codex alimentarius commission

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

WORLD HEALTH ORGANIZATION

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CODEX COMMITTEE ON FOOD ADDITIVES AND CONTAMINANTS
Thirty-first Session
The Hague, The Netherlands, 22-26 March 1999

DISCUSSION PAPER ON CADMIUM
(Prepared by Denmark)

REQUEST FOR COMMENTS AND INFORMATION

Governments and interested international organizations wishing to submit comments on the following Position Paper on Ochratoxin A are invited to do so **no later than 15 January 1999** as follows: Ms. S.P.J. Hagenstein, Netherlands Codex Contact Point, Ministry of Agriculture, Nature Management and Fisheries, P.O. Box 20401, 2500 EK The Hague, The Netherlands (Telefax: +31 70 378.6141; E-mail: s.p.j.hagenstein@mkg.agro.nl), with a copy to the Chief, Joint FAO/WHO Food Standards Programme, FAO, Via delle Terme di Caracalla, 00100 Rome, Italy.

INTRODUCTION

1. The 30th Session of the Codex Committee on Food Additives and Contaminants (CCFAC) accepted the offer of Denmark to revise the Discussion Paper on Cadmium (CX/FAC 98/22) for circulation, comment and consideration at its current meeting (ALINORM 99/12, paras. 98-100). This paper was based upon previous work of the CCFAC, including Draft Guideline Levels for Cadmium and Lead in Cereals, Pulses and Legumes (CX/FAC 97/20) as well as government comments received on cadmium as a contaminant (CX/FAC 97/22).

2. In 1995, France presented to the 27th CCFAC a "Position Paper on Cadmium" (CX/FAC 95/19). This paper contained a review of relevant information on cadmium as a contaminant in foodstuffs, compiled as agreed in the General Standard on Contaminants and Toxins in Food (GSCT). This position paper recommended a number of measures, including

- the CCFAC should propose international limits for cadmium in foods;
- that a number of general measures are taken to reduce the cadmium contamination of foods; and
- that some specific measures are taken with respect to food production, processing and storage.

The CCFAC agreed to include the recommendations in the Draft Code of Practice on Source Related Measures to Reduce Contamination of Foodstuffs (CX/FAC 96/20 and CX/FAC 98/20), and to request more information.

3. Following the request for more information, data were received on the content of cadmium in some foodstuffs and subsequently discussed at the 28th, 29th and 30th CCFAC. A large compilation of data on exposure in Europe was published by the European Commission, Scientific Committee for Food (SCOOP 1996). The 28th CCFAC, moreover, noted that the CCCPL had been adjourned *sine die* and, consequently, the CCFAC was responsible for the proposed draft maximum limit for cadmium in cereals, pulses and legumes, retained at step 7 of the stepwise procedure.

This paper provides:

- a short resume of the toxicological evaluation of cadmium, as presented in the "Position paper on Cadmium", presented by France to the 27th CCFAC (CX/FAC 95/19);
- a revised overview of recent data on the content of cadmium as a contaminant in food; and
- a revised set of Draft Maximum Levels for Cadmium in the foodstuffs that contribute most cadmium intake via the diet, or that have given rise to problems in international trade.

4. Cadmium present in soil, even in small quantities, moves readily into the plant, which is in contrast to other toxic elements like lead. Vegetables and cereals are therefore generally known as the most significant sources of cadmium in the diet. Atmospheric fall-out will contribute to the content of cadmium, especially for leafy vegetables and grain. Cadmium accumulates in particular in the kidney and liver of animals, hence offal is a source of cadmium in the diet. Horses that are often slaughtered at a comparatively late age will contain much more cadmium than pigs and poultry, which are slaughtered at a younger age. Fish contain normally only small amounts of cadmium, whereas crustaceans and molluscs, being filterfeeders, may absorb larger amounts of cadmium from their environment. The release of cadmium from food contact materials such as ceramics, alloys and plastics may also contribute to the intake until such sources are eliminated.

