Levels of Arsenic in the United States Food Supply

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At the present time, the Food and Drug Administration (FDA) accords the highest priority to mercury, lead, cadmium, arsenic, selenium, and zinc in its program on toxic elements in foods. The only regulatory levels for arsenic in foods in the U. S. are the tolerances which have been established for its residues in specified foods, resulting from the application of arsenical pesticides on food and feed crops and from animal feed additives. FDA has monitored for arsenic in its Total Diet Survey since the inception of this program. The data from this program indicate that the average daily intake for arsenic (as As$_2$O$_3$) has decreased from about 130 $\mu$g/day in 1968 to about 20 $\mu$g/day in 1974. Most of the arsenic is found in the meat-fish-poultry food class of the total diet. In individual foods, the highest levels were found in fish, with a mean level of about 1.5 ppm (as As$_2$O$_3$) in the edible portion of finfish. Much lower levels were found in all the other food types analyzed; of these, the highest levels found were a mean level of 0.08 ppm in chicken and 0.16 ppm in rice. FDA toxicologists do not believe that the average daily intake of arsenic, or its levels in the different food commodities, pose a hazard to the consumer.

The Food and Drug Administration has conducted various studies on toxic elements in foods for many years. At the present time, the Agency accords highest priority to mercury, lead, cadmium, arsenic, selenium and zinc.

This report summarizes the results FDA has obtained in recent years in monitoring for arsenic in foods. Neither the toxicological aspects of arsenic nor details of analytical methodology will be discussed in detail, but will be referred to only as they are related to our monitoring activities.

The only regulatory levels for arsenic in foods in the U. S. are the tolerances that have been established for its residues in specified foods, resulting from the application of arsenical pesticides on food and feed crops and from animal feed additives. Generally, the tolerance for arsenic residues (as As$_2$O$_3$) on various fruits and vegetables resulting from pesticidal use of copper, magnesium and sodium arsenates is 3.5 ppm As$_2$O$_3$ (Table 1). Tolerances for residues resulting from the use of lead arsenate, sodium arsenite, and the sodium salts of methane arsionic acid and of cacodylic acid are also given.

A number of arsenic compounds are also permitted for use in food producing animals either as growth stimulants or for prevention or treatment of diseases. Among these are arsanilic acid and its sodium salt, 4-nitrophenylarsonic acid, 3-nitro-4-hydroxyphenylarsonic acid, and 4-nitrophenylarsonic acid. Tolerances for total combined arsenic residues (calculated as As) resulting from these uses are given in the Code of Federal Regulations, Title 21, part 556.60. Essentially, the tolerances are as follows: 0.5 ppm arsenic in eggs; 0.5 ppm in the muscle of chickens, turkeys, and swine; and 2 ppm in edible by-products of chickens and turkey and the livers and kidneys of swine. The tolerance for arsenic in other edible by-products in swine is 0.5 ppm. A 5-day withdrawal period is required when arsenicals are used in these species to allow for excretion, so that residue levels in the tissues will not exceed these tolerances.

The Food and Drug Administration has monitored for arsenic in its Total Diet ("market basket") Survey since the inception of this program, to determine the levels of this element in the average diet. The composition of the "market basket" used in FDA's Total Diet Program (I) is based in large part on the survey of U. S. household food consumption conducted by the U. S. Department of Agriculture (USDA) in 1965. Diet guides are provided for each of four geographical regions of the U. S. as defined by USDA: South, Northeast, North Central, and West. Each market basket rep-
Table 1. Tolerances for residues of arsenic-containing pesticides.

| Code of Federal Regulations, Title 40 | Pesticide | Tolerance |
|--------------------------------------|-----------|-----------|
| Part 180.192                          | Calcium arsenate | 3.5 ppm As$_2$O$_3$, numerous fruits and vegetables |
| 180.193                              | Copper arsenate | 3.5 ppm As$_2$O$_3$, numerous vegetables |
| 180.194                              | Lead arsenate | 7 ppm lead, numerous fruits and vegetables |
| 180.195                              | Magnesium arsenate | 3.5 ppm As$_2$O$_3$, beans |
| 180.196                              | Sodium arsenate | 3.5 ppm As$_2$O$_3$, grapes |
| 180.289                              | MSMA (methanearsonic acid, monosodium salt) | 0.7 ppm As$_2$O$_3$, cottonseed |
| 180.311                              | DSMA (methanearsonic acid, disodium salt) | 0.35 ppm As$_2$O$_3$, citrus fruit |
| 180.335                              | Cacodylic acid (dimethylarsenic acid) | 2.8 ppm As$_2$O$_3$, cottonseed |
|                                    | Sodium arsenite | 1.4 ppm As$_2$O$_3$, beef kidney and liver |
|                                    |             | 0.7 ppm As$_2$O$_3$, cattle meat, fat, by-products, other |
|                                    |             | 2.7 ppm As$_2$O$_3$, beef and horse kidney and liver |
|                                    |             | 0.7 ppm As$_2$O$_3$, beef and horse meat, fat and by-products, other |

