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No. 51

**EVALUATION
OF CERTAIN FOOD ADDITIVES
AND THE CONTAMINANTS
MERCURY, LEAD, AND CADMIUM**

**Sixteenth Report
of the Joint FAO/WHO Expert Committee
on Food Additives**

Geneva, 4–12 April 1972



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Monographs containing summaries of relevant biological data and toxicological evaluations, comments on levels of the contaminants in food, and methods for their analysis will be issued separately by FAO and WHO under the title :

Evaluation of mercury, lead, cadmium and the food additives amaranth, diethylpyrocarbonate, and octyl gallate

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CORRIGENDUM

Page 23, line 29

Delete 1 mg/kg

Insert 1 µg/kg

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JOINT FAO/WHO EXPERT COMMITTEE ON FOOD ADDITIVES

Geneva, 4-12 April 1972

Members invited by FAO :

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- Professor F. Cotta-Ramusino, Istituto Superiore di Sanità, Rome, Italy
- Dr H. Egan, Government Chemist, Department of Trade and Industry, London, England (*Rapporteur*)
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Members invited by WHO :

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EVALUATION OF CERTAIN FOOD ADDITIVES AND THE CONTAMINANTS MERCURY, LEAD, AND CADMIUM

Sixteenth Report of the Joint FAO/WHO Expert Committee on Food Additives

A Joint FAO/WHO Expert Committee on Food Additives met in Geneva from 4 to 12 April 1972. The meeting was opened by Dr T. A. Lambo, Assistant Director-General, WHO, on behalf of the Directors-General of the Food and Agriculture Organization of the United Nations and of the World Health Organization. Dr Lambo stated in his opening address that the substances to be discussed by the Committee were of current interest in many parts of the world. All of them had given rise to some concern about their safety: some were cumulative and might cause irreversible damage if sufficient quantities were ingested; others were suspected of being carcinogenic or having other adverse effects. Furthermore, the fact that the principal substances to be considered — mercury, lead, and cadmium — were food contaminants rather than intentional food additives reflected the worldwide awareness of problems of environmental contamination in general and food contamination in particular.

1. INTRODUCTION

As a result of the recommendations of the Joint FAO/WHO Conference on Food Additives held in September 1955,¹ fifteen Joint FAO/WHO Expert Committees on Food Additives have met (see Annex 1). The present meeting was convened on the recommendations made in the fifteenth report of the Joint FAO/WHO Expert Committee on Food Additives. Its terms of reference were: (1) to evaluate the toxicological and related data on the total load of mercury, lead, and cadmium in man from food and other sources, (2) to review the levels of these metals in various foods and the methods for their analysis, and (3) to re-evaluate amaranth, caramel, diethylpyrocarbonate, and octyl gallate.

¹ *FAO Nutrition Meetings Report Series*, 1956, No. 11; *Wld Hlth Org. techn. Rep. Ser.*, 1956, No. 107.

In order to facilitate the discussions, the Committee constituted itself into two groups; one group gave major attention to toxicological evaluation, while the other dealt mainly with the sources of the contaminants, their levels and methods of analysis, and with chemical specifications of some food additives.

2. GENERAL CONSIDERATIONS

2.1 Scope

During the past few years health authorities in many parts of the world have become increasingly concerned about the presence of certain metal contaminants in food. The problem of lead and mercury was considered in the tenth report.¹ In the light of the information available at that time, it was only possible to indicate a "maximum acceptable daily load" for lead, and mercury could not be evaluated at all. In its fourteenth report² the Committee again postponed consideration of mercury because important studies were in progress.

The primary task of the present Committee was to determine the sources of mercury, lead, and cadmium, their levels in food, and their significance to the health of man. The main point needing detailed consideration was the total load of a given contaminant in man, from various sources such as food, water, and air. The Committee did not consider, except where necessary, exposure due to industrial or occupational sources, nor did it consider the effects of these contaminants on the environment generally.

The main purpose of the Committee in examining the sources of mercury, lead, and cadmium was to indicate which sources should be taken into account by those responsible for their control. Measures for the control of these sources and the economic effects of such controls were regarded as falling outside the terms of reference of the Committee, since other international programmes are concerned with these matters. This report does not claim to provide a complete survey of the subject of metal contaminants in food, but it does indicate the hazards these contaminants may present to human health and draws attention to useful and extensive reviews of the subject.

2.2 Methods of analysis

Some of the remarks in this section on methods of analysis, and in particular on the general problems presented by the methods of analysis

¹ See Annex 1, ref. 13.

² See Annex 1, ref. 22.

for the metallic contaminants under consideration, will seem obvious, particularly to experienced analysts; but if this report is to be useful to all countries, it is necessary to present a full account of the problems.

It is obviously of fundamental interest to know the final use to which the results of analyses will be put. The accuracy and reliability required and the speed with which the results are obtained govern the selection of methods. When definitive surveys are being made, or if enforcement is contemplated, an unequivocal method will be needed with representative sampling of the products in question.

Even an experienced analyst, when using a new technique for the first time, will recognize the necessity of carrying out a number of pilot experiments. A number of elementary points of analytical technique are emphasized in the monographs¹ because with some of the methods referred to there it has proved difficult to obtain uniform results on identical samples in experienced laboratories around the world. The Committee felt that international exchange of samples between laboratories would be helpful.

In previous reports, it has been the practice to describe methods of analysis for assessing the purity of the individual additives to be used in food, as indicated in Annex 4 to the tenth report.² However, the Committee has not hitherto described methods of analysis for the additives present in food, except in the cases of antibiotics and extraction solvents for which no generally acceptable methods of analysis were available. In the tenth report, where consideration was given to mercury, lead, copper, arsenic, zinc, and tin, no specific methods of analysis for these contaminants in food were proposed.² However, the Committee now recognizes the desirability of giving some information on the types of method that are of value for the control of the metallic contaminants under consideration. The monographs therefore provide guidance on the types of analytical method that should be used for detecting traces of mercury, methylmercury compounds, lead, and cadmium in foods. The precise technique will depend on the particular food being examined.

The Committee has not elaborated detailed methods of trace analysis, since a number of such methods are already being considered by the Joint FAO/WHO Codex Alimentarius Commission. In addition, the International Union of Pure and Applied Chemistry and other bodies are continuing their efforts to develop new international methods for the estimation of trace metals in food. It is important to establish internationally agreed methods, and desirable to achieve uniformity of approach between the various bodies concerned.

¹ See p. 2.

² See Annex 1, ref. 13.

2.3. Levels of metal contaminants and need for monitoring

The levels of contaminants in food are considered in this report, together with significant levels in other media, such as air and water; the chemical form of the contaminant is also taken into account. Problems may arise according to the nature of the food, the biological species concerned, and its geographical origin. While the Committee does not provide a list of the levels of metal contaminants found in all foods, including water, it draws attention to potential problems in an attempt to assist food control authorities in considering a programme for the examination of foods.

A considerable amount of data from different parts of the world on the levels of mercury, lead, and cadmium in different foods was available to the Committee. In the case of mercury in particular, a great deal of information has become available on fish and other marine foods. It appears that systematic investigations have been carried out in only a few countries, and it was not possible to make a satisfactory summary of these data because of lack of information on the type and extent of sampling involved and on the methods of analysis used. Moreover, for certain classes of food the data were inadequate.

