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Environmental health aspects of lead

Die gesundheitlichen Aspekte der Umweltverschmutzung durch Blei

Les problèmes sanitaires posés par le plomb présent dans l'environnement

LEAD INTAKE FROM FOOD

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LONDON, ENGLAND

Amsterdam, October 2 - 6, 1972

SUMMARY

The food components of the national diet have been extensively monitored for lead. Analyses of food samples representative of the average diet indicated a mean lead concentration in the diet of 0.13 mg/kg from which it was estimated that the daily intake of the average person in the United Kingdom amounted to about 200 micrograms of lead. It was clear that there was no food or food category which was a major source of lead. More lead was present in canned food than in the corresponding fresh food although this was of minor significance in the diet.

Introduction

Lead has been a ubiquitous contaminant of food for centuries. In the United Kingdom, regulations exist to limit the amount of lead which may be present in food, and by the gradual control of potential contaminators such as lead based pesticides, lead treated equipment, lead containing food colourings etc, the lead contents of many foods have been reduced. Under the present regulations, a general limit of 2.0 mg/kg, on a wet weight basis, is applied to most foods, for a few, a higher limit is allowed and in some special cases, such as soft drinks, a lower limit is required (1).

The present concern about the effects of traces of heavy metals in the environment has rekindled interest in lead contamination of food. For the majority of people, the diet represents the only source of exposure to most heavy metals; lead is the obvious exception in that water and the atmosphere may represent other major sources. It is therefore important that the contribution by food to the total intake of lead is accurately known in order to make a meaningful assessment of the hazards of the different sources of lead to man.

Although there is much published information on the lead content of food, much of this was obtained before the recent improvements in analytical techniques and increase in accuracy and sensitivity of lead determination. There are also new environmental interests such as the effect of lead contamination of food crops by industrial lead deposition, lead fallout from vehicle emissions, lead in sewage sludge used on agricultural land and lead discharges into water, and for these there is little detailed information. The Ministry of Agriculture, Fisheries and Food in this country has therefore carried out a detailed survey of the lead content of food. The aims of this survey were:-

(a) to assess the intake of lead from food by the average consumer;

(b) to assess the contents of lead in major foods of the national diet;

(c) to determine whether any class of food might present special features with respect to lead content, including reassessment of some foods for which special provisions exist in the Lead in Food Regulations;

(d) to make special checks on the lead content of foods in some areas that might be affected by local contamination of the environment.

A summary report on the results obtained so far in this survey has been published (2) and this paper deals in greater detail with the first two objectives; only a limited amount of data has been obtained in relation to the last two objectives, investigations are still in progress.

Description of the Survey

The survey was essentially a collaborative exercise with various specialist laboratories undertaking particular sections of the analytical work. Thus Fisheries Laboratories of this Ministry and the Department of Agriculture and Fisheries for Scotland examined fish and shellfish, the Plant Pathology Laboratory of this Ministry examined fruit and vegetables, and the Government Chemist looked at other foods.

Lead was determined at all laboratories by atomic absorption spectrophotometry but extraction procedures varied, and a lower limit of determination was attained at some laboratories. The method of extraction was either by wet oxidation of the sample using a mixture of sulphuric and nitric acids or by dry-ashing. Improvement in recovery was achieved by chelating with ammonium pyrrolidine dithio carbamate and extracting the complex with 4-methyl pentan-2-one for the final determination. For the results reported here, the lowest level of determination was 0.01 mg/kg.

The daily intake of lead from food by the average individual was estimated from the results of analyses of "market basket" samples, called for convenience the Total Diet Study (3). This was originally designed to assess the amount of pesticide residues in the diet and is presently being analysed for lead, mercury and cadmium. In the study, cooperation is sought from domestic science colleges throughout the country who purchase, prepare and cook the food where appropriate, and blend together samples of food representative of the diet in the area of the college. The proportions of different foods in the sample are based on National Expenditure Estimates and The National Food Survey. The foods are grouped into eight analytically compatible subgroups before blending and analysis; these groups are cereals, meat and fish, fish, fats and oils, fruits and preserves, root vegetables, green vegetables, and milk. Each of the eight groups contain each food in that category in the correct proportion for each region and season, in the edible form. The samples are obtained at quarterly intervals so that each college produces 4 sets of samples which are analysed at a central laboratory. In the case of lead, extra precautions are required since lead may be transferred to the food during preparation, and cooking from water used for cooking or lead in the equipment used. A sample of the water is therefore analysed and checks are made on the equipment if the results indicate that this is necessary.

A wide variety of individual foods were also examined for lead contents.

Results

The results of the Total Diet Study are summarised in Table 1. The mean lead content of the diet is estimated to be in the region of 0.13 mg/kg of diet and therefore it is estimated that a person consuming 1.5 kg of a normal diet each day would take in about 200 micrograms of lead from the food. Furthermore it has been estimated that the daily

intake of lead in the United Kingdom from beverages is about 20 micrograms (4) making a total intake from food and beverages of about 220 micrograms.

Some small differences in lead content between the food groups were observed. Vegetables were found to contain the most lead with cereals and meats not very far behind, these groups averaging in the region of 0.2 mg/kg. These categories constitute about 50% by weight of the food in the diet as a whole and it is estimated that they contribute some 75% of the dietary lead. Fruits contained about 0.1 mg/kg but because they represent a fairly large component of the diet, their relative contribution of lead is similar to that of the above groups. Fats are a minor dietary component and contribute little lead. Unlike mercury, the amount of lead in fish appears to be less than in other foods and because of the relatively low consumption of fish in this country, the amount of lead in the diet from this source is negligible, in the region of 1% of dietary lead. Milk contained the least amount and many of the samples examined contained less than 0.01 mg/kg. Although a figure of 0.03 mg/kg is quoted it is likely that the real value is very much lower. Results from other laboratories have indicated that the value is possibly in the region of 0.002 - 0.003 mg/kg.

