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

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DISCUSSION PAPER ON MAXIMUM LEVEL FOR LEAD IN FISH

(Prepared by the Philippines with the assistance of South Africa and the United Kingdom)

I. INTRODUCTION

At the 37th CCFAC, "the Committee decided not to develop a list of fish and to consider setting a maximum level for lead in a range between 0.2 – 0.5 mg/kg for all fish, taking into account the results of the 53rd JECFA, the WHO data on lead contamination in fish and other relevant information such as those provided at the 36th Session of CCFAC. For this purpose, the Committee agreed to request an electronic working group led by the Philippines, to prepare a discussion paper that compiles the information necessary to develop an appropriate maximum level for lead in fish for consideration at its next session". Comments were received from South Africa and the United Kingdom.

As requested by the 37th CCFAC, this paper gathers the information requested above as well as others that could facilitate decision-making on an appropriate ML. The information contained covers the following:

- Analytical data on lead in fish
- Toxicological information from JECFA
- Potential trade problems
- CCFAC principles and guidelines for the establishment of an ML

The draft ML for lead in fish was first proposed at 0.5 mg/kg in 1996 to the 28th CCFAC (CX/FAC 96/23). Although most fishes were found to contain less than 0.1 mg/kg lead, the ML proposed was higher to cover results of surveys on lead in fish (CX/FAC 96/23).

In 1999 at the 31st CCFAC, the draft ML was reduced from 0.5 mg/kg to 0.2 mg/kg. This was done due to concerns over the impact of lead on children and because higher levels of lead in earlier reports were considered to be due to poor quality control of the data (CX/FAC 99/19). The draft ML has been under discussion at a level of 0.2 mg/kg.

II. ANALYTICAL DATA ON LEAD IN FISH

2.1. Sources of data

Data on lead in fish was submitted to CCFAC by Germany, the Slovak Republic (31st CCFAC), the Netherlands, (32nd CCFAC), Canada, Spain (33rd CCFAC) Australia, Brazil, Denmark, the European Community, Morocco, Philippines, Republic of Korea, United States (34th CCFAC), Japan, South Africa, Spain, (36th CCFAC) Cuba, Thailand (37th CCFAC). Earlier data was collected from the published literature. Data from the WHO GEMS/Food data base was also cited. Most of the data came from the analysis of different species of fish by countries.

Occurrence levels for lead in fish and fish products in 13 EU countries is reported in SCOOP (reference no. 5).

2.2. Data support for the current draft ML

Analytical data on lead in fish submitted to CCFAC has been the major basis in setting the proposed draft ML at 0.2 mg/kg. The ML represents what is considered "as low as reasonably achievable" (ALARA), from the analytical data submitted. The use of 'ALARA' as a basis for setting the ML, is based on concerns that lead is a serious hazard to health especially to children (US, Netherlands, EC, 34th CCFAC).

It has been difficult for CCFAC to come to agreement on the "achievability" of the proposed draft ML. For while the available analytical data indicates that most fish will support an ML of 0.2 mg/kg or less, there are species that need a higher ML of 0.4 – 0.5 mg/kg.

An ML of 0.4 mg/kg has been recommended by the EC for the following species of fish: Spotted sea bass, Eel (*anguilla anguilla*), Grunt, Horse mackerel or scad (*Trachurus species*), Grey mullet, Sardine, Sardinops, Scabbard fish, Seabream, Wedge sole (CRD 10, 36th CCFAC). The recommendation was based on an analysis by Denmark, of internationally traded fish species that will not meet an ML of 0.2 mg/kg (CX/FAC 04/36/26, 36th CCFAC). The list of internationally traded fish species was obtained from FAO and the EC. In addition, Thailand also recommended an ML of 0.4 mg/kg for the following species of fish: Mackerels, Jack and Horse Mackerel; Sardine, Sardinella, Brisling, Sprat, Tuna, Skipjack tuna, Yellowfin tuna, Bonito (CX/FAC 05/37/27, Add.1).

The above tiered approach which will assign a higher ML for a limited list of internationally traded fish species, has been extensively discussed at CCFAC. There have been difficulties in its adoption because of difficulties in the establishment of acceptable criteria for identifying species for which a higher ML should be applied. This is due to regional variations in levels of contamination and differences in consumption patterns. Trade problems could also arise for important species not found in the list (37th CCFAC).