Because of the potential health hazards of environmental pollution in general and food contaminants in particular, the Committee recommends the development of internationally coordinated and statistically valid systems for the collection and evaluation of data on contaminants in food from different parts of the world. Although the basic monitoring systems are set up at the national level, the results of such monitoring should then be assembled at the international level, evaluated, and made available to governments. Such evaluation will be useful in indicating problem areas and foods to which specific control measures need to be applied and in pointing out areas for epidemiological surveys. Foods can also serve as indicators for sources of contamination and thus supplement other international programmes on the monitoring of sources of pollution in the total environment.

The Committee attaches particular importance to total diet studies based on foods as prepared for consumption and on known dietary patterns, since such studies have proved the most useful way of indicating the contribution through foods to the total load of a given contaminant. FAO and WHO should encourage and advise national authorities, where necessary, on carrying out such studies. The results of the studies should be combined with figures for the contribution from air, water, and possibly other sources, such as tobacco smoke, so as to arrive at an estimate of the total loads that a given contaminant may impose on an average person. The studies will enable governments to take scientifically based action to protect the average population from hazards of contaminants in foods.

Obviously, these average estimates do not permit the required protection of special populations consuming more than the average amount of certain foods or consuming foods with unavoidably high levels of contaminants, and the Committee recommends that separate assessments should be made in such cases.

3. PRINCIPLES GOVERNING TOXICOLOGICAL EVALUATION

3.1 Metal contaminants

The metal contaminants considered here — mercury, lead, and cadmium — are major environmental pollutants that are harmful to health. Pollution with these metals, if permitted to continue, is likely to result in the loss of large sources of food in the foreseeable future.

3.1.1 *The process of evaluation*

Over the years, the Joint FAO/WHO Expert Committees on Food Additives have adopted certain approaches to the evaluation of safety. For the majority of additives the following sequence of decisions has been taken :

(1) Acceptance of a no-effect level established in the course of some appropriately conducted long-term test or tests in laboratory animals.

(2) Application of an arbitrary safety factor which, in the opinion of the Committee, was in keeping with the nature of the compound being evaluated, with the circumstances of its intended use, and with the quality of the experimental studies available.

(3) Allocation of unconditional, conditional, or temporary acceptable daily intakes (ADIs), where appropriate, on the basis of considerations set forth in the eleventh report.¹

Only on rare occasions have data been available on human exposure. Such information supplemented the otherwise total reliance on the results of animal studies for the purpose of safety evaluation.

In retrospect, it is plain that the concept of an ADI for any substance is based on the assumption that each day's intake is ultimately cleared from the body and that, for the most part, such clearance is rapid and complete (unless the compound gives rise to biotransformation products that enter into intermediate metabolism within the body). Exceptions to this general

¹ See Annex 1, ref. 14, pp. 9–11.

rule have been encountered in the past, and have involved the storage of low levels of lipophilic compounds in the body fat of man.

It is inappropriate to attempt to set ADIs for heavy metals such as mercury, lead, and cadmium, for the following reasons :

(1) The metals and some of their organic derivatives are cumulative and may attain equilibrium within the body only after prolonged exposure ; selective localization of such materials in susceptible organs and tissues of the body may cause injury when high levels are attained. There is also the problem of distinguishing accurately the relative proportions of different forms of the contaminant, such as inorganic mercury and methylmercury compounds, in view of their distinctive toxicological implications.

(2) A narrow margin exists between the exposure of "normal" populations in many countries and the exposure known to cause overt symptoms and signs of intoxication. The allocation of an ADI on the basis of animal experiments, using a reasonable safety factor, might result in figures that would not permit a normal intake of food.

(3) There is uncertainty concerning many of the essential facts about the response to current levels of population exposure :

(a) the degree to which individual adults vary in their susceptibility, and the influence of the usual variables within and between populations, are still unknown ;

(b) the special susceptibility of the fetus, neonate, and child cannot at present be accurately expressed ;

(c) subclinical indices of effect, as distinct from measurements indicating exposure, have not been adequately delineated ;

(d) the possibility of genetic effects exists, but the levels of exposure needed to bring them about (if, in fact, genetic damage is elicited in man) are unknown ;

(e) the potential biological interactions of heavy metals with each other and with neurotoxic, nephrotoxic, and lipophilic chemicals present in food or derived from the environment have not been evaluated.

(4) ADIs are intended to be used in allocating the acceptable amounts of an additive to specific intended uses where it will serve necessary technological purposes and will be employed in accordance with good manufacturing practice. Such concepts are inapplicable to trace contaminants.

3.1.2 *Provisional tolerable weekly intake*

In view of the above considerations, a new approach is needed in dealing with heavy metal contamination of food. In its evaluation, the Committee has allocated a *provisional tolerable weekly intake* for each of

the metal contaminants considered. The basis for this approach was as follows :

(1) The contaminants are able to accumulate within the body at a rate and to an extent determined by the level of intake and by the chemical form of the heavy metal present in food. Consequently, the basis on which intake is expressed should be more than the amount corresponding to a single day. Moreover, individual foods may contain above-average levels of a heavy metal contaminant, so that consumption of such foods on any particular day greatly enhances that day's intake. Accordingly the provisional tolerable intake is expressed on a weekly basis.

(2) The term "tolerable", signifying permissibility rather than acceptability, is used in those cases where intake of a contaminant is unavoidably associated with the consumption of otherwise wholesome and nutritious foods, or with inhalation in air.

(3) The use of the term "provisional" expresses the tentative nature of the evaluation, in view of the paucity of reliable data on the consequences of human exposure at levels approaching those with which the Committee is concerned.

3.2 Re-evaluation of certain intentional food additives

The need to re-evaluate amaranth, diethylpyrocarbonate, and octyl gallate arose from the availability of fresh data that posed entirely new problems. In addition, a revised specification was adopted for caramel colours made by the ammonia process.

4. COMMENTS ON INDIVIDUAL SUBSTANCES ON THE AGENDA

Further details on the data used in the toxicological evaluation, and comments on levels of the contaminants in food and methods for their analysis, may be found in the relevant monographs (see p. 2). A summary of the evaluations is given in Annex 2.

4.1 Metal contaminants

4.1.1 Mercury

(a) Sources

Air. Except in occupational exposure, the contribution of inhaled mercury is insignificant in relation to intake by other routes.

Water. The sources of direct pollution due to man's activities can have only local effects on the mercury levels found in fish, e.g., in estuaries and coastal areas. The largest reservoir of mercury is in the open seas, and is not appreciably affected by pollution caused by man. There is also natural geological contamination of individual lakes or watercourses due to underlying mineral deposits containing mercury, which leach into the water under natural circumstances. WHO has recommended that the tentative upper limit for mercury in drinking-water should be 1 µg per litre, this figure being related to levels found in natural waters used for drinking purposes.¹ At the ingestion rate of 2.5 litres of water per day used in the calculations for the *International standards*, the upper limit of mercury intake would be 2.5 µg per person per day, mainly in the inorganic form. It is obvious, however, that chemicals used in water treatment may be impure and contribute small amounts of mercury to the water.

The levels of mercury found in treated water are lower than those found in food. Moreover, mercury in water is found in inorganic form. In terms of methylmercury, therefore, the contribution to the body load in man from water and air is unlikely to be significant.