5. Additional to the dietary intake of cadmium, smokers may absorb large amounts of cadmium through the lungs, as the tobacco plant accumulates cadmium in the leaves, and some people may occupationally be exposed to cadmium. These aspects are further discussed in the position paper (CX/FAC 95/19).

6. Though there are indications that source-directed measures to reduce cadmium contamination of the food chain show some effect, the ongoing pollution of the environment with cadmium is an important reason to take further action.

A SHORT RESUME OF CADMIUM TOXICOLOGY

7. Cadmium was last assessed by the JECFA at its 41st Meeting in 1993. The Committee retained the Provisionally Tolerable Weekly Intake (PTWI) of 7 μg/kg body weight, as expressed by the 33rd JECFA, pending further research, and reiterated the statement made previously that "there is only a relatively small safety margin between exposure in the normal diet and exposure that produces deleterious effects." Cadmium has an extremely long biological half-life in humans and is accumulated in body tissues, particularly in the liver and kidney. Cadmium is nephrotoxic and may produce renal tubular dysfunction, characterised by increased excretion of proteins.

8. Since the 1993 JECFA assessment the International Agency for the Research on Cancer, IARC, had classified cadmium and cadmium salts in group I, as substances carcinogenic to humans, based on evidence from human studies, mainly those of lung cancer associated with cadmium inhalation in the work place, and from animal studies. The IARC classification is qualitative only. The Council of Europe has published a review "Cadmium in Food", mainly discussing the toxicology of cadmium (Council of Europe, 1995). This and other new information will be discussed when the JECFA in 2000 is scheduled to evaluate cadmium again.

CADMIUM AS CONTAMINANT IN THE MOST IMPORTANT FOODSTUFFS

9. There are a number of fairly recent studies estimating the average daily intake of cadmium from foods from approximately 10 to 50 μg in areas without intense anthropogenic activity (UNEP/FAO/WHO 1992; 41st JECFA 1993; SCOOP 1996). This corresponds well with the results of the conservative estimates given in table 1.

10. These studies agree that for the average consumer, largely the most significant sources of cadmium in the diet are cereals and vegetables, including potatoes. Meat and especially liver and kidney follow in importance (UNEP/FAO/WHO 1992; 41st JECFA 1993; SCOOP 1996). The foods mentioned cover more than 80% of the intake of the normal consumer. Molluscs and crustaceans constitute only a small part of the diet, so these commodities do not contribute much to the cadmium intake for the average consumer, though both products may contain high levels of cadmium. There are, however, indications that single exposures of high levels may result in a more efficient uptake of cadmium, possibly making such products more important, even though the consumption is irregular. Fish, too, contain small quantities of cadmium. The contribution from other foods are generally found to be negligible, unless accidentally contaminated.

11. The concentration levels found in most vegetables, including bulbs, roots and tubers, are normally well below 0.050 mg/kg, whereas slightly higher average levels may be found in leafy vegetables such as spinach. Some wild mushrooms may contain high levels of cadmium, even when they have grown in uncontaminated soil. The cadmium may, however, be bound chemically, so that the bioavailability and thus the toxicity may be limited (ref. 1). This needs further investigation.

12. Oilseeds, like sunflower seeds and linseeds, accumulate cadmium from the soil so that the content in the seeds may well exceed 0.5 mg/kg (SCOOP 1996; ref. 2 - 5) independent of the concentration in the soil, and the same applies to cocoa beans (SCOOP 1996; ref. 6).

13. The levels of cadmium found in fruit are low, in the parts per billion range, and often below or close to the limit of determination of the commonly used analytical methods (SCOOP 1996). Thus fruit is only a minor contributor to the intake of cadmium.

14. Cereals are the other main source of cadmium in the diet. The cadmium is found mainly in the outer parts of the grain, wholly or partly removed in the milling processes, so the levels of cadmium found in flour or bread are lower than the levels found in grain. Wholemeal bread types contain more cadmium than other types, though the average content in bread rarely exceeds 0.1 mg/kg. Wheat, in particular durum wheat, may contain somewhat higher levels of cadmium (ref. 7).

