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# Safety evaluation of certain food additives and contaminants

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**3-CHLORO-1,2-PROPANEDIOL**
**(addendum)**
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## *3-CHLORO-1,2-PROPANEDIOL (addendum)*

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### *1. EXPLANATION*

3-Chloro-1,2-propanediol is formed when chloride ions react with lipid components in foods under a variety of conditions, including food processing, cooking, and storage. The compound has been found as a contaminant in various

foods and food ingredients, most notably in acid-hydrolysed vegetable protein (acid-HVP) and soy sauces.[1] 3-Chloro-1,2-propanediol was first evaluated by the Committee at its forty-first meeting (Annex 1, reference 107). The Committee concluded that it is an undesirable contaminant in food and expressed the opinion that its concentration in acid-HVP should be reduced as far as technically achievable.

3-Chloro-1,2-propanediol was re-evaluated by the Committee at its fifty-seventh meeting (Annex 1, reference 154). Short- and long-term studies in rodents showed that 3-chloro-1,2-propanediol is nephrotoxic in both sexes and also affects the male reproductive tract and male fertility. At that meeting, the Committee considered that the kidney was the main target organ and tubule hyperplasia in the kidney the most sensitive end-point for deriving a tolerable intake. This effect was seen in a long-term study of toxicity and carcinogenicity in male and female Fischer 344 rats given drinking-water containing 3-chloro-1,2-propanediol. The Committee concluded that 1.1 mg/kg bw per day, the lowest dose, was a lowest-observed-effect level (LOEL) and that this was close to a no-observed-effect level (NOEL). The Committee established a provisional maximum tolerable daily intake (PMTDI) of 2 µg/kg bw for 3-chloro-1,2-propanediol on the basis of this LOEL, using a safety factor of 500. This factor was considered adequate to allow for the absence of a clear NOEL and to account for the effects on male fertility and for inadequacies in the studies of reproductive toxicity. Data available to the Committee at that time indicated that the estimated mean intake of 3-chloro-1,2-propanediol for consumers of soy sauce would be at or above this PMTDI.

The present re-evaluation was conducted in response to a request from the Codex Committee on Food Additives and Contaminants (CCFAC) at its Thirty-seventh Session (Codex Alimentarius Commission, 2005a) for the JECFA Committee to review and summarize all new data on the toxicology and occurrence of 3-chloro-1,2-propanediol. In particular, the Committee was asked to carry out an exposure assessment for 3-chloro-1,2-propanediol based on the contributions from all food groups in the diet (not only soy sauce), with particular consideration to population groups that might have higher levels of exposure.

Since the Committee's last evaluation of 3-chloro-1,2-propanediol (Annex 1, references 154, 155) this substance has also been evaluated by the Food Standards Australia New Zealand (FSANZ, 2003).

[1] The term 'soy sauce' is used to encompass liquid seasonings made from soya beans by a range of methods including acid-hydrolysis and traditional fermentation, possibly with the addition of acid-HVP. In some countries, the term 'soy sauce' is reserved solely for fermented products.

## *2. BIOLOGICAL DATA*

### *2.1 Biochemical aspects*

No new information was available.

### *2.2 Toxicological data*

#### *2.2.1 Short-term studies of toxicity*

*Rats*

In a study to investigate effects on neurobehaviour, groups of 10 male and 10 female Sprague-Dawley rats were given 3-chloro-1,2-propanediol as oral doses at 0, 10, 20, or 30 mg/kg bw per day for 11 weeks. Although body-weight gain was significantly decreased in the males at the highest dose, no significant effects on the results of tests for motor activity, landing foot splay, or forelimb grip strength were found in treated rats at weeks 1, 3, 5, 7, 9, or 11 when compared with control rats that received saline. These results suggest that 3-chloro-1,2-propanediol, at the doses used, does not produce neuromotor deficits (Kim et al., 2004).

#### *2.2.2 Long-term studies of toxicity and carcinogenicity*

No new studies were available.

#### *2.2.3 Genotoxicity*

The previously reviewed reports from Fellows (2000) and Marshall (2000) have now been published (Robjohns et al., 2003).

The formation of micronuclei in bone marrow erythrocytes was studied in groups of six male Crl:Han Wist(Glx:BRL)BR rats given 3-chloro-1,2-propanediol as oral doses at 0, 15, 30 or 60 mg/kg bw per day for two consecutive days, based on a preliminary dose range-finding experiment in which a dose of 60 mg/kg bw per day was close to the maximum tolerated dose. Administration of 3-chloro-1,2-propanediol at the highest dose produced signs of toxicity (piloerection) and a reduction in the ratio of polychromatic to normochromatic erythrocytes, indicating toxicity to erythropoietic cells. No increase in micronucleated polychromatic erythrocytes was produced by 3-chloro-1,2-propanediol, while the positive control, cyclophosphamide, was clearly active.

Unscheduled DNA synthesis in hepatocytes was studied in groups of four male Crl:Han Wist(Glx:BRL)BR rats given 3-chloro-1,2-propanediol as single oral doses at 0, 40 or 100 mg/kg bw, based on a preliminary dose range-finding experiment in which 100 mg/kg bw per day was close to the maximum tolerated dosage. In one part of the experiment, hepatocytes were isolated at 2–4 h after dosing and in the second, at 12–14 h after dosing. Hepatocytes were cultured with [$^{3}$H]thymidine, incorporated during unscheduled DNA synthesis, which was measured autoradiographically. The administration of 3-chloro-1,2-propanediol did not elicit any increase in the net number of nuclear grains indicative of

unscheduled DNA synthesis, while the positive controls, 2-acetylaminofluorene and dimethylnitrosamine, were clearly active (Robjohns et al., 2003).

### *2.2.4 Reproductive toxicity*

#### *Rats*

To study mechanisms of antifertility in male rats, groups of 15 male Sprague-Dawley rats aged 8 weeks were given 3-chloro-1,2-propanediol daily by intragastric instillation at a dose of 0, 0.01, 0.05, 0.25, 1 or 5 mg/kg bw per day for 28 days. At the end of the treatment period, male rats were mated overnight with untreated females. Males successfully inducing pregnancy were sacrificed to assess sperm parameters, histopathology of reproductive organs, and spermatogenesis. The pregnant females were sacrificed on day 20 of gestation to evaluate pregnancy outcome. The paternal administration of 3-chloro-1,2-propanediol did not affect body or reproductive-organ weights. The highest dose produced adverse effects on male fertility and pregnancy outcome without inducing histopathological changes in the testes and epididymides of animals that successfully impregnated females. At doses of 0.25 mg/kg bw per day and greater, sperm counts were decreased. The authors applied statistical analysis to the numbers of motile sperm and reported statistically significantly reduced sperm motility at doses of 0.25 mg/kg bw and greater. However, no statistical analysis was performed on the appropriate measure, i.e. motile sperm as percentage of total sperm. There were also errors in the reported percentages of motile sperm; recalculation of percentages yielded the following values: 83%, 80%, 85%, 73%, 73%, and 72% for the control group, and the groups at 0.05, 0.25, 1, and 5 mg/kg bw per day, respectively. There was no apparent effect on the percentage of motile sperm at any dose. The copulation index was unaffected by treatment, while the fertility index was markedly reduced at the highest dose, 14.3% vs 100% in controls. At the highest dose, reductions occurred in the numbers of corpora lutea (10.5 vs 19.8 in controls), total implants (10.5 vs 15.9 in controls) and total live fetuses (1.0 vs 14.5 in controls). 3-Chloro-1,2-propanediol did not affect concentrations of testosterone or luteinizing hormone in the blood of male rats. The NOEL for effects on male fertility and on pregnancy outcome was 1 mg/kg bw per day (Kwack et al., 2004).