The average levels of arsenic (as As$_2$O$_3$) found in the different food composites from 1967 to 1974 are shown in Table 2. It can be seen that the levels in all food categories have decreased significantly since 1967–1970, to the extent that the meat-fish-poultry composites now are the only major source of arsenic in the total diet.

Table 3 shows the estimated average daily intake of arsenic (as As$_2$O$_3$) represented by the different food composite categories. Again, the levels of arsenic intake from all the food categories have significantly decreased, with the meat-fish-poultry category contributing most to the daily intake. It is believed that much of this drop may be due to the decreased use of arsenic-containing pesticides on food crops since the late 1960s. To explain the apparent increase in arsenic levels in the meat-fish-poultry and fruit categories from 1973 to 1974, it will be necessary to evaluate the data from the Total Diet Studies for several more years to determine whether this represents a trend, or if it is merely the random variation one may expect from year to year.

The estimated average daily intake of As$_2$O$_3$ from the total diet has varied from about 100 µg/day in 1967–1969 to about 10–20 µg/day in 1971–1974. FDA toxicologists believe that these levels do not represent a hazard to the consumer, but that they do warrant continued surveillance. On a priority basis, mercury, lead, and cadmium have been of more concern to FDA in recent years than has arsenic.

To obtain a better idea of the levels of arsenic in individual food items, during the past three years (Fiscal Years 1974–1976), FDA has carried out exploratory surveys for arsenic in various food commodities in interstate commerce, which are obtained primarily at the retail level.

The data obtained on arsenic levels in meats, eggs, and milk are shown in Table 4. The mean levels in meats were all less than 0.1 ppm As$_2$O$_3$. The highest levels were found in chicken, with a mean value of 0.08 ppm and a maximum level of 0.5 ppm. Generally the levels were about the same in the samples of muscle and liver examined.
The U.S. Department of Agriculture (USDA) conducts a continuing monitoring program for various contaminants in red meat and poultry obtained in slaughterhouses. USDA has the responsibility for assuring the safety of meat products in the U.S. and has, therefore, examined many more meat samples than FDA has. The mean levels of arsenic that USDA found in chicken, swine, and cattle meat products in 1975 agreed fairly well with the FDA findings presented in Table 4. One difference was that USDA found somewhat higher levels in liver than in muscle; the highest was an average of about 0.8 ppm arsenic as As$_2$O$_3$ in chicken livers. Actually, we would expect to find somewhat higher values in the liver, since it is the target organ for arsenic. As in the FDA survey, levels in chickens were higher than those found in swine or cattle. The higher levels in chickens may result partially from...
the greater use of arsenical additives in poultry feed.

Table 5 presents the results that FDA obtained for arsenic levels (as As$_2$O$_3$) in vegetable and fruit products in the 1974–1976 period. The mean levels in all types examined were well below 0.1 ppm. The highest value in any single sample was 0.3 ppm As$_2$O$_3$ in a potato product.

### Table 5. Arsenic (as As$_2$O$_3$) in fruit and vegetable products.**

| Product                  | Number of samples | As, ppm   |
|--------------------------|-------------------|-----------|
| Applesauce               | 28                | 0.03 ND-0.1|
| Tomatoes, fresh and canned| 28                | 0.03 ND-0.1|
| Carrots and carrot products| 28                | 0.02 ND-0.1|
| Lettuce                  | 28                | 0.02 ND-0.05|
| Pork and beans           | 28                | 0.03 ND-0.1|
| Onions and onion products| 256               | 0.02 ND-0.1|
| Potatoes and potato products| 268               | 0.01 ND-0.3|

*Limit of quantitation approximately 0.1 ppm As$_2$O$_3$ in an individual analysis. Detections below that level are estimations only.