Rice will most frequently contain less than 0.1 mg/kg cadmium. Japan previously reported substantially higher levels, but later investigations have shown a decrease, and in a recent Japanese survey only 23% of the samples exceeded this level (IPCS EHC 134; CX/FAC 97/22). Moreover, the cadmium in some cereals may be chemically bound, so that the bioavailability is limited. This, however, needs to be further investigated. There is a draft guideline level of 0.1 mg/kg for cadmium in cereals, pulses and legumes at step 7, coming from the CCCPL, for consideration of the CCFAC.

15. Meat of cattle, pig and poultry as well as sheep may contain cadmium as a consequence of a cadmium content in fodder and feedingstuffs. The levels in meat from muscle are in the order of 0.01 mg/kg for the animals as normally slaughtered (ref. 8).

16. Horse-meat in particular from old horses may, however, often contain substantially higher levels of cadmium. Mean contents exceeding 2 mg/kg have been reported, but it is not always clear whether such concentrations apply to meat or offal. Such contents are to be expected, as a

consequence of their diet and lifespan. On the other hand, mean levels well below 0.5 mg/kg are reported from several countries (SCOOP, 1996). Most consumers world-wide eat horsemeat only rarely and in limited quantities, but there are consumers who eat horse-meat products in quantities comparable to other meat types. There have been problems recorded in the trade of horse-meat because of the cadmium content.

17. The content of cadmium in liver and especially kidney, is substantially higher than in the animal muscle. In liver of calf, pig and poultry, which is most frequently consumed, the levels normally found range from 0.02 to 0.2 mg/kg. Higher levels of cadmium may again be found in liver from older animals.

As cadmium accumulates in the animal kidney bound to metallothioneines, this organ may contain rather high levels of cadmium. The cadmium levels generally found in kidney from calf and pig normally range from 0.05 to 0.5 mg/kg, whereas the content in bovine kidney may approach 1 mg/kg. Kidney and liver from horse (if at all considered a food) may exceed 10 mg/kg, and should be avoided, or only eaten rarely.

18. Fish will normally not be a major source to cadmium. The contents reported are generally low, in the parts per billion range. Contents reported are most frequently in the order of 0.02 mg/kg, though higher levels are occasionally found in some species or in fish from contaminated waters and sediments (SCOOP 1996; ref. 9).

19. Crustaceans, especially crabs, and some bivalve molluscs may contain substantial amounts of cadmium. The "brown meat" of the crab which is normally removed before consumption may accumulate more than 10 mg/kg cadmium (MAFF, 1983). Bivalve molluscs will normally contain perhaps 0.2 mg/kg cadmium, but as the molluscs may accumulate cadmium from contaminated waters by filtration, the contents found are sometimes considerably higher.

20. In other foods, unless incidentally contaminated, the average cadmium content will be negligible and will not contribute significantly to the intake.

21. The content of cadmium in food, as reflected in intake estimates, appears to decrease only slowly or to remain constant within the uncertainty of surveys from recent years (Council of Europe 1995; Danish VFA 1995 and 1999). Source-directed measures like those recommended in the "Position Paper on Cadmium" (CX/FAC 95/19) and the Draft Code of Practice for Source-related Measures (CX/FAC 96/20 and CX/FAC 98/20) will certainly have an impact on lowering the environmental burden. However, these measures still await full implementation.

INTAKE CONSIDERATIONS

22. The dietary intake of cadmium for many countries world-wide is presented by surveys from UNEP (UNEP/FAO/WHO, 1992) and also by the SCF (SCOOP, 1996) and others, see table 2. The methods of estimation used are different and they are reported in the original papers. The average intake is approximately 10 to 50 μg/day in areas of normal exposure, but may be higher in certain countries (ICPS EHC 134, 1992). These figures, providing documentation for the statement concerning the small safety margin between exposure from the normal diet and exposure that produces deleterious effects, confirm the reason for taking action to reduce the exposure to cadmium from the diet, both for the average consumer and even more so for those who are particularly exposed because of local contamination, particular dietary habits or because they are additionally exposed as tobacco smokers or occupationally.