Industrial sources. Occupational exposure apart, the main hazard arises from the contamination of food and possibly of drinking-water. The direct pollution of water by industrial sources is likely to affect fish more than other foods.

Mercury or mercury salts entering water may eventually result, primarily through microbial but also through other biological and chemical processes, in the formation of methylmercury compounds that can be absorbed and accumulated by aquatic organisms. Transformations are discussed more fully in the monographs. Furthermore, once these pollutants have been deposited in watercourses or estuaries they may remain and give rise to the formation of methylmercury compounds by bacterial action over a period of many years.^{2, 3} Thus, both past and present sources of the contaminants must be considered.

Measures to control industrial sources can bring about a considerable reduction of new pollution. However, the problem presented by levels of mercury in fish taken from already polluted watercourses and estuaries will continue for a long time.

Agricultural sources. Alkyl, alkoxyalkyl, aryl, and inorganic mercurial fungicides have been used for seed dressings, as turf fungicides, and in orchards. The amount of mercury entering the food supply from agricultural use is small compared with that entering from other sources. However,

¹ *International standards for drinking-water*, 1971, Geneva, World Health Organization, 3rd ed.

² Wood, J. M., Scott Kennedy, F. & Rosen, C. G. (1968) *Nature (Lond.)*, **220**, 173.

³ Jensen, S. & Jernelöv, A. (1969) *Nature (Lond.)*, **223**, 753.

accidents have occurred as a result of the misuse as food or animal feed of seed treated with alkyl mercury compounds. The Committee feels that the use of alkyl or aryl mercury fungicides as seed treating agents should be discouraged, and recommends that the use of mercurial compounds in agriculture be reviewed, in the light of this report, by the FAO Working Party of Experts on Pesticide Residues and the WHO Expert Committee on Pesticide Residues.

Other sources. Mercury compounds used in pharmaceuticals, cosmetics, etc., are examples of additional sources of possible mercury intake. In the Committee's opinion, the use of mercurial pharmaceuticals should be discouraged and suitable alternatives should be sought. Furthermore, medication with mercurial compounds may cause difficulty in interpreting the levels of some of the indicators used for estimating the intake of methylmercury from food. Close attention should be paid in epidemiological inquiries to occupational and medical history, including the usage of mercury-containing pharmaceuticals, and to the use of cosmetics and toiletries preserved with mercury compounds.

(b) *Levels in food*

The amount of methylmercury compounds found in plant produce is very small or nil. Low levels of total mercury can occur in meat and dairy produce and can include a proportion of methylmercury compounds, derived presumably from residues in feeds containing fish-meal or treated cereal grains.

Fish constitute a special problem. Since the tragic accidents at Minamata and Niigata in Japan, aquatic pollution with mercury and its resulting uptake and accumulation by edible fish has been given special attention in many parts of the world. In recent years thousands of analyses have been performed and comprehensive studies have been reported. The results show that increased levels are consistently found in places where the water is contaminated with mercury from industrial and mining processes. In fish from unpolluted waters, comprising most of the world's total catch of food fish, low values are generally found. Some of the larger specimens of predatory species may contain high levels, apparently derived from natural sources since the same levels are found in museum specimens caught 50–100 years ago.

The ratio of methylmercury to total mercury is often high (approaching 100%), especially where the total mercury level is itself relatively high. In shellfish, however, the proportion is only 50% or even less when the total mercury level is high. Marine fish, which constitute the bulk of the fish in international trade, have been investigated more extensively in the last few years.

Total diet studies for individuals in Sweden¹ and the United Kingdom,² where the average fish consumption (in terms of the edible portion) is approximately 50 g per day and 20 g per day respectively, indicate an average daily intake of total mercury of the order of 5–10 µg per person. It is estimated that, in any given community, the average intake of mercury per person per day in the form of methylmercury will not exceed 2 µg, depending on the amount and type of fish consumed.

The available information shows that some 99% of the world's commercial catch has a total mercury content not exceeding 0.5 mg/kg, and 95% probably contains less than 0.3 mg/kg. In 1971 the United States Food and Drug Administration conducted a nationwide survey and found less than 3% of 1400 random samples of market fish in the USA to contain mercury in excess of 0.5 mg/kg.

Fish, shellfish, crustaceans, and eels that constitute the local population in polluted estuaries may contain high values of mercury. As they may represent a valuable local fish supply, they should be more extensively surveyed.

Levels in oysters and shellfish can be controlled by anti-pollution measures. Levels in fish from certain lakes in Sweden and certain rivers in Japan have also fallen after the elimination of contamination sources. Fish caught in certain other bodies of fresh water have not shown such a response with respect to mercury levels, but the period of observation was relatively short.

(c) *Toxicological evaluation*

A large amount of information has been collected in recent years on the toxic effect of mercury. Wherever evidence of effects on man was available, this formed the basis for evaluation. For such potential hazards to man as teratogenicity and mutagenicity, where little information on man was available, animal data were taken into consideration. The clinical manifestations of poisoning by various forms of mercury have been described in detail in many publications, and extensive reviews have already appeared on most animal tests carried out with a large variety of mercury compounds.³ Consequently the Committee has prepared only a brief monograph including those data that were considered especially relevant to its task.

¹ Dencker, I. & Schütz, A. (1971) *Läkartidn.*, **68**, 4031.

² United Kingdom, Working Party on the Monitoring of Foodstuffs for Mercury and other Heavy Metals (1971) *First report: Survey of mercury in food*, London, H.M. Stationery Office.

³ National Institute of Public Health (1971) *Methyl mercury in fish: report of an expert group*, Stockholm (*Nord. hyg. T.*, Suppl. 4); Lu, F. C., Berteau, P. E. & Clegg, D. J. (1972) *The toxicity of mercury in man and animals*. In: *Mercury contamination in man and his environment*, Vienna, IAEA (*Technical Report Series No. 137*).

The available information is insufficient to determine whether an increased body burden of mercury, in particular methylmercury, could give rise to clinical manifestations of ill health not at present recognized as a feature of methylmercury poisoning. The Committee is also unable to define the levels of mercury present in blood, hair, and tissues at a stage when there is a possibility of marginal effects that might not necessarily be interpreted as evidence of toxicity. There is only sparse information on the fetal, and none on the teratogenic and possible mutagenic effects on man of exposure to mercury and its compounds.

Since methylmercury compounds are much more toxic than all other forms of mercury, it is important to know the proportion of the total mercury in the human diet that is present in the form of methylmercury. Comparison of the results obtained by different investigators has shown significant variations in this ratio. There is little doubt that some of the earlier analyses for methylmercury were hampered by inadequate methodology.

Total mercury consumption from contaminated fish has been shown to correlate with total blood mercury and also with the mercury content of erythrocytes. Similar relationships have been found between mercury intake and the total mercury concentration detectable in hair. A correlation has also been demonstrated between levels of mercury present in whole blood or erythrocytes and the levels present in hair. In addition, data are available from Japanese subjects poisoned through consuming a large quantity of fish containing a high concentration of methylmercury compounds in the Niigata and Minamata incidents.

Most of these data referred to total mercury estimation in blood and hair, and so may have included other sources of exposure in addition to methylmercury from food. Interpretation of the data thus became more difficult. However, separate estimation of total mercury in whole blood and erythrocytes was of value in determining the type of exposure, since methylmercury concentrates mainly in the erythrocytes whereas other forms of mercury are more evenly distributed throughout the blood.