Groups of six rats aged 8 weeks were given intraperitoneal doses of 3-chloro-1,2-propanediol at 10 or 100 mg/kg bw, and testes and epididymides were examined 3, 6, 12, and 24 h later. In the testes of animals treated with 3-chloro-1,2-propanediol at a dose of 100 mg/kg bw, apoptosis was not detected by DNA laddering, deoxynucleotidyl transferase-mediated dUTP-biotin nick end-labelling (TUNEL) staining, or caspase-7 protein expression. The level of $H^+$-ATPase as assessed immunohistochemically in the cauda epididymis was reduced. These results indicate that 3-chloro-1,2-propanediol had a spermatotoxic effect, which was mediated by reduced $H^+$-ATPase expression in the cauda epididymis. Reduced $H^+$-ATPase activity is predicted to produce an altered pH in the cauda epididymis, which might lead to a disruption of sperm maturation and motility (Kwack et al., 2004).

To study testicular organogenesis, groups of pregnant rats were given 3-chloro-1,2-propanediol as intragastric doses at 0, 5, 10 or 25 mg/kg bw per day from days 11 to 18 of gestation. On day 19 of gestation, the testes were removed

from fetuses for histological examination, measurement of testosterone production and expression of eight testicular genes was assessed by reverse transcription-polymerase chain reaction (RT-PCR). 3-Chloro-1,2-propanediol and its main metabolite, β-chlorolactic acid, were detected in maternal plasma and in fetal tissues at 0.5–3.0 h after dosing. The mean body-weight gains of pregnant rats treated with 3-chloro-1,2-propanediol at 10 and 25 mg/kg bw were decreased. Testes of exposed fetuses exhibited normal histology and produced testosterone at levels that were similar to controls. In addition, 3-chloro-1,2-propanediol did not alter gene expression in the fetal testes. Thus, 3-chloro-1,2-propanediol had a minimal effect on rat testicular organogenesis (El Ramy et al., 2006).

### *2.3 Observations in humans*

No new information was available.

## *3. ANALYTICAL METHODS*

### *3.1 Chemistry*

3-chloro-1,2-propanediol (CAS Registry No. 96-24-2) is a colourless, slightly oily liquid with a faint and pleasant odour. 3-Chloro-1,2-propanediol boils at 213 °C at atmospheric pressure, does not distill with water vapour, has a density of 1.3204 g/cm$^3$ (20 °C), and is readily soluble in water and ethanol. 3-Chloro-1,2-propanediol is relatively unstable in aqueous alkaline media and are decomposed to glycerol via the intermediate epoxyde glycidiol according to a reaction commonly used to reduce the levels of 3-chloro-1,2-propanediol in commercial hydrolysed vegetable protein (HVP) (Hamlet et al., 2002).

### *3.2 Description of analytical methods*

The application of mass spectrometric detection in recent years has increased sensitivity of analysis. A validated gas chromatography-mass spectrometry (GC/MS) method capable of measuring 3-chloro-1,2-propanediol in food and food ingredients at concentrations as low as 0.010 mg/kg is available and has been accepted as a first action status method by the Association of Official Analytical Chemists (AOAC) (Method No. 2000.01) (Brereton et al., 2001). Results shown that the method is satisfactory when used by analysts not specialized in the determination of 3-chloro-1,2-propanediol and that the method can also be applied to a wide range of foods and ingredients.

The Central Science Laboratory (CSL) of the UK Government Department for Environment Food and Rural Affairs (Crews et al., 2002) and the United States Food and Drug Administration (FDA) (Nyman et al., 2003a) have developed a fully in-house validation method to allow both extraction and analysis of 3-chloro-1,2-propanediol and 1,3-dichloropropanol in the same GC/MS run.

In a paper published in 2006, the Chinese authors also proposed a methodology that allows the simultaneous separation and determination of chloropropanols (1,3-dichloropropanol, 2,3-dichloropropanol, 3-monochloro-

propane-1,2-diol and 2-monochloro-1,2-propanediol) in soy sauce and other flavouring, using GC/MS in negative chemical and electron-impact ionization modes, at concentrations of around 0.6 µg/kg (Xiamin Xu et al., 2006).

## 4. LEVELS AND PATTERNS OF CONTAMINATION OF FOOD COMMODITIES

### 4.1 Surveillance data

Acid-HVPs are widely used in seasonings and as ingredients in processed savoury food products. They are used to flavour a variety of foods, including many processed and prepared foods such as sauces, soups, snacks, gravy mixes, bouillon cubes, etc. As a result of these uses, 3-chloro-1,2-propanediol has been identified in many foods and food ingredients, most notably in acid-HVP and soy sauces (Codex Commission on Food Additives and Contaminants, 2006)

Recent studies have demonstrated that 3-chloro-1,2-propanediol may also be formed in other processed foods, particularly in meat products (salami and beef burgers), dairy products (processed cheese and cheese alternatives), a range of cereal products subjected to heat treatments such as baking, roasting or toasting (toasted biscuits, doughnuts, malt and malt extract) and some other foods. It seems evident that chloropropanediols and possibly also dichloropropanols in these foods are formed from chlorides and naturally and/or intentionally added lipids (Food Standards Agency, 2005a).

Fatty acid esters of monochloropropanols have recently been identified in a range of processed and unprocessed foods (Svejkovska et al., 2004). To date, only a limited number of analyses have been reported, but the amount of esterified 3-chloro-1,2-propanediol in many of the samples is higher than the amount of free (non-esterified) monochloropropanol in the same samples. The significance of the presence of esterified 3-chloro-1,2-propanediol in food has yet to be determined.

### 4.2 National occurrence of 3-chloro-1,2-propanediol

Data on the occurrence of 3-chloro-1,2-propanediol in food were provided by 14 countries: member states of the European Union (European Union, 2004) (Austria, Denmark, Finland, France, Germany, Ireland, the Netherlands, Norway, Sweden, the United Kingdom (UK) (Food Standards Agency, 2005b), Australia (FSANZ, 2003), Hong Kong Special Administrative Region of China (SAR) (Food and Environmental Hygiene Department, 2005), Japan (Ministry of Agriculture, Forestry and Fisheries of Japan , 2005 and 2006), Thailand (Ministry of Agriculture and Cooperatives of Thailand, 2006) and by the International Hydrolyzed Protein Council (IPHC; International Hydrolyzed Protein Council, 2005). Data on soy sauces and related products were also available for the United States of America (USA) from the literature (Nyman et al., 2003b).

Since the fifty-seventh meeting of the Committee in 2002 (Annex 1, reference 154) at which only soy sauces and related products were evaluated, more occurrence data have been collected on 3-chloro-1,2-propanediol in heat processed foods like bread and bakery waves, malt, batter, meat and fish products.

Table 1 summarizes the distribution-weighted concentration of 3-chloro-1,2-propanediol in soy sauce and soy sauce-based products, in other foods and in food ingredients from various countries, between 2001 to 2006.