The levels obtained for arsenic (as As$_2$O$_3$) in cereal, nut, and sugar products are shown in Table 6. The mean values are again all well below 0.1 ppm, with the exception of rice, where the mean level was 0.16 ppm. The highest individual level in the foods in Table 6 was 0.4 ppm in a sample of rice.

FDA also conducts a continuing surveillance program for residues of heavy metals in samples of oysters and clams obtained from approved commercial harvesting areas.

Table 7 shows the results obtained by FDA in its Fiscal Year 1974 Comprehensive Fish Survey and in its Fiscal Years 1974 and 1975 Heavy Metals in Shellfish Program. Since it was possible to analyze only 105 samples in the comprehensive fish survey, we do not feel that we can draw conclusions about species likely to have higher arsenic contents, and thus we have classified the species from this survey only as “finfish” and “shrimp.”

### Table 6. Arsenic (as As$_2$O$_3$) in cereal, nut, sugar products.**

| Product        | Number of samples | As, ppm   |
|----------------|-------------------|-----------|
| Flour          | 15                | <0.01 ND-0.05|
| Corn meal      | 29                | 0.04 ND-0.2|
| Rice           | 27                | 0.16 ND-0.4|
| Breakfast cereals| 29               | 0.04 ND-0.2|
| Bakery products| 202               | 0.01 ND-0.05|
| Protein meat extender| 22 | 0.04 ND-0.1|
| Peanut butter  | 27                | 0.03 ND-0.2|
| Sugar          | 28                | 0.04 ND-0.3|
| Soft drinks    | 18                | 0.04 ND-0.1|

*Limit of quantitation approximately 0.1 ppm As$_2$O$_3$ in an individual analysis. Detections below that level are estimations only.

### Table 7. Arsenic (as As$_2$O$_3$) in finfish and shellfish.**

| Species              | Number of samples | As, ppm   |
|----------------------|-------------------|-----------|
| Finfish              | 95                | 1.47 ND-19.1|
| Shrimp               | 10                | 0.67 0.3-1.5|
| Eastern oyster       | 627               | 0.09 ND-1.2|
| Pacific oyster       | 86                | 0.07 ND-0.4|
| Soft shell clam      | 164               | 0.14 ND-0.9|
| Quahog               | 225               | 0.12 ND-1.4|

*Limit of quantitation approximately 0.1 ppm As$_2$O$_3$ in an individual analysis. Detections below that level are estimates only.

As can be seen, there is very wide variation between the levels found for individual samples.
highest finding in an individual sample of finfish (19 ppm) was more than 10 times the mean level (1.47 ppm). Similarly, some individual samples of molluscs contained more than 10 times as much arsenic as the mean level for the species.

With respect to the results for arsenic in clams and oysters, we should point out again that all samples were obtained from approved commercial harvesting areas. We do not know whether the same general levels would be found in molluscs in all areas where they may be caught.

The nature of the sampling in FDA’s comprehensive fish survey precludes the ability to determine the precise origin of catch, since entire lots of fish are sampled primarily at the wholesale level.

Even though analysis of a lot is an appropriate method of determining the average intake of arsenic for the general public, it will be beneficial to learn more about the levels of specific species caught in specific locations. In this regard, surveys being conducted by the National Marine Fisheries Service will provide valuable additional information, since their sampling population is much larger, and they obtain their samples at specified locations.

In summary, the total diet monitoring program carried out by FDA since 1967 shows that the average daily intake of arsenic (as As$_2$O$_3$) has decreased drastically from about 130 µg/day in 1968 to about 20 µg/day in 1974. Most of the arsenic is found in the meat-fish-poultry composite of the total diet survey. In analyses carried out on individual foods, the highest levels were found in fish, with a mean level of 1.47 ppm in finfish. Much lower levels were found in all other food types; of the latter, the highest levels found were a mean level of 0.08 ppm in chicken and 0.16 in rice. We do not believe that this average daily intake, or the levels in the various foods, pose a hazard to the consumer. However, we do believe that continued surveillance for arsenic in our food supply is necessary.

For the future, FDA plans (1) to continue to measure arsenic in its total diet studies to determine whether there are any trends in arsenic levels in the average U. S. diet, and to follow up on any unusually high total diet findings; and (2) to carry out special surveillance programs on individual food commodities when unexpected levels warrant.

REFERENCES

1. Duggan, R. E., and McFarland, F. J. Residues in fish and food. Pestic. Monit. J. 1: 1 (1967).