Surveys of persons who do not consume fish have shown mean blood cell values of 0.004 $\mu\text{g/g}$ in Sweden and of 0.005 $\mu\text{g/g}$ in the United Kingdom. For hair the mean value was less than 2.5 $\mu\text{g/g}$ in both countries.

The lowest recorded whole blood level for a patient showing neurological symptoms in Niigata was 0.2 $\mu\text{g/g}$, corresponding to approximately 0.4 $\mu\text{g/g}$ mercury in the blood cells. This value is approximately 100 times higher than the mercury content in the blood of persons who do not consume fish, and 40 times higher than that of the average fish eater in Sweden. The Committee noted that no toxic incidents had been reported from Scandinavian countries, although 7 of the subjects studied had whole blood mercury levels above 0.1 $\mu\text{g/g}$ and in 2 subjects the level exceeded 0.2 $\mu\text{g/g}$.

Differences in individual sensitivity to the action of methylmercury may be an important factor in determining the appearance of clinically manifest poisoning. Recent studies suggest that dietary factors may also afford protection against the effects of exposure to mercury.

Mutagenicity and teratogenicity tests gave results that are difficult to relate to man. Similarly, the significance of morphological chromosomal aberrations noted in tissue cell cultures from a limited group of individuals showing high blood levels of mercury cannot as yet be assessed.

The available data indicate that almost all the methylmercury in the diet is derived from methylmercury present in fish, but other kinds of food contribute to the total mercury level. Since methylmercury is probably by far the most toxic form of mercury encountered in food, the Committee feels that, except where occupational exposure occurs, the contribution of other forms of mercury can be given less weight in establishing a provisional tolerable intake of mercury from food. The question of intake of mercury through other routes might usefully be referred to other expert bodies.

The Committee established a *provisional tolerable weekly intake* of 0.3 mg of total mercury per person, of which no more than 0.2 mg should be present as methylmercury, CH_3Hg^+ (expressed as mercury); these amounts are equivalent to 0.005 mg and 0.0033 mg, respectively, per kg body weight. Where the total mercury intake in the diet is found to exceed 0.3 mg per week, the level of methylmercury compounds should also be investigated. If the excessive intake is attributable entirely to inorganic mercury, the above provisional limit for total mercury no longer applies and will need to be reassessed in the light of all prevailing circumstances.

Epidemiological studies have uncovered populations with high methylmercury consumption from fish, but in only two established incidents of specific high pollution was there clinical evidence of methylmercury intoxication. The Committee recognizes that the existing levels of methylmercury in the food of some fish-eating populations will lead to an intake in excess of the provisional tolerable weekly intake of 0.2 mg, but is of the opinion that this can probably be tolerated for a limited period without producing a health hazard. The Committee emphasizes that in these circumstances suitable investigations should be instituted in exposed populations and all possible steps should be taken to keep the levels of methylmercury in food as low as possible.

4.1.2 Lead

(a) Sources

Air. In rural areas levels of lead in air of $0.1 \mu\text{g}/\text{m}^3$ or less are found. However, depending upon the degree of pollution due to urbanization, the amounts of lead in city air range from 1 to $3 \mu\text{g}/\text{m}^3$, and will occasionally

be much higher under peak traffic conditions.^{1, 2} On the basis of the information before the Committee, and depending upon the degree of urbanization of the area concerned, its topographical situation, weather conditions, and habitat, it may be assumed for the purposes of this report that the intake of lead by inhalation in cities could on occasion be 100 µg/day. Lead-containing dusts are present in many manufacturing processes and may add to the lead content in all foods to a small degree.^{2, 3}

A source of lead that calls for particular consideration is the lead tetra-alkyls used as petrol (gasoline) additives. In the internal combustion engine, the lead tetra-alkyls are oxidized, and the Committee did not consider that the intake of alkyl lead as such was significant. However, the lead derived from petrol additives contributes not only to the intake through inhalation but also to the intake through ingestion as a result of fallout from vehicle exhausts on nearby food crops. An increased lead content may be found in crops at distances up to 50 m from highways, depending on weather conditions and traffic volume.⁴ Although formerly significant, the atmospheric contribution to total lead levels from fossil fuels is now negligible compared with that from lead-containing petrol additives.²

Some unconfirmed reports have suggested that a very small proportion of the total lead in urban air might be in organic form. This is a separate problem that needs to be considered by experts in air pollution. The contribution of lead from air to the total intake can be estimated solely from the total body burden. Intake through tobacco smoking is considered below.

Water. The levels of lead encountered in water supplies are probably about 0.01 mg/litre. However, the *International standards for drinking-water*⁵ suggest a tentative limit for lead of 0.1 mg/litre. Assuming a consumption of 2.5 litres of water per day the maximum lead intake from this source would be 250 µg; this would contribute significantly to the total amount of lead taken in by man.

Agricultural sources. The use of lead arsenate in agriculture has diminished. Where its use is still permitted on orchard crops, it contributes only a small proportion of the total intake of lead in man. It is suggested

¹ Ludwig, J. H., Diggs, D. R., Hesselberg, H. E. & Maga, J. A. (1965) *Amer. industr. Hyg. Ass. J.*, **26**, 270.

² Miettinen, J. K. (1972) Unpublished data.

³ Shy, C. M., Hammer, D. I., Newill, V. A. & Nelson, W. C. (1971) *Health hazards of environmental lead*, US Environmental Protection Agency, Bureau of Air Pollution Sciences, Community Research Branch.

⁴ Motto, H. L., Daines, R. N., Chilko, D. M. & Motto, C. K. (1970) *Environm. Sci. Technol.*, **4**, 231.

⁵ *International standards for drinking-water*, 1971, Geneva, World Health Organization, 3rd ed.

that, in the light of the present report, the matter of lead arsenate be reconsidered by the FAO Working Party of Experts on Pesticide Residues and the WHO Expert Committee on Pesticide Residues. The use of lead arsenate in tobacco has likewise diminished, and this has contributed to the decreased lead intake by smokers, although more recent analytical data are needed.

Industrial sources. Lead is used in a large number of industrial processes. People exposed occupationally to lead by inhalation will show increased body loads of lead. In addition, these industrial processes also contribute to the body load of lead through contamination of food grown nearby. Unless precautions are taken these sources will result in an increasing environmental load. Lead may enter the environment from lead smelters and from dumps where lead-containing material has been discarded, and affect the food supply locally. Epidemiological surveys are needed to watch for evidence of resulting increases in lead body burden.

Other sources. Other uses that may occasionally affect the amount of lead ingested by man are associated with indoor use of lead paint. In older dwellings this source represents a considerable hazard to children suffering from pica.^{1, 2} Another possible source of contamination that has aroused concern is food containers in the widest sense, including water pipes. Depending on pH, mineralization, and other factors, traces of lead may leach into food or drink from such containers. It is recognized that the use of lead piping for drinking-water supplies is not advisable, but such pipes are still in use in some older houses. Lead glazes are used on ceramic cooking vessels and tableware because they allow more flexibility in the kiln temperatures, and for decorative purposes. The leaching of lead from inadequately fired glazes has been investigated and is known to present a serious health hazard in vessels used as containers for acidic foods and beverages. Pewter containers and tinned copperware, in which the use of impure tin was a frequent source of lead, have now largely been replaced by aluminium and stainless steel vessels in modern food preparation.