### *4.2.1 Soy sauce and soy sauce-based products*

#### *(a) Australia*

Australia submitted occurrence data for 39 individual samples of different soy and oyster sauces based on food surveys conducted in 2001 and 2002 (FSANZ, 2003). Selected soy and oyster sauces and a range of other foods available at Australian retail outlets were sampled. The method used for the quantitative analysis of 3-chloro-1,2-propanediol was based on AOAC Method No. 2000.01. The limit of quantification (LOQ) for 3-chloro-1,2-propanediol was 0.01 mg/kg. The majority of soy and oyster sauces did not contain 3-chloro-1,2-propanediol at detectable concentrations. A small number of samples contained high concentrations of 3-chloro-1,2-propanediol.

- The average was calculated by assigning a value of half the reporting limits to the 44% of samples for which the reported value was less than the limit.
- The highest average concentration was reported for soy seasoning sauce product, with a maximum at 74.3 mg/kg. For the other sauces, the reported average concentration is 0.16 mg/kg.

#### *(b) Hong Kong SAR*

Hong Kong submitted occurrence data for 3-chloro-1,2-propanediol in aggregate samples of different soy sauce and sauce-based products, using the Global Environment Monitoring System—Food Contamination Monitoring and Assessment Programme (GEMS/Food) reporting format. Sampling was performed in 2003 and included the analytical results for 84 samples. Based on the very low level of the limit of detection (LOD) and LOQ, respectively 2.5 and 7.5 µg/kg, analysis was carried out using GC/MS. No indicator of analytical quality assurance was described in the submitted data (Food and Environmental Hygiene Department, 2005).

- The average was calculated by assigning a value of half the reporting limit to the 84% of samples for which the reported value was less than the limit
- A higher average concentration of 3-chloro-1,2-propanediol is reported for concentrated sauce (105 µg/kg) and concentrated soup (14.6 µg/kg). Other averages reported for sauce-based products are between about 2.5 and 5.0 µg/kg.

#### *(c) European Union*

Individual data on 3-chloro-1,2-propanediol were submitted for 10 countries of the European community—Austria, Denmark, Finland, France, Germany, Ireland, the Netherlands, Norway, Sweden and the UK—from the reports on Tasks for Scientific Cooperation on levels of 3-chloro-1,2-propanediol and related substances in foodstuffs (European Union, 2004). The Joint Research Centre of the European

Commission assisted in the task by providing advice on analytical methodology. Participants agreed that only occurrence data obtained after 1997 until the year before the publication of the report in 2004 should be submitted as there was concern about the robustness of data acquired prior to that date. Some occurrence data provided by participants were from targeted sampling of products suspected to contain chloropropanols at high concentrations.

Results of analysis of 3-chloro-1,2-propanediol in over 2035 samples of soy sauce and soy sauce-based products were provided by all 10 member states of the European Union : Austria ($n$ = 316), Denmark ($n$ = 43), Finland ($n$ = 163), France ($n$ = 73), Germany ($n$ = 692), Ireland ($n$ = 178), the Netherlands ($n$ = 273), Norway ($n$ = 51), Sweden ($n$ = 76) and UK ($n$ = 170). The LOQ for soy sauce and soy sauce-based products was mainly between 0.006 mg/kg and 1 mg/kg (98%). A few results (less than 2%) were provided with a LOQ of 2.5 or 5 mg/kg.

- The average was calculated by assigning a value of half the reporting limit to the 65% of samples for which the reported value was less than the limit.
- The weighted average for the group was reported to be 9.16 mg/kg. The highest average concentration of 3-chloro-1,2-propanediol was reported for seasoning sauce (40.9 mg/kg), mushroom soy sauce and light soy sauce (15.5 mg/kg), soy sauce (7.8 mg/kg), dark soy sauce (5.3 mg/kg) and teriyaki sauce (3.4 mg/kg). Others averages reported for sauce-based products were less than 1 mg/kg. The distribution of contamination in products differs according to the country of origin. Products from China (not including Hong Kong), Thailand and Viet Nam had the highest mean concentrations of 3-chloro-1,2-propanediol, with respectively 51%, 61% and 95% of samples with quantifiable levels containing 3-chloro-1,2-propanediol at greater than 10 mg/kg.

*(d) Japan*

Japan submitted occurrence data on the levels of 3-chloro-1,2-propanediol in aggregate and individual samples of acid-HVP containing soy sauce, using the GEMS/Food reporting format. Sampling was performed in 2005–2006 and included analysis results for 3-chloro-1,2-propanediol in 200 samples of soy sauce made with acid-HVP and in 104 samples of soy sauce made by traditional fermentation. The method used for analysis of 3-chloro-1,2-propanediol had been validated in-house using GC/MS. The analytical method has been published published in a paper cited in MAFF (2005 and 2006).[2] The LOD and LOQ were 0.002 mg/kg and 0.004 mg/kg, respectively.

Eighty-nine percent of analytical results from samples of soy sauce made by traditional fermentation are below the LOQ versus (vs) 0.6% of results for samples of soy sauces made with acid-HVP. The highest concentration reported was 33 mg/kg for soy sauces made with acid-HVP and 0.008 mg/kg for soy sauce made by traditional fermentation. The average concentration of 3-chloro-1,2-propanediol was 1.8 mg/kg for soy sauces made with acid-HVP and 0.003 mg/kg for soy sauce made by traditional fermentation.

[2] *Journal of Food Hygienic Society of Japan* 1995, 36(3):360–364.

*(e) International Hydrolyzed Protein Council (IHPC)*

Data based on the annual surveys in 2004 were submitted by IHPC for consideration by the Committee at its present meeting. In all, 26 commercial samples of soy sauce made with acid-HVP were analysed for 3-chloro-1,2-propanediol content by at least two different laboratories. No information on the sampling protocol or analytical methods used was provided, nor were indicators of analytical quality assurance described in the report submitted to JECFA. Differences in the analytical sensitivites between laboratories were between 0.01 and 0.065 mg/kg.

Eighty-nine percent of analytical results from soy sauce were below the LOQ. The highest concentration reported was 4 mg/kg. The average concentration of 3-chloro-1,2-propanediol was 0.18 mg/kg.

*(f) Thailand*

- Thailand submitted occurrence data on the concentrations of 3-chloro-1,2-propanediol in seasoning soy sauces from aggregate samples (212 samples, of which 190 were collected from household surveys and 23 from market surveys) and other foods (56 samples, of which 24 were collected from household surveys and 32 from market surveys) (Ministry of Agriculture and Cooperatives of Thailand, 2006). The method used for quantitative analysis of 3-chloro-1,2-propanediol was based on AOAC Method No. 2000.01. The LOD and LOQ for 3-chloro-1,2-propanediol were 0.001 mg/kg and 0.010 mg/kg respectively. No information was available on the number of samples in which 3-chloro-1,2-propanediol was present at less than the LOQ, nor on how censored data had been treated in the calculation of the average content of 3-chloro-1,2-propanediol in different seasoning products.
- 3-chloro-1,2-propanediol was quantified only in seasoning products from household surveys. The average concentration of 3-chloro-1,2-propanediol in seasoning sauce (acid-HVP) (30 samples) was reported to be 0.454 mg/kg and the highest concentration was 5.12 mg/kg. The average concentration of 3-chloro-1,2-propanediol in fermented soya bean (35 samples) was reported to be 0.087 mg/kg and the highest concentration was 2.64 mg/kg. The average content of 3-chloro-1,2-propanediol in soup powder (seven samples) was reported to be 0.032 mg/kg and the highest concentration was 0.085 mg/kg. The average content of 3-chloro-1,2-propanediol in local dark sauce (38 samples) was reported to be 0.010 mg/kg and the highest concentration was 0.043 mg/kg.
- Average concentrations reported for other seasoning products and other foods were less than 0.01 mg/kg.
- The weighted average for the soy sauce group has been calculated to be 0.09 mg/kg.