The detailed results for the individual foods are not given in this paper. They have been presented elsewhere (2). It is sufficient to say that the results for the lead contents of the staple foods were in good agreement with the results of the Total Diet Study. However, some aspects of this part of the survey merit further attention in particular the amount of lead in canned food. The amounts of lead in some canned foods are compared in Table 2 with the amounts present in the corresponding foods when not contained in cans. It is clear that for a wide variety of foods, the lead value is enhanced by canning. For baby foods, carrots, peas and pears, there is approximately 0.2 mg more lead per kg when canned than when fresh. This difference is very much larger, of the order of 1.0 mg/kg, in the case of corn and spinach, but these latter results were based on a very limited number of samples. As expected, canned corned beef also contained more lead than fresh beef. Milk was the only item which appeared to be unaffected. The levels of lead in cream both in cans and jars were similar and canned evaporated milk contained a low level of lead. Further work is in progress.

Discussion

The only other figure for comparison of the daily intake of lead from food by the average consumer in this country is that reported in 1949(5). The figure quoted then was between 200 and 250 micrograms for the average adult which is comparable to the figure obtained in the present survey. In the United States, the average daily intake was reported in 1964 to be 120 - 130 micrograms per day (6), and in 1965 to be about 400 micrograms per day (7), and in 1968 to be in the region of 350 micrograms per day (8). These figures agree fairly

well with one another and therefore are probably reliable estimates but are somewhat higher than the figures obtained for the United Kingdom. This may not necessarily reflect a real difference and the difference may lie in the methods of estimating lead intake from food. Thus the U S figures are estimated for an adult man based on an average daily food consumption of 2.0 kg as opposed to 1.5 kg used for the U K estimate which is the average daily food consumption for the population as a whole based on figures taken from the National Food Survey. Similarly the U K figure is representative of the average diet of the population and therefore the much larger milk consumption by children than by adults will have a large influence on the size of the milk component in the average diet. The U S figures are representative of adult diets which contain much less milk.

It should be pointed out that the daily intake of 200 microgrammes from food is probably a slight overestimate. Results of less than 0.01 mg/kg, the limit of determination, for individual samples have been taken to equal 0.01 mg/kg in estimating the overall means ie - making the worst assumption. If values of less than 0.01 mg/kg are assumed to equal zero, a lower estimate by some 10 micrograms is obtained. Also if it is assumed that milk contributes a negligible amount of lead, the daily intake may well be in the region of 170 - 180 microgrammes.

It is not clear how much dietary lead is of natural origin and how much results from the use of lead by man. It has been reported that foods grown in areas remote from urban, industrial or mining activities all contained traces of lead (9) and the natural lead content of food has been estimated to be 0.01 mg/kg wet weight (7). On this basis, a person consuming 1.5 kg of food would be expected to have a dietary intake of 15 microgrammes per day of lead from natural sources which would mean that over 90% of the lead in food arose from other sources. To take the argument one step further, if, as it appears, all the major food groups contribute roughly similar amounts of lead to the diet and no group appears to be an excessive or persistent source of dietary lead, then the major proportion of lead in the most foods is not immediately of natural origin. It is far from clear at the present time what these sources are and how they effect food. Alternatively, the natural content of lead in food may be higher; this may be the case in the United Kingdom where base rocks have been reported to be richer in lead than in some other countries.

Although major improvements in canning technology over the years have produced considerable reductions in the lead contents of canned foods, it is apparent that residual amounts of lead over and above that ordinarily present in food may still occur in canned foods. From the results of this survey, this residue may be of the order of 0.1 - 0.2 mg/kg. According to the National Food Survey (10), the consumption of canned foods by the average person amounts to about 100 grams per day. It is therefore estimated that canned foods contribute some 10 - 20 microgrammes of lead to the average diet or some 5 - 10% of the total lead. For babies, however, the proportion may be considerably greater since canned baby food may form the major item of the diet of some babies.

The average lead content of canned baby food was found to be 0.24 mg/kg. A new regulation has been proposed which will lower the limit for the amount of lead permitted in baby foods and steps have already been taken by manufacturers in the United Kingdom to lower the lead level by modifications to the canning processes.

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TABLE 1.

Lead contents and consumption estimates of the main food categories of the national diet in the United Kingdom

Food Category	Mean lead concentration mg/kg (wet weight)	Estimated weight of food eaten kg per day	Estimated lead intake micrograms per day
Cereals	0.17	0.27	46
Meat and fish	0.17	0.18	31
(Fish)	(0.08)	(0.02)	(2)
Fats	0.08	0.08	6
Fruits and preserves	0.12	0.25	30
Root vegetables	0.20	0.21	42
Green vegetables	0.24	0.11	26
Milk	0.03	0.40	12
Total	0.13 (weighted mean)	1.5	about 200

Note

The mean lead content of the diet as a whole is weighted according to the relative proportions of the different food groups consumed.

TABLE 2.

A comparison of the lead content of some food when canned and when not in cans

Food	Mean lead concentration (mg/kg wet weight)	
	Not in cans	Canned
Baby foods	0.04 (in jars)	0.24
Carrots	0.02	0.22
Peas	0.02	0.21
Corn	0.01	1.22
Spinach	0.02	0.95
Beef	0.23	1.2 (corned beef)
Cream	0.12 (in jars)	0.10
Milk	0.03	0.05 (evaporated milk)
Pears	0.10	0.29
Cherries	0.05 (in jars)	0.17