Tinplate cans with soldered seams have been investigated as possible sources of lead contamination for a variety of foods. The tin coating itself contains little lead, if any, but the solder used for the seam may contain up to 98% lead. However, such solder does not readily give up lead to the canned food even if the contact area is large, since tin-lead alloys exhibit a positive potential in relation to tin and iron. The latter elements dissolve preferentially at the pH of widely different canned foods. Where lead is found, this may be due either to lead-containing dusts or to solder droplets not washed out of the can before filling.

¹ Chisholm, J. J. (1971) *Sci. Amer.*, **224**, No. 2, 15.

² Chisholm, J. J. & Kaplan, E. (1968) *J. Pediat.*, **73**, 942.

In the past, lead residues in food additives were another source of lead. Modern legislation and trade practice, and the adoption in food additive standards of limits for lead recommended in previous reports of the Committee, have virtually eliminated this hazard.

(b) *Levels in food*

The results of total diet studies in industrialized countries appear to indicate an intake of lead of the order of 200–300 μg per person per day. These amounts are similar to those found at various times in the past 30–40 years and do not suggest any upward trend. The contamination is generally distributed over all food groups, including water, although kidney and liver may contain much higher levels than other foods.¹

A reduction in the air levels of lead in urban areas where at present the levels are substantially above those in rural areas would not necessarily affect the levels of lead in food, but would reduce the total intake of lead. However, it is outside the competence of the present Committee to suggest standards for lead levels in urban atmospheres, and it is recommended that the matter be referred to the relevant expert body for evaluation in the light of this report.

(c) *Toxicological evaluation*

Since lead is a cumulative poison, it is important to consider the amount absorbed and retained in the body rather than the total intake. In the case of lead in food and water, about 10% of the ingested lead may be absorbed. Dietary factors such as calcium, phytic acid, and protein content affect the absorption of ingested lead. In the case of inhaled lead as much as 40% may be absorbed, but the degree of absorption depends partly on particle size. Inhaled lead may thus contribute an important proportion of the total absorbed lead.

In adults without occupational or other specific exposure, the blood lead level is below 400 ng per ml of blood, urinary lead excretion is usually less than 80 μg /litre, urinary coproporphyrin less than 150 μg /litre, and urinary δ -aminolevulinic acid (ALA) levels are less than 6 mg/litre. Where the blood level is between 400 and 800 ng per ml of blood, urinary lead excretion is usually less than 150 μg /litre, urinary coproporphyrin 150–500 μg /litre, and urinary ALA 6–20 mg/litre. While the last two parameters must be taken as an indication of an interference with the biosynthesis of haem, these levels are not associated with anaemia or the clinical features of lead intoxication. In the context of occupational exposure these levels are usually considered as acceptable, and indicative only of lead exposure. In the same context high exposures, with blood lead levels of 800–1200 ng/ml, are considered excessive but again not usually associated with clinical abnormality. Symptoms of lead poisoning are usually associated with

¹ Cheftel, H. (1950) *Ann. Falsif. Fraudes*, **43**, 230.

blood levels in excess of 1.2 µg/ml and urinary coproporphyrin in excess of 1.5 mg/litre. The blood lead level and the urinary coproporphyrin and urinary ALA excretion can be considered as critical indicators of exposure to lead. In addition, the ALA dehydratase content of erythrocytes has been shown to fall proportionately with the increase in the level of blood lead. This is also an indicator of exposure and, because of its extreme sensitivity, is valuable at low lead levels. Unlike urinary ALA, coproporphyrin, and porphobilinogen, it is not indicative of metabolic interference with porphyrin synthesis, as ALA dehydratase has no known function in the mature erythrocyte.

Children can be considered a high-risk group in relation to lead exposure. In the first place, they may have increased opportunities to ingest lead from sources in their environment. More than 5% of children in some urban environments have been shown to have blood levels in excess of 400 ng/ml. The high calorie intake of children means that, on a body weight basis, a child will ingest more lead than an adult on the same diet. Because of his higher metabolic rate, a child will also inhale 2 or 3 times as much of a given air pollutant as an adult, again on the basis of body weight. The absorption of calcium is high in children, and it is likely that lead absorption and retention are also increased. There is no evidence that the classical manifestations of lead poisoning occur at lower levels of lead absorption in the child than in the adult; however, excessive exposure gives rise to renal tubular damage in the child, and this is unusual in the adult. Lead encephalopathy in children is usually followed by permanent brain damage. A causal relationship between excessive lead absorption and general mental retardation in children has been suggested, but investigations of blood levels of lead in mentally handicapped children have not produced any conclusive evidence of this.

On the assumption that only 10% of lead ingested from food and water is absorbed, the Committee established in adults a *provisional tolerable weekly intake* of 3 mg of lead per person, equivalent to 0.05 mg/kg body weight. This level does not apply to infants and children. Any increase in the amount of lead derived from drinking-water or inhaled from the atmosphere will reduce the amount that can be tolerated in food. The lead in air is probably the contribution that is most accessible to action for reducing the total body burden of lead, especially where this fraction is large compared with that absorbed from food. Alkyl lead as such was not considered to be a significant source of lead intake (see page 17).

4.1.3 Cadmium

(a) Sources

Natural and geological sources. Cadmium is closely related to zinc and is found wherever zinc is found in nature. Its concentration varies, and

cadmium-to-zinc ratios of 1 : 1000 to 1 : 12 000 have been found in most minerals and soils.^{1, 2, 3}

Agricultural uses. Cadmium is absorbed from the soil and translocated in plants. It may occur as a contaminant in phosphate fertilizers and municipal sludges and so enter the food supply. In addition, crops may be contaminated with cadmium-containing dusts. The contribution from cadmium-containing pesticides is probably insignificant because their use has never been extensive and is thought to have been discontinued in some areas.

General uses. A major use of cadmium is in electroplating. The use of cadmium-plated utensils in the food industry should be strongly discouraged, since cadmium dissolves in weak organic acids present in many foods. Likewise, leachable cadmium in pottery glazes may be a source of cadmium in the food. Since commercial zinc may contain up to 1% of cadmium, galvanized food utensils may also contribute to cadmium levels in food. Other sources include the dumping of polyvinylchloride plastics and paints in which cadmium was used as a stabilizer, paints containing cadmium pigments, and cadmium batteries. In addition, cadmium-emitting factories, such as zinc or other metal refineries, and water and air downstream from factories where cadmium is used in electroplating or where cadmium batteries are made may cause localized problems, but such sources should not influence the amount found in food generally.

Air. Where there are no cadmium-emitting factories, the levels observed in air as a result of generalized pollution are around 0.001 µg/m³, which would lead to a maximum inhaled amount of 0.02 µg per person per day. However, in major cities levels approaching 0.03 mg/m³ may be found, and industrialized areas with cadmium-emitting factories may show even higher levels. Even if the rate of absorption following inhalation is greater than that following ingestion, the maximum amount absorbed by inhalation would still be insignificant compared with that absorbed from food. Recent studies indicate that one cigarette may contain up to 2 µg of cadmium, of which only about 10% is present in inhaled smoke. For a heavy smoker, this could mean an intake of 5 µg or more per day.^{1, 4}

Water. Municipal waters in industrialized countries generally contain less than 1 µg of cadmium per litre, but higher levels have been found in some instances. The tentative upper limit set in the *International standards*

¹ Friberg, L., Piscator, M. & Norberg, G. (1971) *Cadmium in the environment*, Cleveland, Ohio, Chemical Rubber Co.

