3-Nitro® / BMD® / Clinacox™	Roxarosone; Bacitracin Methylene Disalicylate; Diclazuril
200-080	3-Nitro® / Flavomycin® / Sacox®	Roxarosone; Bambermycins, Salinomycin Sodium
200-081	3-Nitro® / BMD® / Sacox®	Roxarosone; Bacitracin Methylene Disalicylate, Salinomycin Sodium
200-086	3-Nitro® / Albac® / Sacox®	Roxarosone; Bacitracin Zinc, Salinomycin Sodium
200-090	3-Nitro® / Lincomix® / Sacox®	Roxarosone; Lincomycin; Salinomycin Sodium
200-091	3-Nitro® / Aureomycin® / Sacox®	Roxarosone; Chlortetracycline Calcium Complex, Salinomycin Sodium
200-094	3-Nitro® / Sacox® / Stafac®	Roxarosone; Salinomycin Sodium; Virginiamycin
200-097	3-Nitro / Sacox	Roxarosone; Salinomycin Sodium
200-143	3-Nitro® / Baciferm® / Sacox®	Roxarosone; Bacitracin Zinc, Salinomycin Sodium
200-170	3-Nitro® / Lincomix® / Nicarmix 25®	Roxarosone; Lincomycin; Nicarbazin
200-172	3-Nitro® / Nicarmix 25®	Roxarosone; Nicarbazin
200-206	3-Nitro® / Albac® / Deccox®	Roxarosone; Bacitracin Zinc; Decoquinate

NADA number	Trade name	Active ingredients(list separately)
200-207	3-Nitro® / Albac® / Coyden 25®	Roxarosone; Bacitracin Zinc; Clopidol
200-208	Avatec® / 3-Nitro® / Albac®	Roxarosone; Bacitracin Zinc; Lasalocid
200-209	3-Nitro® / Albac® / Sacox®	Roxarosone; Bacitracin Zinc; Salinomycin Sodium
200-211	3-Nitro® / Albac® / Coban®	Roxarosone; Bacitracin Zinc; Monensin
200-214	3-Nitro® / Albac® / Amprol Hi-E®	Roxarosone; Amprolium; Bacitracin Zinc; Ethopabate
200-215	3-Nitro® / Albac® / Bio-Cox®	Roxarosone; Bacitracin Zinc; Salinomycin Sodium
200-217	3-Nitro® / Albac® / Amprol Hi-E®	Roxarosone; Amprolium; Bacitracin Zinc; Ethopabate
200-259	3-Nitro® / ChlorMax™ / Sacox®	Roxarosone; Chlortetracycline; Salinomycin Sodium
200-260	3-Nitro® / Bio-Cox® / ChlorMax™	Roxarosone; Chlortetracyclin; Salinomycin Sodium
200-355	Pennchlor™ / Bio-Cox® / 3-Nitro®	Roxarosone; Chlortetracycline; Salinomycin Sodium
007-616	Histostat®-50 Type A Medicated Article	Nitarsone
141-088	BMD® / Histostat®	Nitarsone; Bacitracin Methylene Disalicylate
010-285	Carb-O-Sep® Type A Medicated Article	Carbarsone
038-879	Carb-O-Sep® / Zoamix®	Carbarsone; zoalene
039-646	Carb-O-Gain	Carbarsone; bacitracin methylene disalicylate;
118-507	Amprol / Carb-O-Sep®	Carbarsone; amprolium
130-661	Carb-O-Sep / Flavomycin®	Carbarsone; bambermycines
136-484	Baciferm® / Carb-O-Sep®	Carbarsone; bacitracin zinc
200-203	Albac® / Carb-O-Sep®	Carbarsone; bacitracin zinc
008-019	Pro-Gen Plus Feed Supplement	Arsanilic acid
038-241	Erythro® (High Lev) / Zoalene plus Arsanilic Acid	Arsanilic acid; Erythromycin thiocyanate zoalene
038-242	Erythro® (Low Lev) / Amp plus Etho	Arsanilic acid; amprolium; Erythromycin thiocyanate; ethopabate
038-624	Pro-Gallimycin-10	Arsanilic acid; Erythromycin thiocyanate
049-462	Rainbrook Broiler Premix No.1	Arsanilic acid; amprolium; Ethopabate; Penicllin G Procaine; Streptomycin

Source: U.S. Food and Drug Administration, Center for Veterinary Medicine, 2004 Online Green Book, accessed 01/15/05 at http://www.fda.gov/cvm/greenbook/elecgbook.html

Appendix B: Testing methodology

We purchased a total of 151 packages of raw chicken products from supermarkets in Minneapolis-St. Paul, Minnesota and San Francisco, California in late November and December 2004. Products were then packed in ice in coolers.