*(g) USA*

Occurrence data for individual samples of 55 different soy sauce and sauce-based products purchased from retail outlets in metropolitan areas in 2002 had been published by the FDA (Nyman et al., 2003a). The method used for quantitative analysis of 3-chloro-1,2-propanediol was based on AOAC Method No. 2000.01. An

LOQ of 0.025 mg/kg was established for 3-chloro-1,2-propanediol. Tha authors concluded that all samples that contained 3-chloro-1,2-propanediol at > 1 ppm (I mg/kg) were manufactured in Asia, indicating that at the date of the publication some Asian manufacturers had not made the necessary processing changes to control the formation of chloropropanols in acid-HVPs.

A small number of samples contained 3-chloro-1,2-propanediol at high concentrations (> 6 mg/kg). The highest concentration was reported for a soy sauce, with a maximum concentration of 3-chloro-1,2-propanediol of about 876 mg/kg.

- The average was calculated by assigning a value of half the reporting limit to the 40% of samples for which the reported value was less than the limit
- The average concentration reported for soy sauce and sauce-based products was 44.1 mg/kg.

*4.2.2 Food ingredients*

*(a) European Union*

Results of the analysis of 3-chloro-1,2-propanediol in more than 295 samples of ingredients were available in the European Union report (European Union, 2004). 3-Chloro-1,2-propanediol has been investigated in the following food ingredients: breadcrumbs (6 samples), caramel (5 samples), gelatin (12 samples), HVPs (146 samples), meat extract (16 samples), malts (63 samples), modified starches (9 samples), yeast extract (12 samples) and seasonings (15 samples). Of these samples, 34% contained 3-chloro-1,2-propanediol at a concentration greater than the LOQ set at 0.010–0.020 mg/kg in the following ingredients:

- *HVPs:* results for 146 samples were provided. 3-Chloro-1,2-propanediol was quantified in 39% of samples. The weighted average for this food category was reported to be 0.171 mg/kg.
- *Meat extract:* results for 16 samples were provided. 3-Chloro-1,2-propanediol was quantified in 31% of samples. The weighted average for this food category was reported to be 0.064 mg/kg.
- *Malts:* results for 63 samples were provided. 3-Chloro-1,2-propanediol was quantified in 49% of samples. The weighted average for this food category was reported to be 0.096 mg/kg.
- *Modified starches:* results for nine samples were provided. 3-Chloro-1,2-propanediol was quantified in 22% of samples. The weighted average for this food category was reported to be 0.059 mg/kg.
- *Seasonings:* results for 15 samples were provided. 3-Chloro-1,2-propanediol was quantified in 27% of samples. The weighted average for this food category was reported to be 0.016 mg/kg.

*(b) Japan*

Japan submitted the results of occurrence data in aggregate and individual samples on the concentrations of 3-chloro-1,2-propanediol in acid-HVPs, using the WHO GEMS/Food reporting format. Sampling was performed in 2005–2006 and included results for 3-chloro-1,2-propanediol in acid-HVPs in 148 samples from

well-controlled production processes and 49 from other production processes The published method used for the analysis of 3-chloro-1,2-propanediol had been validated in-house using GC/MS (cited in MAFF, 2005, 2006).[3] The LOD and LOQ were 0.002 mg/kg and 0.004 mg/kg, respectively.

- All the results for 3-chloro-1,2-propanediol in acid-HVPs from well-controlled production processes or from other production processes were less than the LOQ. The highest concentration reported was 44 mg/kg for acid-HVPs from other production processes vs 0.14 mg/kg for acid-HVPs from well-controlled production processes. The average concentration of 3-chloro-1,2-propanediol was 6.5 mg/kg for acid-HVP from other production processes vs 0.047 mg/kg for acid-HVPs from well-controlled production processes.

*(c) IHPC*

Data from the last three annual surveys 2000–2002 were submitted by IHPC for consideration by the Committee at its present meeting. In all, 86 commercial samples of acid-HVP had been analysed for 3-chloro-1,2-propanediol content by at least two different laboratories (21 commercial samples in 2000, 38 in 2001 and 22 in 2002). No information on the preparation of the samples or analytical methods used by the laboratories was presented, and there was no indication that analytical quality assurance had been performed, according to the report submitted to the Committee. Differences in analytical sensitivities observed between laboratories were expressed on a dry-substance basis (in 2000 the LOD ranged from 0.01 to 0.2 mg/kg; in 2001, from 0.007 to 0.025 mg/kg; in 2002, from 0.003 to 0.1 mg/kg).

- 9% of analytical results were less than the LOQ. The highest concentration reported was 2.54 mg/kg. The average concentration of 3-chloro-1,2-propanediol was calculated to be 0.103 mg/kg.

### *4.2.3 Other products*

Few countries have reported data on 3-chloro-1,2-propanediol for products other than soy sauce and sauce-based products. Australia and the European Union submitted occurrence data on foods and food groups likely to contain 3-chloro-1,2-propanediol as a result of processing or storage conditions. Analysis of several products included in the diet, such as cereals, meat and meat products, dairy products, fish and seafood products, was reported.

*(a) Australia*

Australia submitted occurrence data for 204 individual samples of different foods based on food surveys conducted in 2001 and 2002 (FSANZ, 2003). Selected foods and a range of foods available at Australian retail outlets were sampled. The method used for quantitative analysis of 3-chloro-1,2-propanediol was similar to that used for soy and oyster sauces and was based on AOAC Method No. 2000.01. The LOD was 0.005 mg/kg and the LOQ was 0.01 mg/kg. Analyses have been done on the following food categories: meat and meat products (99 samples), fish and fish products (29 samples), chicken eggs (8 samples), cereals (37 samples), infant

food (3 samples), infant formulas (3 samples), cheese, cheddar and processed (12 samples), starchy vegetables (3 samples), roasted coffee and cocoa paste (6 samples), vegetable oils and fat (4 samples).

Only 9% of the samples were found to contain 3-chloro-1,2-propanediol in quantities greater than the LOQ.

- *Cereals:* none of the 37 samples were found to contain 3-chloro-1,2-propanediol at a quantifiable level. The weighted average concentration for this food category was reported to be 0.003 mg/kg.
- *Fish and fish products:* 3-chloro-1,2-propanediol was quantified in 17% of samples, and only in fish portion crumbed-over baked (0.037 mg/kg). The weighted average concentration for this food category was reported to be 0.009mg/kg.
- *Meat and meat products,* including poultry and game: 3-chloro-1,2-propanediol was quantified in 26% of samples (mainly in bacon dried, sausage fried, raw or cooked and leg ham) at concentrations between 0.006 and 0.069 mg/kg. The weighted average concentration for this food category was reported to be 0.007 mg/kg.

*(b) European Union*

Results of the analysis of 3-chloro-1,2-propanediol in more than 1637 samples of products other than soy sauce were available in the European Union report (European Union, 2004): Denmark ($n$ = 19), Finland ($n$ = 345), France ($n$ = 146), Germany ($n$ = 71), Ireland ($n$ = 25), Norway ($n$ = 54), Sweden ($n$ = 151) and UK ($n$ = 547). Of the samples, 35% contained 3-chloro-1,2-propanediol at a concentration greater than the LOQ, mainly set at 0.010 mg/kg. The overall weighted average concentration of 3-chloro-1,2-propanediol in all 'others' products analysed by member states was reported to be 0.013 mg/kg.