2.3. Analysis of lead in fish

The routine, conventional and internationally validated method for the analysis of lead in fish based on Atomic Absorption Spectrophotometry (AAS), in the Official Methods of Analysis of the Association of Official Analytical Chemists (AOAC) International (2000) 17th Ed., Official Method No. 972.23, will not reach the limit of detection and limit of quantification necessary to reliably analyze lead at 0.2 mg/kg (Philippines, 34th CCFAC; similar comments by Australia and Japan, 28th CCFAC). Developing nations who have routinely used this method for lead analysis may find it difficult to test at these levels.

EU Member States and other countries have been able to determine lead reliably to 0.2 mg/kg or lower. The same analysis can be expected to be carried out by other analysts. The analysis of lead at this level can be carried out by using carbon graphite AAS. This method, however, requires a large investment in new equipment and entails higher analytical cost. The large expense will pose difficulties for developing countries unless justified on the basis of a need for public health protection.

2.4. The significance of the level of Lead in fish

The comments submitted to CCFAC indicate that levels of lead in fish are not influenced by levels in the waters in which they live (CX/FAC 00/24). Contaminants like lead are due to natural processes and their levels in commodities like fish cannot be influenced (India, 34th CCFAC). It is also reported in the literature that lead is not biomagnified in terrestrial and aquatic food chains (CSTEE, reference no 2). Vertebrate fish can regulate the concentrations of inorganic forms of metals in muscle tissue and in these cases concentrations do not exceed regulatory or recommended limits even when the fish are harvested from metal-contaminated lakes or ponds or from marine environments exposed to metal contamination (Howgate, reference no 3).

III. TOXICOLOGICAL INFORMATION FROM JECFA[1]

3.1. JECFA Meetings on Lead

JECFA evaluated lead at its 16th, 22nd, 30th, 41st, and 53rd meetings. At its 30th meeting, it assessed the health risks of lead to infants and children and established a PTWI of 25 ug/kg bw for this population group. The PTWI was reconfirmed at its 41st meeting and extended to all age groups. At its 53rd meeting, JECFA was requested to assess the risks of dietary exposure to lead on infants and children. The most critical effect of lead at low concentrations on children was identified as reduced cognitive development and intellectual performance.

3.2. The Provisional Tolerable Weekly Intake (PTWI) for Lead

Although lead has a Provisional Tolerable Weekly Intake (PTWI) of 25 ug/kg body weight which is considered to be the safe range of intake, there is no experimental data to substantiate this value for reduced cognitive development. There is no evidence of a threshold for reduced intellectual development of children. It is not because lead toxicity is expected at very low levels, but because methods used to test intellectual performance of children are not precise enough to quantify lead toxicity at low levels (M. Luetzow).

The effect of compounding variables and limits in the precision of analytical and psychometric measurements increase the uncertainty of any estimate of the effect of blood lead concentrations below 10-15 ug/dl. Thus, if a threshold does exist, it is unlikely to be detected because of these limitations[2].

It was therefore necessary to approach the problem in a different way and that was to assess the risk at very low levels of exposure. This involved extrapolation of effects from known regions to an unknown region. Data between 20 ppm to 100 ppm, for example could be extrapolated to determine what can happen at 0.5 ppm, 0.2 ppm and 0.1 ppm. This is what JECFA did at its 53rd meeting in 1999 (M. Luetzow).

3.3. The Findings of the 53rd JECFA

3.3.1 Estimates of dietary intake of lead

To determine the health risks, intake levels for lead had first to be evaluated by JECFA. Dietary intakes were estimated using the five WHO regional diets, under three sets of assumptions as follows :

1. All foods contain lead at the limits proposed by Codex (with fish at 0.2 mg/kg).
2. All foods contain lead at a “typical” average concentration.
3. All foods contain lead at “typical” high levels.

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[1] The information in this section is taken from the reports of the 53rd JECFA meeting held in 1999 (WHO Technical Report Series 896 and WHO Food Additive Series : 44). Extensive reference is made to the talk of Dr Manfred Luetzow at a Round Table Discussion on Risk Assessment of Lead in Seafoods held in Manila, Philippines on 2 October 2003, while a member of the Joint FAO/WHO JECFA Secretariat. This was done to facilitate understanding of the findings of the 53rd JECFA meeting.

[2] WHO Technical Report Series 896, p 81

When levels of lead in food at the limits proposed by CCFAC (#1 above and with the ML for lead in fish at 0.2 mg/kg) were used in the assessment, the estimated dietary intake ranged from 13-20 ug/kg of body weight per week (WHO Food Additive Series: 44). When this estimate was carried out with the ML for fish at 0.5 mg/kg., the estimated dietary intake was only slightly increased to a range of 15-21 ug/kg body weight per week[3].