We also purchased 90 orders of prepared chicken products, including fried chicken breast and thighs, strips and nuggets and sandwiches, from select fast food outlets. Five orders of each product were immediately sealed in plastic bags, and packed in ice in coolers. Sandwiches were purchased without toppings or condiments—buns were discarded.

All coolers were shipped overnight to West Coast Analytical Service, Inc., a private, independent commercial analytical chemistry laboratory.[117*] The products, number of packages and point of purchase are listed in Tables 9-11.

Table 9. Raw chicken products purchased from Twin Cities (Minn.) supermarkets

Minn.-purchased brands	Meat type	No. of pkgs.	Point of purchase
Smart Chicken	Breast, non-organic	5	Lunds
Smart Chicken	Thighs, non-organic	5	Lunds
Smart Chicken	Breast, organic	5	Lunds
Raised Right Natural	Leg quarters	5	Whole Foods
Raised Right Natural	Breast	5	Whole Foods
Gerber's Amish Chicken	Breasts	5	Kowalski's
Gerber's Amish Chicken	Thighs	5	Kowalski's
Gold'n Plump	Breast, boneless	5	Cub
Gold'n Plump	Leg quarters, thighs or drumsticks	5	Cub
Gold'n Plump	Livers	5	Cub
Perdue/Roundy's	Breast, boneless	5	Rainbow/ Roundy's
Perdue/Roundy's	Leg quarters	5	Rainbow/ Roundy's
Kadejan	Breast, free roam	5	Wedge
Kadejan	Thighs	5	Wedge
Kadejan	Liver, free roam	5	Wedge
Tyson	Chicken thighs, frozen	1	Sam's Club
Tyson	Chicken breasts, frozen, skinless	1	Sam's Club

Table 10. Raw chicken products purchased from San Francisco-area supermarkets

Calif.-purchased brands	Meat type	No. of pkgs.	Point of purchase
Rocky Jr./Petaluma	Breast, natural boneless skinless	5	Whole Foods
Rocky Jr./Petaluma	Range whole leg	5	Whole Foods
Rosie	Whole leg, organic	5	Whole Foods
Rosie	Breast, organic	5	Whole Foods
Foster Farms	Fryer thighs	5	Safeway
Foster Farms	Breast, boneless	5	Safeway
Trader Joe's	Thighs	5	Trader Joes
Trader Joe's	Breast, boneless skinless	5	Trader Joes
Tyson	Boneless, skinless thighs	4	Smart & Final
Tyson	Chicken strips	5	Smart & Final
Farm Harvest	Breast, boneless skinless	5	Food Maxx
Farm Harvest	Thighs	5	Food Maxx
Spring River Farms	Breasts	5	Food Source
Empire Kosher	Broiler chicken, whole	5	Andronico's
Foster Farms	Livers	5	Food Source

Table 11. Prepared chicken products purchased from select fast food outlets in two states

Retail outlet	Item	No. of orders	State of purchase
Popeyes	Breast, mild	5	Calif.
Popeyes	Thigh	5	Calif.
McDonald's	Select Premium Chicken Breast strips	5	Calif.
McDonald's	Grilled Chicken Sandwich	5	Calif.
Jack in the Box	Chicken Strips	5	Calif.
Jack in the Box	Chicken Club Sandwich	5	Calif.
Church's	Breast	5	Calif.
Church's	Thigh	5	Calif.
Carl's Jr.	Chicken strips	5	Calif.
Carl's Jr.	Santa Fe Chicken Sandwich	5	Calif.
Subway	Oven Roasted Chicken Breast sandwich	5	Minn.
Arby's	Chicken Breast Sandwich	5	Minn.
Wendy's	Ultimate Chicken Grill sandwich	5	Minn.
Wendy's	Crispy Chicken Nuggets	5	Minn.
KFC	Breast, Original Recipe	5	Minn.
KFC	Thigh, Original Recipe	5	Minn.
Hardee's	Grilled Chicken Sandwich	5	Minn.
Hardee's	Chicken Strips, 3 piece	5	Minn.
Subtotal		**90**	

Sample preparation

All test samples were received and kept frozen at the laboratory until needed. After thawing to a workable level, aliquots of chicken flesh were taken from larger pieces and chopped into small chunks to create a composite. Around 2–3 grams of composited material was weighed into a plastic vessel. Five to seven mL of concentrated nitric acid was added and the samples left to react overnight in a chemical "hood."

Digestion of the composite sample was conducted by heating (in an "Environmental Express Hot Block") at around 90 to 110 °C for 1–2 hours, depending on the type of sample. After cooling, 2–3 mL of 30 percent hydrogen peroxide was added to each vessel and swirled by hand to effect mixing.