- *Dairy*: results were submitted for 137 samples, mainly from the UK. 3-Chloro-1,2-propanediol was quantified in 86% of samples, only in cheese, processed cheese and cheese analogue (68 out of 79 samples), at an average concentration of about 0.008–0.012 mg/kg. The weighted average concentration for this food category was reported to be 0.007 mg/kg.
- *Fat and oils, and fat emulsions*: results were provided for 34 samples. 3-Chloro-1,2-propanediol was quantified in 41% of samples, mainly in mixed and/or flavoured products based on fat emulsion product (14 out of 34 samples) at 0.184 mg/kg. The weighted average concentration for this food category was reported to be 0.09 mg/kg.
- *Fruit and vegetables*: results were provided for 37 samples. 3-Chloro-1,2-propanediol was quantified in 62% of samples, mainly in processed vegetables, products made from nuts and seeds (23 out of 37 samples) at 0.068 mg/kg. The weighted average concentration for this food category was reported to be 0.061 mg/kg.
- *Confectionery*: results were provided for 39 samples. 3-Chloro-1,2- propanediol was quantified in 8% of samples, in confectionery products and in sugar-based confectionery (3 out of 39 samples) at 0.007 mg/kg. The weighted average concentration for this food category was reported to be 0.006 mg/kg.

- *Cereals and cereals products*: results were provided for 203 samples. 3-Chloro-1,2-propanediol was quantified in 26% of samples, mainly in products containing flour and starch at 0.010 mg/kg (7 out of 11 samples) and pasta and noodles (94 out of 143 samples) at 0.032 mg/kg. The weighted average concentration for this food category was reported to be 0.024 mg/kg.
- *Bakery wares*: results were provided for 337 samples. 3-Chloro-1,2- propanediol was quantified in more than half of the samples (51%), mainly in crackers (0.030 mg/kg), cake and cookies (0.029 mg/kg), other ordinary bakery products (0.027 mg/kg), bread and rolls and other fine bakery products (0.016 mg/kg), and biscuits (0.013 mg/kg). The weighted average concentration for this food category was reported to be 0.020 mg/kg.
- *Meat and meat products, including poultry and game*: results were provided for 153 samples. 3-Chloro-1,2-propanediol was quantified in 36% of samples, mainly in sausage casings (13.9 mg/kg), processed comminuted meat, poultry and game products non-heat-treated (0.062 mg/kg), processed meat, poultry and game products comminuted or in whole pieces heat-treated or non-heat- treated or frozen (0.012 mg/kg). The weighted average concentration for this food category was reported to be 1.47 mg/kg.
- *Fish and fish products including molluscs, crustaceans and echinoderms (MCE):* results were provided for 60 samples. 3-Chloro-1,2-propanediol was quantified in 25% of samples, mainly in fully preserved fish and fish products, including MCE hot smoked (0.041 mg/kg) and canned (0.017 mg/kg), and in processed fish and fish products, including MCE cooked/or fried (0.010 mg/kg). The weighted average concentration for this food category was reported to be 0.013 mg/kg.
- *Salts, spices, soup sauces, salads, protein products*: results were provided for 454 samples. 3-Chloro-1,2-propanediol was quantified in 45% of samples, mainly in non-emulsified sauce (e.g ketchup, cheese sauce, cream sauce, brown gravy where 2 out of 59 samples were highly contaminated, containing 3-chloro-1,2-propanediol at a concentration of 2.82 mg/kg), in herbs, spices, seasoning and condiments where 75% of samples contained 3-chloro-1,2-propanediol at quantified levels (166 out of 221 samples, 0.259 mg/kg), in protein products (1 out of 7 samples, 0.210 mg/kg), in sauces and like products (0.048 mg/kg), in mixes for sauces and gravies (0.033 mg/kg) and in mixes for soups and broths (0.011 mg/kg). The weighted average concentration for this food category was reported to be 0.286 mg/kg.
- *Foodstuffs intended for particular nutritional uses:* very few samples were analysed but all of them four were quantified. The weighted average concentration for this food category was reported to be 0.030 mg/kg.
- *Beverages excluding dairy products*: results were provided for 131 samples. 3-Chloro-1,2-propanediol was quantified in 7% of samples (9 out of 131), mainly beer and malt beverages, being found at a low concentration (0.006 mg/kg). The weighted average concentration for this food category was reported to be 0.007 mg/kg.

- *Ready-to-eat savouries*: results were provided for 23 samples. 3-Chloro-1,2-propanediol was quantified in 34% of samples, mainly in snacks—potato, cereal, flour or starch-based foods (0.013 mg/kg). The weighted average concentration for this food category was reported to be 0.010 mg/kg.
- *Composite foods*: results were provided for 24 samples. 3-Chloro-1,2-propanediol was quantified in 21% of samples. The weighted average concentration for this food category was reported to be 0.013 mg/kg.

*(c) Thailand*

Occurrence data on the concentrations of 3-chloro-1,2-propanediol found in aggregate samples of other foods (56 samples: 24 collected by household survey and 32 by market survey) (Ministry of Agriculture and Cooperatives of Thailand, 2006) were available. 3-Chloro-1,2-propanediol has only been found at quantified levels in snack food products (5 samples) from household-survey sampling; the average concentration 3-chloro-1,2-propanediol was < 0.010 mg/kg and the highest value was 0.028 mg/kg.

*Summary of occurrence data for 3-chloro-1,2-propanediol*

Data on the occurrence of 3-chloro-1,2-propanediol in food were provided by 14 countries and by IHPC. Data on 3-chloro-1,2-propanediol in soy sauces and related products for an additional country were available from the literature.

The average concentration of 3-chloro-1,2-propanediol present in soy sauce and soy sauce-related products was much higher (8 mg/kg; range, 0.01 to 44.1 mg/kg) than in any other food or food ingredient (< 0.3 mg/kg). Data from Japan show that soy sauce produced by traditional fermentation contains insignificant average amounts of 3-chloro-1,2-propanediol (0.003 mg/kg) compared with soy sauce made with acid-HVP (1.8 mg/kg).

## 5. ESTIMATED DIETARY INTAKE

### 5.1 National assessments of intake from diet

National dietary intake data for 3-chloro-1,2-propanediol were provided for 10 countries (Denmark, Finland, France, Germany, Ireland, the Netherlands, Norway, Sweden, UK, Thailand). These national intakes were calculated by linking data on individual consumption and body weight from national food consumption surveys with mean occurrence data obtained from food contamination surveys.

Consistent with their national food consumption data, all countries except Germany calculated estimates for the adult population and children. Mean occurrence data used in the calculation are those reported in section 4 of this monograph, in which all values classified as being less than the LOQ were assumed to contain 3-chloro-1,2-propanediol at a concentration equal to LOQ/2, except for Thailand where no information was available concerning the treatment of values less than the LOQ. Intake estimates were calculated on a per kilogram of body weight basis. Estimates reported by each country were described according to the

following two variables of intake distribution for mean and high-percentile dietary exposures: average estimates (average food consumption combined with mean occurrence data for food consumed); and the 95th percentile of the intake distribution (P95).

Table 2 summarizes estimates of national dietary intakes of 3-chloro-1,2-propanediol from various food sources, including soy sauce and soy sauce-based products.