When "typical average" levels of lead in food were used (#2 above), the estimated dietary intake ranged from 1-2 ug/kg of body weight per week. When "typical high" levels of lead in food were used (#3 above), the estimated dietary intake of lead ranged from 2-4 ug/kg body weight per week. The typical "average" and "high" levels were derived from monitoring studies in the USA and were similar to those reported in other countries.

The above shows that the dietary intakes are lower than the PTWI, that Codex ML's are much higher than the levels of lead actually found during the monitoring of food, and that changing the Codex ML from 0.2 mg/kg to 0.5 mg/kg has little effect on the intake.

Dietary intakes for lead using the WHO regional diets do not specifically take into account the intake of infants and children. In this regard, it is useful to refer to a report of the EU Directorate General Health and Consumer Protection[4], which indicates that intake estimates for children in 13 EU Member States do not exceed the PTWI for lead.

3.3.2 Estimate of blood lead concentration from dietary intake of lead

The most widely used biomarker of exposure to lead is the concentration in blood measured in ug/dl. In order to predict the biological effects of lead, the Committee used models to relate the concentration of lead in the diet to changes in the level of lead in the blood. The Committee arrived at the following relationship on the effect of long term exposure to lead on blood lead concentrations:

a) 1 ug / kg bw per day of lead in the diet

increases the level of lead in the blood by 1 ug/dl

OR

b) 1 ug/ kg bw per week of lead in the diet

increases the level of lead in the blood by 0.14 ug/dl (1/7 = 0.14)

The above relationship represents the upper estimate for infants and the worst case scenario. The relationship is valid during the long term exposure period (in utero + 10 years)[5]

3.3.3 Blood levels of lead and intellectual performance

There is a negative correlation between blood lead levels and intellectual performance, the more lead, the lower the IQ. There are a lot of compounding factors because children with high levels of lead may live in more polluted areas. More often, these are areas with less income, less income leads to less schooling and so on. In these studies one tries to eliminate these compounding factors (M. Luetzow).

The Committee came up with Table 14 (below) which shows the estimated net decrease in IQ for the median population at four values of blood lead concentration, with a range of uncertainty for each estimate.

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3 Philippines, 37th CCFAC

4 SCOOP. Reports on tasks for scientific cooperation. "Assessment of the dietary exposure to arsenic, cadmium, lead and mercury of the population of EU Member States", Directorate General Health and Consumer Protection, March 2004.

5 WHO Technical Report Series 896

Table 14 : Net decrease in IQ associated with blood lead concentration[6]

Concentration of lead in blood (ug/dl)	Median IQ decrement(95%confidence interval)
5	0.4 (0.0-1.5)
10	1.7 (0.5-3.1)
15	3.4 (1.1-5.0)
20	5.6 (1.6-6.9)

The above table shows that an increase in blood levels of lead by 5 ug/dl will reduce the IQ by 0.4. If we consider an IQ of 110, this means a reduction to 109.6. The precision of IQ testing varies with time, today you have 105, tomorrow you have 115. These are very minor effects that are involved. If the increase in blood level is 20 ug/dl, then we have a big effect, the decrease in IQ is 5.6 (M. Luetzow).

The Committee used the relationship in Table 14 to determine the effect of dietary intakes of lead on intellectual performance.

The highest dietary intake calculated from a WHO regional diet and with all foods containing lead at the Codex ML's in section 3.3.1, was 20 ug/kg bw week. Since long term exposure to lead of 1 ug/kg bw-week increases blood lead concentration by 0.14 ug/dl, an intake of 20 ug/kg bw-week should result to an overall increase in blood lead concentration of 3 ug/dl (0.14 x 20). From Table 14, a blood lead concentration of 3ug/dl would represent a reduction in IQ of between 0.4 and 0 which is minimal, but also represents the worst case scenario (M.Luetzow).

The estimate of dietary intake using "typical high" levels of lead in section 3.3.1 is 2-4 ug/kg bw week. This will increase blood lead concentration to 0.3 to 0.6 ug/dl (2 x 0.14) and (4 x 0.14). From Table 14 this increase in blood lead concentrations would be equivalent to a decrease in IQ of only 10% of that obtained from dietary intakes using the Codex ML's where blood lead concentrations reach 3ug/dl (M. Luetzow). This is why the Committee reported that "the results show/provide confidence that the levels of lead that are found currently in foods would have negligible effects on the neurobehavioral development of infants and children"(M. Luetzow).