After 15–20 minutes, the digestion vessels were placed on a cool "Hot Block" and the temperature increased to around 90 °C for another 15–20 minutes to complete digestion of any remaining organic material. After cooling a second time, an internal standard was added to the solution and it was transferred to a 125 mL plastic bottle and the final mass brought to 100 grams with deionized water (water cleansed of metals and other impurities). The sample solution is now ready for determination of its total arsenic.

Instrumental methodology

To measure total arsenic in the digested samples, the laboratory used a process called "Inductively Coupled Plasma Mass Spectrometry" (ICPMS). As part of this process a variety of steps were taken to minimize any bias unintentionally introduced by the methodology itself, as well as to minimize measurement uncertainty introduced by the measurement devices.

As noted, this methodology is capable of detecting total arsenic down to around 2 parts per billion. Since conducting sampling with higher limits of detection was less expensive, there were a few instances where WCAS initially determined total arsenic using a limit of detection of 10 ppb. If the arsenic found in those samples exceeded 10 ppb, the testing was not repeated, since that would have incurred a needless expense. In all other cases, the arsenic testing was repeated with methods carrying the lower 2 ppb limit of detection.

Our laboratory, WCAS, did not report a margin of error for measurement of each individual sample. For arsenic testing in general, WCAS scientists informed us that one could assume a margin of error of around 10 to 20 percent. The margin of error rises slightly for samples with total arsenic approaching the limit of detection.

For the individual samples that we tested, a conservative estimate would be for a margin of error of about 20 percent. It's worth noting, however, that we report the total arsenic for brands of chicken products as an average of the levels found for, generally, five different packages of that product.

We chose not to report other statistical measures, such as a standard error of mean (SEM). This is a measure that indicates how much individual samples of chicken from a particular brand of product varies from one another in the total arsenic detected. SEM is best used when sampling is random and the number of samples is 30 or more. Since ours was not an academic study, these conditions were not applicable. We did not feel that SEM would contribute meaningfully to public understanding of our conclusions, so we chose not to include it in this report. The calculations are, however, available on our Web site.

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7. Typically, three different diets are used during broiler production, although in the future feed may be managed differently to optimize feed efficiency while reducing antibiotic use. For example, the National Research Council (2003) cites a 2000 study by Angel showing that use of four different diets during the grow-out period could reduce nutrient requirements by 5 percent. Since this implies an economic need for less feed, it also suggests the use of fewer antibiotics, and as a result less excretion of antibiotics and arsenicals into poultry manure and litter, potentially reducing the impact on environmental reservoirs of these compounds.
8. NAS/NRC 2003. p. 30.
9. *Ibid.*
10. EPA (2001), Development Document for the Proposed Revisions to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Feeding Operations. EPA-821-R-01-003. p. 4-41. Accessed July 10, 2005 at http://www.epa.gov/Region8/water/wastewater/cafohome/cafodownload/cafodocs/DDChapters1-4.pdf
11. *Ibid.*
12. Note: While young broilers for some markets are slaughtered at six weeks of age, other birds slated for further meat processing or for sale as roasters are raised until seven or eight weeks.
13. NAS/NRC (2003). pp. 37-38.
14. Florini K, Dennison R, Stiffler T, Fitzgerald T, Goldburg R. 2005. Resistant bugs and antibiotic drugs: State And County Estimates Of Antibiotics In Agricultural Feed And Animal Waste. Environmental Defense: Washington, DC. Accessed June 2, 2005 at www.environmentaldefense.org.
15. Antibiotic, strictly speaking, refers to a naturally occurring chemical (i.e., one not manufactured by humans), but the term is commonly used to include synthetic chemicals that also kill or inhibit the growth of bacteria. Generally, it also is used to include compounds (technically known as "antimicrobials") that affect other microbes, such as parasites and fungi.
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25. Agri Stats Inc., 6510 Mutual Drive, Fort Wayne, IN 46823. Phone: (260) 407-2700; Fax: (260) 407-2710.
26. NAS/NRC (1999). pp 31-34
27. Coccidiosis is a parasitic infection in poultry caused by protozoa, not bacteria. It can sicken or kill significant percentage of broiler flocks. At least 15 antimicrobial feed additives for broilers are approved for treatment, control or prevention of coccidiosis. These "coccidiostats" include sulfonamide antibiotics, ionophores, as well as other agents.
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29. *Ibid.,* Figure 7.
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32. Official descriptions of the FDA-approved uses of roxarsone and arsanilic acid in broiler feed can be found in Title 21, Part 558 of the Code of Federal Regulations, accessible at http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?CFRPart=558.
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35. The remaining five are liquids to be added to drinking water supplies.
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