*(a) Australia*

Australia submitted the results of an assessment of dietary exposure to chloropropanols (FSANZ, 2003). Intake calculations were made in a deterministic way using the dietary modelling computer program (DIAMOND), multiply mean concentration of chloropropanols in a wide range of foods, including soy and soy sauces, consumed by each individual reported in the 1995 National Nutrition Survey based on a 24 h-recall methodology. To provide a more refined estimate of dietary exposure, concentrations reported to be less than the reporting limits (LOR = 78%) were assigned by a concentration equal to the LOR.

Dietary exposure assessment was conducted using food groupings based on the Codex system of classification for food additives. Foods are classified according to major food types as raw and processed foods, and analytical concentrations fit easily to these to these food groupings. Calculations are made by assigning values for 3-chloro-1,2-propanediol concentrations to food groups for food eaten “as is”, as well as as used as ingredients in mixed foods. Where a single food from a food group was analysed, the concentration of 3-chloro-1,2- propanediol reported was assigned to the whole group, assuming that like foods would contain 3-chloro-1,2-propanediol at similar concentrations. This is likely to result in an over-estimation of dietary exposures, but assumes a worst-case scenario.

The intake estimates for the whole population aged more than 2 years ranged from an average of 0.20 µg/kg bw per day to 0.65 µg/kg bw per day for consumer sat the 95th percentile. Children aged from 2 to 12 years had exposures ranging from an average of 0.17 µg/kg bw per day to 0.18 µg/kg bw per day for consumers at the 95th percentile. Children aged from 13 to 19 years had exposures ranging from an average of 0.19 µg/kg bw per day to 0.65 µg/kg bw per day for the consumer at the 95th percentile. Adults aged 20 years and greater had exposures ranging from an average of 0.21 µg/kg bw per day to 0.75 µg/kg bw per day for consumers at the 95th percentile.

Major contributors to total exposure were soy and oyster sauce, ranging from 86% for children to 94% for adults

Where estimated exposure was expressed as a percentage of the PMTDI set by the Committee in 2001 (2 µg/kg/bw per day), the estimated dietary exposure to 3-chloro-1,2-propanediol from a wide range of foods, including soy sauce and related products, was far less than the PMTDI for all groups reported, both for mean consumption (< 10%) and for consumers at the 95th percentile (< 40%). Intakes ranged from 8.5% to 9% for children aged 2–12 years, from 9.5% to 33%, for children aged 13–19 years, and from 10% to 38% for adults aged 20 years and greater.

***Table 1. Summary of the distribution-weighted concentration of 3-chloro-1,2-propanediol in soy sauce and soy sauce-based products, in other foods and in food ingredients from various countries, 2001 to 2006***

| Product | Country and date | LOQ (mg/kg) | *N* | *N* < LOQ | Mean[a] (mg/kg) | Maximum (mg/kg) |
|---|---|---|---|---|---|---|
| Soy sauce and soy sauce-based products | EC (Scoop task 3.2.9, 2004) | 0.006–5.000 | 2035 | 1321 | 9.16 | 1779 |
| | Hong Kong SAR, 2003 | 0.0075 | 84 | 71 | 0.01 | 0.2 |
| | USA, 2003 | 0.012 | 55 | 8 | 44.1 | 876 |
| | Australia, 2001–2002 | 0.01 | 39 | 17 | 15.4 | 148 |
| | Japan, 2005–2006 | 0.002 | 200 | 1 | 1.8 | 33 |
| | Thailand, 2004–2005 | 0.01 | 190 | NA | 0.09 | 5 |
| | IHPC, 2004 | 0.01–0.1 | 26 | 15 | 0.18 | 4 |
| | All data | 0.006–5.000 | 2629 | 1433 | 8.39 | 1779 |
| Dairy products (cheeses) | EU, 1997–2002 | 0.01–0.02 | 137 | 126 | 0.007 | 0.095 |
| | Australia, 2001–2002 | 0.005 | 12 | 12 | 0.0025 | 0.0025 |
| | All | 0.005–0.010 | 149 | 138 | 0.007 | 0.095 |
| Fat and oils, and fat emulsions | EU, 1997–2002 | 0.01 | 34 | 20 | 0.09 | 1.5 |
| | Australia, 2001–2002 | 0.005 | 4 | 4 | 0.0025 | 0.0025 |
| | All | 0.005–0.010 | 38 | 24 | 0.081 | 1.5 |
| Nuts and seeds, processed vegetables | EU, 1997–2002 | 0.01 | 37 | 14 | 0.061 | 0.69 |

***Table 1.*** *(contd)*

| Product | Country and date | LOQ (mg/kg) | *N* | *N* < LOQ | Mean[a] (mg/kg) | Maximum (mg/kg) |
|---|---|---|---|---|---|---|
| Cereals and cereal products (flours and starch, pasta and noodles and bakery wares) | EU, 1997–2002 | 0.01–0.02 | 540 | 314 | 0.024 | 0.945 |
| | Australia, 2001–2002 | 0.005 | 37 | 34 | 0.0028 | 0.007 |
| | All | 0.005–0.020 | 577 | 348 | 0.023 | 0.945 |
| Meat and meat products | EU, 1997–2003 | 0.01 | 152 | 97 | 0.041 | 0.41 |
| | Australia, 2001–2002 | 0.005 | 99 | 73 | 0.006 | 0.069 |
| | All | 0.005–0.010 | 251 | 170 | 0.027 | 0.41 |
| Fish products | EU, 1997–2002 | 0.01 | 60 | 45 | 0.013 | 0.191 |
| | Australia, 2001–2002 | 0.005 | 29 | 23 | 0.01 | 0.083 |
| | All | 0.005–0.010 | 89 | 68 | 0.012 | 0.191 |
| Salts, spices, soup sauces, salads, protein products | EU, 1997–2002 | 0.01–2.5 | 454 | 248 | 0.286 | 50.7 |
| Foodstuffs intended for particular nutritional uses | EU, 1997–2002 | 0.01–0.08 | 131 | 122 | 0.007 | 0.02 |
| | Australia, 2001–2002 | 0.005 | 6 | 6 | 0.0025 | 0.0025 |
| | All | 0.005–0.080 | 137 | 128 | 0.007 | 0.02 |
| Ready-to-eat savouries | EU, 1997–2002 | 0.006–0.020 | 23 | 15 | 0.01 | 0.041 |
| Composite food | EU, 1997–2002 | 0.01 | 24 | 19 | 0.013 | 0.113 |