For fish alone, Table 2 of the JECFA report[7] indicates that at the Codex ML of 0.2 mg/kg, the resulting dietary intake of lead is 6.7 micrograms/person/day for the European diet. This is equivalent to an intake of about 0.1 ug/kg body weight per day (for a 60 kg person) and to a blood lead concentration of 0.1 ug/dl. Considering that a blood lead concentration of 1 ug/dl translates to 1/5 of a 0.4 decrease in IQ, (Table 14), the above estimate is still a negligible effect. Estimates of effects on IQ of this magnitude led Dr Luetzow to state that "one hour of TV everyday has a greater impact on the IQ of children than lead".

The simulation model presented at the 53rd JECFA can be used to evaluate the effects of any proposed regulatory intervention to reduce exposure to lead. This model of intake-blood level-IQ deficiency can assess whether the amounts of lead in food will lead to a considerable effect on the IQ. A cause and effect can be established because the model shows an effect at any level of lead. There is no threshold, but one can see how big or small the effect of dietary intakes are on IQ (M. Luetzow).

6 WHO Food Additive Series: 44 page 36
7 WHO Food Additive Series: 44

IV. POTENTIAL PROBLEMS IN TRADE

4.1 Data from the WHO GEMS/Food database

As reported to the 37th CCFAC (CX/FAC 05/37/27), the WHO GEMS/Food has a database of 453 aggregate records representing 8820 individual measurements on lead contamination in fish available on the Summary of Information on Global Health Trends website. The data was evaluated based on the percent of records that would exceed one of the three Maximum Levels (ML) of 0.2, 0.4 and 0.5 parts per million (See Table 1 below) being discussed at CCFAC. The results of the evaluation was considered a measure of the potential "violation rates" of fish at the various ML's.

Table 1 Evaluation of Draft Maximum Levels of Lead in Fish with GEMS/ Food Database

Proposed Ml's	0.2 ppm	0.4 ppm	0.5 ppm
Mean	14%	2%	.7%
Median	7%	3.8%	2%
90th Percentile	21%	11%	7.7%
Maximum Reported	38%	24%	17%

http://sight.who.int/newsearch.asp?cid=131&user=GEMSuser&pass=GEMSSu

In the case of the mean values, results below the Limit of Determination (LOD) are based on assigning values of LOD/2 for the results. Consequently, the median values were reported to be more reliable in predicting distributions. If regulatory sampling is not likely to produce a reliable mean or median, the values provided for the 90th percentile may be useful in assessing the likelihood of a high sample exceeding a proposed ML (CX/FAC 05/37/27. Add. 1) .

Irrespective of the statistic employed, the above table shows that an increase in ML leads to measurable reductions in potential 'violation rates' and on the percentage of fish (and of good quality protein) that will be taken out of commerce.

4.2 Data from the Rapid Alert System For Foods and Feeds (RASFF)

RASFF accessed through the internet, indicated the following cases of actual rejection in 2003 and 2004 of tuna fillets from Indonesia and Yemen, by Italy :

- Refrigerated tuna fillets, on 10/6/2003 from Indonesia. ID 987
- Fresh tuna fillets, on 10/8/2003 from Indonesia. ID 1013
- Tuna, (Thunnus albaceres) on 3/25/2004 from Yemen. ID 2403

The ML for lead in bonito and tuna in the EU was originally set at 0.2 mg/kg but was revised to 0.4 mg/kg and adjusted to 0.2 mg/kg in February 2005.

V. CCFAC PRINCIPLES FOR SETTING AN ML

CCFAC principles for setting ML's for contaminants serve as a guide to the Committee for arriving at an appropriate ML for contaminants and toxins in foods. For lead in fish, those principles most relevant to the discussions and which were cited in country comments, are as follows: (Australia, 34th CCFAC, Philippines 36th CCFAC).

5.1 CCFAC shall base its risk management recommendations to the CAC on JECFA's risk assessments, including safety assessments, of food additives, naturally occurring toxicants and contaminants in food (Risk Analysis Principles as Applied by CCFAC).

The 31st CCFAC (CX/FAC 99/19) reviewed the exposure of children to lead based on the report of the 41st JECFA (1993). The detailed findings of the 53rd JECFA meeting in June 1999, which specifically focused on the effects of low level exposure to lead on the intellectual performance of children have not been considered in the establishment of the ML.

5.2 ML's shall be set as low as reasonably achievable. Providing it is acceptable from the toxicological point of view, ML's shall be set at a level which is (slightly) higher than the normal range of variations in levels in foods that are produced with current adequate technological methods, in order to avoid disruption of production and trade (CODEX STAN 193).

The findings of the 53rd JECFA should be evaluated in relation to the need to set the ML on the basis of 'ALARA'.