² Bowen, H. J. M. (1966) *Trace elements in biochemistry*, London, Academic Press.

³ Schroeder, H. A., Nason, A. P. & Balassa, J. J. (1967) *J. Nutr.*, **93**, 331.

⁴ Miettinen, J. K. (1972) Unpublished data.

for drinking-water is 10 µg/litre.¹ On the basis of an estimated daily consumption of 2.5 litres, this would amount to a maximum cadmium intake of 25 µg per person per day. There may also be some dissolution of cadmium from galvanized pipes or from other parts of the piping systems. Elevated levels of cadmium occur in foods, particularly crustacea and shellfish, in association with high zinc levels, and the levels are even higher if there is contamination of the estuaries with cadmium. Likewise, cadmium can enter food from contaminated water used to irrigate crops.

(b) *Levels in food*

The preliminary results of a number of total diet studies for cadmium currently in progress indicate that dietary intake probably varies according to country from 50 µg per day or less up to 150 µg per day.

Cadmium occurs in food because it is taken up from the soil in food crops and from widespread contamination from various sources (dumps, fertilizers, electroplate, etc.). Elevated levels may also be found in the liver and kidney of mammals and in shellfish.

(c) *Toxicological evaluation*

Cadmium is apparently a non-essential trace metal that is virtually absent from the body at birth, but which accumulates with age until a maximum is reached about the age of 50. At this age the average occupationally non-exposed person has 20–30 mg of cadmium in his body, one half to three-quarters of which is present in the kidneys and liver. The total body burden is related to the absorption of cadmium from food, water, and other environmental sources. Only a small proportion of ingested cadmium is absorbed — probably not more than 5% and almost certainly less than 10%, the actual figure being dependent on dietary factors such as the intake of protein, calcium, and vitamin D and the intake of other trace metals such as zinc. A greater proportion of inhaled cadmium is absorbed, and figures of 10–40% have been quoted depending on the physical state of the inhaled material. Following dietary absorption, cadmium accumulates mainly in the kidneys, with lesser amounts in the liver and other organs. Very little is excreted in the urine, and it is not known if it is excreted into the intestinal tract. Cadmium is therefore accumulated in the body with time. Its biological half-life is extremely long, and is estimated to lie between 16 and 33 years.

The target organ for ingested cadmium is the kidney; for inhaled cadmium, following industrial exposure to inhaled fumes or dust, the target organs are the kidney and the lung. Renal damage may occur when the concentration of cadmium in the renal cortex exceeds 200 mg/kg wet

¹ *International standards for drinking-water*, 1971, Geneva, World Health Organization, 3rd ed.

weight. Renal damage is characterized by mild proteinuria in which a number of proteins of low molecular weight are excreted, and by glycosuria, abnormal amino-aciduria, inability to concentrate urine or to excrete a highly acid urine, and hypercalciuria as found in other renal tubular disorders. The condition rarely progresses to renal failure, but hypercalciuria may occasionally lead to a negative calcium balance and to osteomalacia. Environmental contamination resulting in high levels of cadmium in food and water over long periods has been implicated as the likely cause of "itai-itai" disease in Japan. This condition is characterized by tubular proteinuria with osteomalacia and pseudo-fractures, and has occurred in multiparous women over the age of 50 living predominantly on a rice diet with a high cadmium content. The excretion of cadmium in the urine increases when renal damage develops; this results in a decrease in cadmium concentration in the kidney, so that in more advanced cases the renal concentration of cadmium may be low. No evidence has yet been found in man to indicate that increased absorption of cadmium is related to the development of hypertension or to testicular atrophy. Reports that exposure to cadmium has given rise to cancer of the prostate have not so far been substantiated.

Attempts to determine acceptable levels of exposure to cadmium have been based on calculations involving so-called "normal" and "critical" values of cadmium in the renal cortex and on what is known of the rate of accumulation of cadmium in this organ. Levels of cadmium in the renal cortex of adult subjects, without known occupational exposure to the metal, vary between a mean of about 30 mg/kg wet weight in Sweden, 25-50 mg/kg wet weight in the USA, and 50-100 mg/kg wet weight in Japan. In view of the critical level of 200 mg/kg, the Committee feels that present-day levels of cadmium in the kidney should not be allowed to rise further. If the total intake of cadmium does not exceed 1 mg/kg body weight per day, it is unlikely that the levels of cadmium in the renal cortex will exceed 50 mg/kg, assuming an absorption rate of 5% and a daily excretion of only 0.005% of the body load (reflecting the long half-life of cadmium in the body). The Committee therefore proposes a *provisional tolerable weekly intake of 400-500 µg per individual*. However, because of the many uncertainties involved, this estimate should be revised when more precise data and better evidence become available.

At the present time the cadmium intake of many populations is unknown, and analytical methods, although adequate, require further standardization. There are uncertainties regarding the absorption and excretion of cadmium in various nutritional and metabolic states, and it is not known whether populations with excessive cadmium loads derived from the diet have developed proteinuria.

Such diet surveys as have been performed indicate that in some areas cadmium levels approach or even exceed the values recommended above,

because of environmental pollution. At present, cadmium inhaled from the urban atmosphere does not contribute a significant proportion of the total body burden. However, significant absorption through heavy smoking is possible. The continuing contamination of the environment from industrial and other sources is likely to increase the cadmium concentration in food, and in the future this may lead to hazardous levels. The Committee recommends that every effort should be made to limit, and even to reduce, the existing pollution of the environment with cadmium.

4.2 Certain food additives

4.2.1 *Amaranth*

Specifications for amaranth were prepared at the eighth meeting of the Joint FAO/WHO Expert Committee on Food Additives in 1964.¹ These were not reviewed by the present Committee. However, the Committee realized that there may be a need to revise the specifications and methods of analysis for colours, taking modern analytical techniques into account.

This colour was toxicologically evaluated at the eighth meeting of the Committee and was given an unconditional ADI on the basis of several well conducted and comprehensive studies carried out in several species. Recent work in the USSR, using various preparations of amaranth, has produced results that are difficult to interpret in the light of earlier studies. In addition, results from further reproduction studies and teratogenicity studies have become available, and studies now in progress will be of great relevance to the evaluation of the available data. Because the new evidence is inconclusive, and in the expectation of further data to come, the Committee has decided to postpone a definitive evaluation of this food colour until the results of the further work become available. Meanwhile the Committee recommends a temporary ADI of 0-0.75 mg/kg body weight. In view of the similar chemical nature of some other food colours in use, it will be desirable to re-evaluate them at some future date in the light of the further work currently in progress.

4.2.2 *Caramel colours (ammonia process)*

The subject of caramel colours was considered at the thirteenth² and fifteenth³ meetings of the Joint FAO/WHO Expert Committee on Food Additives. A specification for caramel colours not made by the ammonia process was prepared at the fifteenth meeting. At the same meeting the

¹ See Annex 1, ref. 8.

² See Annex 1, ref. 19.

³ See Annex 1, ref. 26.