***Table 1.*** *(contd)*

| Product | | Country and date | LOQ (mg/kg) | *N* | *N* < LOQ | Mean[a] (mg/kg) | Maximum (mg/kg) |
|---|---|---|---|---|---|---|---|
| Eggs | | Australia, 2001–2002 | 0.005 | 8 | 8 | 0.0025 | 0.0025 |
| Root and tubers (potato crisps) | | Australia, 2001–2002 | 0.005 | 3 | 3 | 0.0025 | 0.0025 |
| Beverages: | Coffee roasted | EU, 1997–2002 | 0.01 | 20 | 20 | 0.005 | 0.005 |
| | | Australia, 2001–2002 | 0.005 | 3 | 3 | 0.0025 | 0.0025 |
| | | All | 0.005–0.010 | 23 | 23 | 0.005 | 0.005 |
| | Cocoa paste and chocolate products | Australia, 2001–2003 | 0.005 | 3 | 1 | 0.014 | 0.03 |
| | | EU, 1997–2002 | 0.01 | 12 | 12 | 0.005 | 0.005 |
| | | All | 0.005–0.080 | 15 | 13 | 0.007 | 0.005 |
| | Beer and malts beverages | EU, 1997–2002 | 0.01–0.08 | 100 | 92 | 0.008 | 0.017 |
| | | All | 0.005–0.080 | 138 | 128 | 0.008 | 0.03 |
| Confectionery, sugar-based (chewing gum, candy, nougats…) | | EU, 1997–2002 | 0.01 | 27 | 24 | 0.007 | 0.023 |
| Food ingredients | Acid HVPs | IHPC, 2000–2002 | 0.01–0.1 | 81 | 7 | 0.103 | 2.5 |
| | | EU, 1997–2002 | 0.01–1.15 | 146 | 89 | 0.171 | 1.84 |
| | | Japan, 2005–2006 | 0.004 | 148 | 0 | 0.047 | 0.14 |
| | | All | 0.01–1.15 | 375 | 96 | 0.107 | 2.5 |
| | Meat extracts | EU, 1997–2002 | 0.01–0.02 | 16 | 11 | 0.064 | 0.55 |

***Table 1.*** *(contd)*

| Product | Country and date | LOQ (mg/kg) | *N* | *N* < LOQ | Mean[a] (mg/kg) | Maximum (mg/kg) |
|---|---|---|---|---|---|---|
| Malts | EU, 1997–2002 | 0.01 | 63 | 32 | 0.096 | 0.85 |
| Modified starches | EU, 1997–2002 | 0.01 | 9 | 7 | 0.059 | 0.49 |
| Seasonings | EU, 1997–2002 | 0.02 | 15 | 11 | 0.016 | 0.06 |
| Others | EU, 1997–2002 | 0.01 | 11 | 9 | 0.008 | 0.025 |
| | All | 0.01–1.15 | 489 | 262 | 0.099 | 2.5 |

EU: European Union; IHPC: International Hydrolyzed Protein Council; LOQ: limit of quantification; NA: not available; SAR: Special Administrative Region of China.

[a] Data below the LOD or LOQ have been assumed to be half of those limits (except for Thailand in soy sauce, where no information was available) and the mean is weighted according to the number of samples per country

*(b) European Union*

Member States provided their own national estimates of dietary intake of 3- chloro-1,2-propanediol in reports on Tasks for Scientific Cooperation on levels of 3-chloro-1,2-propanediol and related substances in foodstuffs (European Union, 2004). As adequate national data were available, participants used their own data to calculate exposure to 3-chloro-1,2-propanediol from soy sauce. However, as adequate national data for other foods were not available, participants used pooled occurrence data to calculate dietary exposure to 3-chloro-1,2-propanediol from all other foods. Eight participants from the European community provided intake data: Denmark, Finland, France, Germany, Ireland, the Netherlands, Sweden and UK. Estimated intakes were described only for 3-chloro-1,2-propanediol in the Scoop task.

The intake estimates for the adult population aged greater than 18 years ranged from an average of 0.16 µg/kg bw per day to 1.38 µg/kg bw per day for consumers at the 95th percentile. Depending on country, children aged 2–14 years had exposures ranging from an average of 0.15 µg/kg bw per day to 2.3 µg/kg bw per day for consumers at the 95th percentile.

Where estimated exposure was expressed as a percentage of the PMTDI, results ranged from 8% to 69% for the adult population, and from 7.5% to 115% for children.

The highest contribution for high-level consumers was from soy sauces and soy sauce-based products, ranging from 5% to 86% of the PMTDI for children and from 1% to 54% of the PMTDI for adults.

*(c) Thailand*

Thailand submitted the results of dietary intake assessments carried out in 2004–2005 (Ministry of Agriculture and Cooperatives of Thailand, 2006). Intake calculations were obtained in a deterministic way by combining mean concentrations of 3-chloro-1,2-propanediol in a wide range of foods, including seasonings, by consumption data collected from different regions of Thailand using a household-seasoning-product disappearance method and a food-frequency method for the consumption of other foods. 1945 individuals in 512 households were surveyed. Per-capita intake per day was derived from the quantity of food available or consumed by the householder, divided by the number of family members. Daily dietary intake was converted to µg/kg bw per day using Thai reference body weights of 57 kg for adults.

The intake estimates for adults aged more than 16 years ranged from an average of 0.02 µg/kg bw per day to 0.06 µg/kg bw per day for consumers at the 95th percentile.

Where estimated exposure was expressed as a percentage of the PMTDI, results for the adult population were less than 5% of the PMTDI set by the Committee in 2001 (2 µg/kg bw per day).

The major contributor to total exposure was seasonings, sauce (acid-HVP) at 74%.

*(d) UK*

The UK submitted dietary intake assessments carried out in 2005 (Food Standards Agency, 2005b). Intake calculations were obtained using mean concentrations of 3-chloro-1,2-propanediol found in a wide range of foods, including compilation of occurrence data from the European Union task report and additional data obtained from Germany, Spain and Finland from activities to monitor 3-chloro-1,2-propanediol. Occurrence data for the products in which HVP may be found and previously not reported in the European Union report as potential sources of exposure, such as casseroles, pizzas and snacks, were therefore identified and incorporated using a recipe database. Consumption data for all foods including the percentage of ingredients in compound foods were derived from the UK National Diet and Nutrition Surveys (NDNS) realized in 1992–1993 for children and from the UK NDNS realized in 2000–2001 for adults aged 19–64 years. Exposure was estimated for consumers only using the UK FSA intake computer program. It was clear in the report that many of these estimations were done with occurrence data that preceded the introduction of European limits for 3-chloro-1,2-propanediol in liquid condiments.

The intake estimates for adults ranged from 0.40 µg/kg bw per day in average to 1.30 µg/kg bw per day for consumers at the 95th percentile. Children aged from 1.5 to 4.5 years had exposures ranging from an average of 0.70 µg/kg bw per day to 2.30 µg/kg bw per day for consumers at the 95th percentile.

Where estimated exposure was expressed as a percentage of the PMTDI, results for adults ranged from 20% to 65% and from 35% to 115% for young children.

The greatest contribution for consumers with a high intake was made by instant noodles for adult s and dark soy sauce for young children.

*Consumption of soy sauce and soy sauce-based products by consumers only from various countries and estimated dietary exposure to 3-chloro-1,2-propanediol*

The percentage of consumers of soy sauce and soy sauce-based products was reported to range from 1.4% to 8% in the adult population and from 1% to 8.7% in children population. Consumption, according to country, ranged from 1 to 30 g/day for the adult population and from 0.6 to 16 g/day in children.

Combining the average levels of contamination for soy sauce produced by traditional fermentation or using acid-HVP (from the Japanese submission) with a figure for daily consumption of soy sauce of 30 g (per-capita consumption for Japan and 95th percentile of consumption from Australia) resulted in dietary exposures of 0.0015 and 0.90 µg/kg bw per day, respectively, assuming a body weight of 60 kg.

*Summary of national intake estimates*

National dietary intake data for 3-chloro-1,2-propanediol were provided for 10 countries (Denmark, Finland, France, Germany, Ireland, the Netherlands, Norway, Sweden, Thailand, UK). These national intakes were calculated by linking data on individual consumption and body weight from national food consumption surveys with mean occurrence data obtained from food contamination surveys.