23. JECFA in 1993 expressed concern about having to use retrospective data for estimating the

intake of cadmium from rice. Moreover the Committee acknowledged the need for research in areas recommended in the WHO ICPS Environmental Health Criteria 134 (ICPS EHC 134, 1992) and highlighted some topics including examination of data on cadmium intake in various countries, data on cadmium content in foods and also studies on the chemical identity (speciation) and bioavailability of cadmium in foods (ref. 10). Since then there are more recent data available showing a lower consumption of rice for rural inhabitants in Japan, as well as a decrease of the content of cadmium in rice (CX/FAC 97/22; Council of Europe 1995).

24. There have been reports indicating a decrease in intake of cadmium from food in recent years, probably because of source-directed action showing some effect. Eliminating cadmium from food contact materials made of ceramics and plastics and reducing cadmium in waste by recycling electric batteries, should contribute to a decrease in intake, though other activities such as spreading of sewage sludge on soil used for cultivating crops for consumption may have an opposite effect. Improvements in analytical quality assurance in recent years may, however, also contribute to this effect by providing more accurate data on low levels of cadmium in food. However, even rather recent data often lack documentation of analytical quality control, hence making use of the data problematic.

25. For the extreme consumer an "extreme daily exposure" may be estimated as well. As a rough estimate, this may conventionally be done by multiplying the typical exposure by three, giving 69 μg (table 1). Another approach was presented by the UK (CX/FAC 98/13), taking the 97.5% fractile from the two food groups contributing most to the exposure (for cadmium: cereals and vegetables) plus the average of the others as an expression of the intake by a high level consumer. This method of calculation gives be 52μg. In the most recent Danish study (VFA 1999), the average daily intake was found to be 17 μg and the 95% and 99% fractile were 28 μg and 35 μg , respectively. All estimates correspond well with the data in table 2. For vulnerable groups, particularly exposed to cadmium, such as vegetarians or people who eat large amounts of mussels or horse-meat, the exposure may be calculated, too, from national consumption data and the content of cadmium in the relevant foods. Concern with respect to the intake of cadmium for consumers with extreme eating habits, nationally regionally or otherwise, can probably best be addressed by relevant advice from national authorities.

26. A Theoretical Maximum Daily Intake (TMDI) calculation analogous to that used in connection with the calculation of the theoretical intake of pesticides has been performed (table 1). A calculation using the typical intake figures and the limits proposed results in a TMDI of 52 μg cadmium, to be compared to a tolerable intake for a 70 kg person of 70 μg (or 60 μg for a 60 kg person), calculated from the JECFA PTWI. Whereas this calculation is theoretical, and may be called philosophical, it illustrates that the figures proposed for ML's theoretically do not completely cover the average consumer. (Reduced ML's for vegetables and meat might resolve this problem).

HEALTH PROBLEMS

27. The "extreme daily exposure" calculated as three times the average exposure, exceeds the JECFA tolerable daily or rather weekly intake. So does the exposure for those consumers who frequently eat large amounts of mussels, or possibly horse-meat. Consumers living in areas that have been particularly contaminated by industry may also fall into this category. For smokers, there is an additional significant contribution to the exposure. Until another JECFA assessment becomes available, the situation may probably best be described by the 33rd JECFA statement that "there is only a relatively small safety margin between exposure in the normal diet and exposure that produces deleterious effects."

POTENTIAL TRADE PROBLEMS

28. There are national maximum limits for cadmium in food in many countries, potentially creating trade barriers. Problems in trade have occasionally been noted, most recently regarding horse-meat.

TECHNOLOGICAL POSSIBILITIES

29. As cadmium in food to a considerable degree is due to the technological use of cadmium, there are certainly possibilities to reduce the exposure by source-directed measures. Cadmium has already been removed or substituted in a number of food contact materials, and efforts to reduce the concentration of cadmium in sewage sludge and in phosphate fertilisers are underway. Such purification or substitution efforts, however, are sometimes difficult, as they may be costly. Other effective measures include e.g. the collection of cadmium containing electric equipment and batteries, so that they do not form part of waste to be incinerated, thus reducing the concentration of cadmium in atmospheric downfall.