5.3 Proposals for ML's shall be based on data from at least various countries and sources, encompassing the main production areas/processes of those products, as far as they are engaged in international trade (CODEX STAN 193).

As data from developing countries is not readily obtained, the information from WHO GEMS/Food database should be better utilized either in evaluating dietary exposure and/or in determining potential problems in trade from a proposed ML.

5.4 ML's should not be lower than a level which can be analyzed with methods of analysis that can be readily applied in normal product control laboratories, unless public health considerations necessitate lower detection limits which can only be controlled by means of a more elaborate method of analysis. In all cases however a validated method of analysis should be available with which an ML can be controlled (CODEX STAN 193).

There is an internationally validated method that has been used routinely for analyzing lead in fish. The setting of the ML at a level that will require its analysis by other methods that greatly increased analytical expense, should be well justified from the toxicological point of view.

VI. SUMMARY OF INFORMATION

The following is a summary of the significant information gathered in this paper which could be considered in making a decision on an appropriate ML for lead in fish.

6.1 Most fishes can achieve an ML 0.2 mg/kg. However, there are other species that require higher ML's of 0.4 mg/kg and 0.5 mg/kg (33rd, 34th, CCFAC). A tiered approach based on a list of internationally traded fish species where a higher ML should be applied, has been difficult to establish due to difficulties in coming to agreement on acceptable criteria for identifying species in the list. Potential trade problems could also occur for species not in the list.

6.2 The current draft ML of 0.2 mg/kg is based on the level that is "as low as reasonably achievable" in most fish species, from analytical data provided to CCFAC. The setting of an ML on the basis of ALARA stems from concern that lead is a serious hazard to health especially to children (US, Netherlands, EC, 34th CCFAC). The use of ALARA needs to be re-evaluated in the light of the findings of the 53rd JECFA Meeting and attendant problems in trade and in methods of analysis.

6.3 A quantitative risk assessment has been carried out by the 53rd JECFA specifically on the risks of low level exposure to lead on the intellectual performance of children. Some important findings of the 53rd JECFA are the following:

- Estimates of dietary intake of lead are always below the PTWI, even in the worst intake scenarios where all foods are assumed to contain lead at the Codex ML's.
- Increasing the ML for fish from 0.2 mg/kg to 0.5 mg/kg has little effect on the contribution of fish to the PTWI for lead.

- At the highest dietary intake of 20ug/kg-bw-week using Codex ML's, the blood level of lead will increase to 3 ug/dl (20 x 0.14) and the reduction in IQ, will be 0-0.4 which is not much. For foods containing typical "high " values of lead, the decrease in IQ is 10% of that obtained using the Codex ML's.

On the basis of the above, the 53rd JECFA came to the conclusion that "levels of lead currently found in food will have negligible effects on the neurobehavioral development of infants and children".

6.4 The WHO GEMS/Food database representing 8820 measurements on lead contamination in fish shows that an increase in ML leads to measurable reductions in potential "violation rates" of fish or a reduction in the potential rejection of good quality protein in the market. There have been actual rejections of fish in trade due to lead, where the ML enforced is 0.2 to 0.4 mg/kg.

6.5 The routine, conventional and internationally validated method for lead in fish will not reach the limits of detection required for the measurement of lead at the draft ML. Methods with lower detection limits will greatly increase analytical expense. Such methods should be well justified from the toxicological point of view.

6.6 CCFAC principles and guidelines for establishing an ML are particularly relevant to the issues that have arisen in this discussion. These principles can form a useful framework for decision-making on a single ML.

VII. REFERENCES

1. CODEX STAN 193 ANNEX 1. Codex General Standard for Contaminants and Toxins in Food.
2. CSTEE . SCIENTIFIC COMMITTEE ON TOXICITY, ECOTOXICITY AND THE ENVIRONMENT, Opinion on LEAD-DANISH NOTIFICATION 98/595/DK, Brussels, 5th of May 2000).
3. Howgate, P. Review of the public health safety of products from aquaculture, International Journal of Food Science and Technology, 1998. 33. 99-125.
4. "RISK ANALYSIS PRINCIPLES APPLIED BY THE CODEX COMMITTEE ON FOOD ADDITIVES AND CONTAMINANTS" ALINORM 05/28/41 Appendix IV, page 1)
5. SCOOP. Reports on tasks for scientific cooperation. "Assessment of the dietary exposure to arsenic, cadmium, lead and mercury of the population of EU Member States", Directorate General Health and Consumer Protection, March 2004.
6. WHO GEMS/Food database
7. http://sight.who.int/newsearch.asp?cid=131&user=GEMSuser&pass=GEMSSu