Committee prepared a tentative specification for caramel colours made by the ammonia process, indicating that more precise information was required on the trace amounts of nitrogen-containing heterocyclic compounds in relation to the strength of colour present in such caramels. The Committee has now received information indicating that the 4-methylimidazole content of these caramels, together with the sulfur dioxide content and the ammoniacal nitrogen content, can generally be related to the tinctorial capacity of the product where that capacity falls within the range of 20 000–90 000 European Brewery Convention (EBC) units. Improved chromatographic methods for the estimation of the 4-methylimidazole of caramels have been communicated to the Committee. On the basis of this information a revised specification has been prepared for caramel colours prepared by the ammonia process, and will be published in due course.¹ Further information is required on the levels of use of caramel colours in foods and beverages. No additional toxicological data were available and a monograph was therefore not prepared.

4.2.3 *Diethylpyrocarbonate*

The Joint FAO/WHO Expert Committee on Food Additives reviewed the technological efficacy of diethylpyrocarbonate at its fourteenth meeting and published a monograph on it.² On the basis of this review, the present Committee is now able to suggest some limitations on the use of the substance.

Diethylpyrocarbonate was evaluated in the ninth report.³ At that time the Committee was told that urethane was one of the possible reaction products between ammonia and diethylpyrocarbonate in treated beverages and wines. No sufficiently sensitive method was available to determine the actual amounts formed, but it was estimated that not more than 10 µg of urethane per litre were likely to be present after treatment. This level was not considered to be a serious reason for refusing the use of diethylpyrocarbonate, particularly as the substance offered some promise as a substitute for sulfur dioxide. Subsequently, some controversial claims about the actual levels of urethane found in treated soft drinks, fruit juices, beer, and wine, led to the development of much more sensitive methods for determining low levels of urethane. These have confirmed that in certain beverages, at a pH below 4.0, no more than 10 µg of urethane per litre are formed. In wine, however, levels up to 50 µg/litre could be detected; it is possible that some of this is of natural origin.

¹ In the meantime the specification can be obtained on request from: Food Policy and Food Science Service, Food and Agriculture Organization of the United Nations, 00100 Rome, Italy.

² See Annex 1, ref. 22.

³ See Annex 1, ref. 11.

The Committee feels there is no reason to be more concerned than previously about the presence of 10 µg of urethane per litre. However, because of recent evidence showing the possibility of higher levels being formed in the presence of certain concentrations of ammonia and at a pH above 4.0, the Committee has decided to reduce the acceptable level of treatment to a maximum of 250 mg/kg,¹ to limit the pH to a maximum of 4.0, and to confine the use of diethylpyrocarbonate to soft drinks, carbonated or not.

The consideration of the biological significance of very small levels of urethane in beverages raised the general question of the presence of carcinogens in foods and their possible risk to the health of the consumer. This problem deserves further study (see recommendation 4 (c) on p. 28).

4.2.4 *Octyl gallate*

Propyl, octyl, and dodecyl gallates were previously evaluated in the sixth and eighth reports of the Joint FAO/WHO Expert Committee on Food Additives.² The present Committee considered recent reports on multigeneration reproduction studies in rats, as well as some recent information on human sensitization. In the reproduction study, high levels of *n*-octyl gallate produced effects on the offspring as a result of some substance transferred through the mother's milk. At lower levels no effect was observed. Because octyl gallate has been shown to be a cutaneous sensitizer in man, and because in some individuals so sensitized a buccal mucosal reaction occurs on oral exposure, the Committee considered that the substance should not be used in beverages. Persons occupationally exposed to gallate esters should be made aware of the sensitizing potential of beverages containing these esters.

5. ESTABLISHMENT OF CONTROL MEASURES BASED ON TOXICOLOGICAL EVALUATION

The purpose of any measure to control food contamination should be to ensure that the consumer does not exceed the tolerable intakes recommended. Nevertheless, the Committee recognizes that there may be occasional single excessive exposures. In addition, a balance must be maintained between several factors, such as the risk to health from the presence of excessive amounts of a contaminant, the possible detrimental effects on nutritional status through restriction of a source of an essential nutrient, and the economic impact of any type of restriction on certain segments of the population. For example, in the case of mercury, fish is the most

¹ Since several national and international bodies have recommended that the abbreviation "ppm" should no longer be used, levels are now expressed in "mg/kg". This does not affect the figures, as 1 mg/kg = 1 ppm.

² See Annex 1, refs 6 and 8.

critical food item. The average consumption of fish in the general population may give no reason for concern ; but for the fraction of the population who regularly consume fish in large quantities, there may be a long-term health hazard calling for suitable control measures.

Priority in the control of food contamination arising from environmental pollution must be given to those contaminants that affect human health. Because of the complexity of the problem and its wide implications, it is recommended that a third conference on food additives and food contaminants be convened jointly by FAO and WHO to set priorities among the contaminants to be considered by the two organizations.

As a basis for control, information is needed on the food consumption patterns of the population and on the levels of the contaminants concerned in different foods. Such information may then indicate the need either for the control of the sources of emission of the contaminants or for the establishment of limits of these substances in foods. Although the control of the sources of emission into the environment is one of the most effective means of reducing the contamination of foods by trace elements and their compounds, the Committee considers that any detailed discussion of such control is outside its terms of reference.

The traditional method for limiting the intake of contaminants in the food supply is to limit the levels permitted in specified foods. The limits should be set, in particular, for foods that contribute significantly to the intake of the pollutant ; they should be set no higher than is consistent with good manufacturing and agricultural practices and with natural levels. Where such limits are not adequate to protect individuals who consume large amounts of certain foods or who are particularly at risk for other reasons, the appropriate authorities should consider advising such individuals to restrict their consumption of certain foods. The restrictions for specific foods can be narrowed even further to those species or varieties to which the contaminant is confined. It is also possible to impose geographical restrictions as to where a catch may be taken or a crop harvested. The delimitation of areas and the restriction of kinds of food should be based on actual observations. All the measures mentioned above have been applied by competent authorities in certain countries.

In view of the importance of information on food consumption patterns and levels of contaminants in different foods in assessing the health hazards of these substances and in instituting appropriate control measures, the Committee recommends that an integrated programme be developed at an international level for the systematic collection of national data on :

- (1) levels of contaminants in foods, based on agreed methods of sampling and analysis ;
- (2) food consumption patterns and total diet studies ; and
- (3) estimated total load of particular contaminants from all sources.

6. RECOMMENDATIONS

6.1 Recommendations to FAO and WHO

(1) In view of the large number of food additives and contaminants requiring evaluation and/or re-evaluation, meetings of the Joint FAO/WHO Expert Committee on Food Additives should continue to be held annually.

(2) FAO and WHO should convene a third conference on food additives and contaminants to consider, at a policy-making level, the special problems of food contamination posed by environmental pollution, to set priorities among the contaminants to be considered, and to give guidance for future action by FAO and WHO.

(3) As part of their programme on environmental contaminants affecting the food and health of man, FAO and WHO should convene a meeting of experts to develop guidelines for the systematic collection of information on the level of contaminants in food, etc., as described in section 5 of this report. With suitable modification such programmes will also facilitate the calculation of the intake of food additives and pesticide residues, as recommended by the Joint FAO/WHO Expert Committee on Food Additives in its fourteenth report.