RECOMMENDATIONS

30. The recommendations of the Position Paper on Cadmium (CX/FAC 95/19) to combat the contamination of food by cadmium by both general management of the use of cadmium in society and more specific measures related to the use in connection with food production should be followed and reviewed from time to time. Source-directed measures to reduce the content of cadmium in the diet are an essential part of a long term strategy to reduce this problem.

31. Further research, such as recommended by the WHO (ICPS EHC 134, 1992) and by JECFA (41st Report JECFA, 1993) is another cornerstone of a long term strategy to reduce the cadmium problem. This applies both to the toxicology, where some progress has been made in recent years, and also in areas such as chemical identity and bioavailability of cadmium species, present in food.

32. The Position Paper on Cadmium also recommends that international limits for cadmium in certain foods are laid down, in accordance with the Codex General Standard for Contaminants and Toxins in Food. In table 1 there is a draft proposal for Codex ML's, as well as a general overview of the content of cadmium in various foods covering all foods giving a substantial contribution to the daily intake of cadmium for the average consumer. The Codex stepwise procedure to establish ML's is a thorough and also sometimes lengthy procedure, so a first discussion of ML's appears appropriate at this stage.

33. The JECFA is scheduled to review cadmium again in 1999. This review may well provide information essential to any discussion of cadmium in food, and particularly to the Codex discussion and decisions and to this paper. The CCFAC discussion based upon this paper should consequently be brought to a conclusion only when the results of the JECFA reevaluation of cadmium is available to the Committee.

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Table 1 - Cadmium in food

Food	**ML (mg-/kg)**	**Daily Intake Range (g)** ***(Typical intake)***	**Cadmium Range (mg/kg)** ***(Typical level)***	**Typical exposure (mg/day)**	**MDI mg/day)**
Fruit	-	100-500 *(200)*	0-0.05 *(0.01)*	2	-
Vegetables (incl. potatoes)	0.05	100-800 *(300)*	0-0.1 *(0.03)*	9	15
Oilseeds and cocoa—beans	-	0-5 *(1)*	0.1-1 *(0.5)*	0.5	-
Cereals, pulses and legumes except wheat grain and rice Wheat grain and rice	0.1 0.2	50-800 *(200)* 20 - 100 *(50)*	0-0.2 *(0.02)* 0-0.2 *(0.05)*	4 2.5	20 5
Meat of cattle, poultry, pig and sheep	0.05	100-250 *(150)*	0-0.1 *(0.02)*	3	7.5
Meat of horse	0.2	0-25 *(2)*	0-2 *(0.1)*	0.2	0.4
Liver of cattle, poultry, pig and sheep	0.5	0-10 *(5)*	0-0.5 *(0.1)*	0.5	2.5
Kidney of cattle, poultry, pig and sheep	1	0-2 *(1)*	0-2 *(0.5)*	0.5	1
Fish	-	10-50 *(30)*	0-0.05 *(0.02)*	0.6	-
Crustaceans, molluscs	0.5	0-10 *(3)*	0-2 *(crustaceans, molluscs: 0.25)*	0.8	1.5
Total				23	52

Table 2: - Cadmium intake (µg/day) for each country

Data from UNEP, 1992 and from SCOOP, 1996

Country	Year	Intake (µg/day)
Australia	1987	27
Austria	1996	10.2
Belgium	1996	23.2
Canada	1981	15
China	1988	10
Cuba	1984	12
Denmark	1999	17
Finland	1996	9.5
France	1996	13.1
Germany	1996	10.2
Greece	1996	57.1
Guatemala	1988	32
Hungary	1985	9
Japan	1987	29
Rep. of Korea	1985	29
Ireland	1996	22.6
Italy	1996	22.9
Netherlands	1989	23
New Zealand	1982	59
Poland	1987	38
Portugal	1996	16.9
Spain	1996	17.7
Sweden	1996	8.6
Switzerland	1989	18
Thailand	1987	177
Turkey	1996	8
UK	1996	15.6
USA	1988	11