(4) A number of potential health hazards noted by the Committee during its deliberations should be studied in depth by the appropriate expert bodies. These include :

- (a) the use of mercurial fungicides in agriculture, taking into account the considerations set forth in the present report ;
- (b) the permissible levels of lead in air and drinking-water ;
- (c) the significance of very low levels of urethane and other carcinogens in food ; and
- (d) special problems relating to the exposure of infants and children to contaminants in food.

(5) FAO and WHO should promote and where necessary coordinate research designed to extend knowledge about the toxicity of mercury, lead, cadmium, and possibly other trace elements.

6.2 General recommendations

In view of the seriousness of the problem of environmental pollution by mercury, lead, and cadmium and its implications for human health and food supply, the Committee recommends that :

(1) all possible steps be taken to reduce such pollution, bearing in mind that the control measures selected will have to be related to the specific problems presented by the sources of each contaminant ;

(2) governments should consider the possibility of making studies, including total diet studies, on the total exposure to the contaminants concerned. It is desirable that the results of such studies should be made generally available.

Annex 1

REPORTS AND OTHER DOCUMENTS RESULTING FROM PREVIOUS MEETINGS OF THE JOINT FAO/WHO EXPERT COMMITTEE ON FOOD ADDITIVES

1. General Principles Governing the Use of Food Additives. First Report. *FAO Nutrition Meetings Report Series*, 1956, No. 11 ; *Wld Hlth Org. techn. Rep. Ser.*, 1956, No. 129.
2. Procedures for the Testing of Intentional Food Additives to Establish their Safety for Use. Second Report. *FAO Nutrition Meetings Report Series*, 1958, No. 17 ; *Wld Hlth Org. techn. Rep. Ser.*, 1958, No. 144.
3. Specifications for Identity and Purity of Food Additives (Antimicrobial Preservatives and Antioxidants). Third Report. These specifications were subsequently revised and published as *Specifications for Identity and Purity of Food Additives*, vol. I. *Antimicrobial Preservatives and Antioxidants*, Rome, Food and Agriculture Organization of the United Nations, 1962.
4. Specifications for Identity and Purity of Food Additives (Food Colours). Fourth Report. These specifications were subsequently revised and published as *Specifications for Identity and Purity of Food Additives*, vol. II. *Food Colors*, Rome, Food and Agriculture Organization of the United Nations, 1963.
5. Evaluation of the Carcinogenic Hazards of Food Additives. Fifth Report. *FAO Nutrition Meetings Report Series*, 1961, No. 29 ; *Wld Hlth Org. techn. Rep. Ser.*, 1961, No. 220.
6. Evaluation of the Toxicity of a Number of Antimicrobials and Antioxidants. Sixth Report. *FAO Nutrition Meetings Report Series*, 1962, No. 31 ; *Wld Hlth Org. techn. Rep. Ser.*, 1962, No. 228.
7. Specifications for the Identity and Purity of Food Additives and their Toxicological Evaluation : Emulsifiers, Stabilizers, Bleaching and Maturing Agents. Seventh Report. *FAO Nutrition Meetings Report Series*, 1964, No. 35 ; *Wld Hlth Org. techn. Rep. Ser.*, 1964, No. 281.

8. Specifications for the Identity and Purity of Food Additives and their Toxicological Evaluation: Food Colours and Some Antimicrobials and Antioxidants. Eighth Report. *FAO Nutrition Meetings Report Series*, 1965, No. 38; *Wld Hlth Org. techn. Rep. Ser.*, 1965, No. 309.
- *9. Specifications for Identity and Purity and Toxicological Evaluation of some Antimicrobials and Antioxidants. *FAO Nutrition Meetings Report Series*, 1965, No. 38A; WHO/Food Add/24.65.
- *10. Specifications for Identity and Purity and Toxicological Evaluation of some Food Colours. *FAO Nutrition Meetings Report Series*, 1966, No. 38B; WHO/Food Add/66.25.
11. Specifications for the Identity and Purity of Food Additives and their Toxicological Evaluation: Some Antimicrobials, Antioxidants, Emulsifiers, Stabilizers, Flour-treatment Agents, Acids and Bases. Ninth Report. *FAO Nutrition Meetings Report Series*, 1966, No. 40; *Wld Hlth Org. techn. Rep. Ser.*, 1966, No. 339.
- *12. Toxicological Evaluation of Some Antimicrobials, Antioxidants, Emulsifiers, Stabilizers, Flour-treatment Agents, Acids and Bases. *FAO Nutrition Meetings Report Series*, No. 40A, B, C; WHO/Food Add/67.29.
13. Specifications for the Identity and Purity of Food Additives and their Toxicological Evaluation: Some Emulsifiers and Stabilizers and Certain Other Substances. Tenth Report. *FAO Nutrition Meetings Report Series*, 1967, No. 43; *Wld Hlth Org. techn. Rep. Ser.*, 1967, No. 373.
14. Specifications for the Identity and Purity of Food Additives and their Toxicological Evaluation: Some Flavouring Substances and Non-Nutritive Sweetening Agents. Eleventh Report. *FAO Nutrition Meetings Report Series*, 1968, No. 44; *Wld Hlth Org. techn. Rep. Ser.*, 1968, No. 383.
- *15. Toxicological Evaluation of Some Flavouring Substances and Non-Nutritive Sweetening Agents. *FAO Nutrition Meetings Report Series*, 1968, No. 44A; WHO/Food Add/68.33.
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* These documents can be obtained on request from: Food Additives, World Health Organization, 1211 Geneva 27, Switzerland, or: Food Policy and Food Science Service, Food and Agriculture Organization of the United Nations, 00100 Rome, Italy.

22. Evaluation of Food Additives. Specifications for the Identity and Purity of Food Additives and their Toxicological Evaluation: Some Extraction Solvents and Certain Other Substances; and a Review of the Technological Efficacy of Some Antimicrobial Agents. Fourteenth Report. *FAO Nutrition Meetings Report Series*, 1971, No. 48; *Wld Hlth Org. techn. Rep. Ser.*, 1971, No. 462.
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Annex 2

EVALUATION OF SOME FOOD CONTAMINANTS
AND ADDITIVES *

<i>Substance</i>	<i>Provisional tolerable weekly intake for man</i>		<i>Acceptable daily intake for man</i>
	<i>(mg/person)</i>	<i>(mg/kg body-weight)</i>	<i>(mg/kg body-weight)</i>
mercury			
total mercury	0.3	0.005	None
methylmercury (expressed as mercury)	0.2	0.0033	None
lead ^a	3	0.05	None
cadmium	0.4-0.5	0.0067-0.0083	None
amaranth			0-0.75 ^b
diethylpyrocarbonate			None ^c
octyl gallate			0-0.2 ^d 0.2-0.5 ^e
caramel colours made by ammonia processes			0-100 ^{b, f} New specification prepared

^a These intake levels do not apply to infants and children.

^b Temporary ADI.

^c Acceptable treatment level 0-250 mg/kg; for further restrictions on use, see pp. 25-26.

^d Unconditional ADI: not to be used in beverages.

^e Conditional ADI: not to be used in beverages.

^f Previously established, see Annex 6 to fifteenth report (ref. 26).

* NOTE. It is important that the evaluations given in this table be used in conjunction with the appropriate sections in the body of the report.