***Table 2. Estimated dietary intake of 3-chloro-1,2-propanediol from various food sources, including soy sauce and soy sauce-based products***

| Country | Population group | Intake (µg/kg bw per day) | |
|---|---|---|---|
| | | Mean | P95[b] |
| Australia | All (≥ 2 years) | 0.20 | 0.65 |
| | 2–12 years | 0.17 | 0.18 |
| | 13–19 years | 0.19 | 0.65 |
| | ≥ 20 years | 0.21 | 0.75 |
| Denmark | Adult | 0.21 | - |
| Finland | Adult | 0.23 | - |
| France | ≥ 18 years | 0.22 | - |
| | 3–14 years | 0.30 | - |
| Germany[a] | Adult | 0.17 | 0.72 |
| | 4 years | 0.48 | 1.70 |
| | 14 years | 0.15 | 0.53 |
| Ireland | Adult | 0.36 | 0.68 |
| Netherlands | Adult | 0.30 | 1.38 |
| | Children | 0.34 | 1.69 |
| Sweden | Adult | 0.16 | 0.48 |
| Thailand | Whole population | 0.02 | 0.06 |
| United Kingdom[a] | ≥ 18 years | 0.40 | 1.3 |
| | 1.5–4.5 years | 0.70 | 2.3 |

[a] Consumers only; [b]95th percentile: only 5% of consumers had exposures above this level.

The Committee concluded that, based on national estimates from a wide range of foods including soy sauce and soy-sauce related products, an intake of 3-chloro-1,2-propanediol of 0.7 µg/kg bw per day could be taken to represent the average for the general population, and an intake of 2.3 µg/kg bw per day could be taken to represent consumers with a high intake. In these estimates for average to high intake, young children are included.

When the estimated exposures are expressed as a percentage of the current PMTDI, the results at the national level ranged from 1% to 35% for average exposure in the general population. For the consumers at the high percentile (95th), the estimated intakes ranged from 3% to 85% and up to 115% in young children. These estimates are based on concentrations of 3-chloro-1,2- propanediol derived before any intervention to reduce occurrence had been undertaken by government or industry.

### 5.2 International estimates of intake for GEMS/Food Consumption Cluster Diets

The new descriptions of the GEMS/Food Consumption Cluster Diets allow a better refinement of intake assessments for 3-chloro-1,2-propanediol, e.g. information is provided on soy sauce consumed as is and oil of soya bean for other uses, cheese processed, which makes the diets more relevant than those used for the previous evaluation by the Committee.

Data on distribution of contamination from aggregate data on food items taking into account the weighting of samples from submitted and published results have been described according to the 13 GEMS/Food Consumption Cluster Diets (WHO, 2006). Table 1 summarizes the distribution-weighted concentration of 3-chloro-1,2-propanediol in soy sauce and soy sauce-based products, in other foods and in food ingredients from various countries from 2001 to 2006 reported as the best available occurrence data to 3-chloro-1,2-propanediol.

In general, the food items analysed were well characterized and it was possible to match sources, contamination and consumption for the 13 revised GEMS/Food Consumption Cluster Diets. Each weighted mean concentration of 3-chloro-1,2-propanediol was taken into account when quantified values for 3-chloro-1,2-propanediol and 1,3-dichloropropanol were reported for a food category or subcategory (e.g cheeses, soy sauce). These concentrations were multiplied by the total mean consumption of food in the corresponding category or subcategory to derive mean total intakes of 3-chloro-1,2-propanediol from all food sources for each cluster diet. Table 3 summarizes estimates of international dietary intake of 3-chloro-1,2-propanediol from all food sources (in µg/kg bw per day).

The range for international mean intakes of 3-chloro-1,2-propanediol from all sources was estimated to be between 0.28 µg/kg bw per day and 3.41 µg/kg bw per day for the 13 GEMS/Food Consumption Cluster Diets, assuming a body weight of 60 kg.

Where estimated exposure was expressed as a percentage of the PMTDI as proposed by the rules of the CCFAC (Codex Alimentarius Commission, 2005b), results ranged from 14% to 170% for the average in the general population. For three diets—clusters K, L and M—exposure to 3-chloro-1,2-propanediol was greater than the PTMDI.

Soy sauce and oil of soya beans are the main contributors to intake of 3-chloro-1,2-propanediol for each diet, representing between 10% and 161% of the PMTDI. Intakes were estimated to be between 0.20 µg/kg bw per day and 3.22 µg/kg bw per day. Wheat-based products contribute more than 5% of the PMTDI in three diets (B, C and D). Others foods mainly contribute less than 5% of the PTMDI in all of the cluster diets.

***Table 3. Summary of estimates of international dietary intake of 3-chloro-1,2-propanediol from all food sources (in µg/kg bw day) for the 13 GEMS/Food Consumption Cluster Diets***

| Cluster Diet | Food category | | | | | | | | | | | | | | Total from all food sources | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Wheat | | Soya [b] | | Nuts and oilseeds | | Meat[c] | | Animal oils and fats | | Beer [d] | | Other foodse | | | |
| | Intake[a] | % PTMDI | Intake[a] | % PTMDI | Intake[a] | % PTMDI | Intake[a] | % PTMDI | Intake[a] | % PTMDI | Intake[a] | % PTMDI | Intake[a] | % PTMDI | Intake | % PTMDI |
| A | 0.033 | 1.7 | 0.220 | 11 | 0.032 | 1.6 | 0.009 | 0.4 | 0.001 | 0.1 | 0.018 | 0.9 | 0.01 | 0.8 | 0.33 | 16 |
| B | 0.150 | 7.5 | 0.913 | 46 | 0.070 | 3.5 | 0.049 | 2.4 | 0.015 | 0.8 | 0.011 | 0.6 | 0.01 | 0.4 | 1.22 | 61 |
| C | 0.161 | 8.0 | 0.849 | 42 | 0.041 | 2.1 | 0.011 | 0.6 | 0.001 | 0.1 | 0.001 | 0.0 | 0.01 | 0.6 | 1.08 | 54 |
| D | 0.147 | 7.4 | 0.559 | 28 | 0.035 | 1.8 | 0.023 | 1.1 | 0.009 | 0.5 | 0.009 | 0.4 | 0.01 | 0.5 | 0.79 | 39 |
| E | 0.089 | 4.5 | 0.911 | 46 | 0.069 | 3.4 | 0.038 | 1.9 | 0.021 | 1.1 | 0.032 | 1.6 | 0.02 | 0.7 | 1.18 | 59 |
| F | 0.082 | 4.1 | 1.030 | 52 | 0.038 | 1.9 | 0.058 | 2.9 | 0.011 | 0.6 | 0.022 | 1.1 | 0.01 | 0.5 | 1.25 | 63 |
| G | 0.065 | 3.3 | 1.525 | 76 | 0.043 | 2.2 | 0.022 | 1.1 | 0.003 | 0.2 | 0.003 | 0.1 | 0.01 | 0.7 | 1.68 | 84 |
| H | 0.030 | 1.5 | 1.487 | 74 | 0.034 | 1.7 | 0.039 | 2.0 | 0.037 | 1.9 | 0.014 | 0.7 | 0.01 | 0.5 | 1.65 | 83 |
| I | 0.026 | 1.3 | 0.277 | 14 | 0.033 | 1.6 | 0.011 | 0.5 | 0.001 | 0.1 | 0.015 | 0.7 | 0.01 | 0.4 | 0.37 | 19 |
| J | 0.016 | 0.8 | 0.196 | 10 | 0.040 | 2.0 | 0.008 | 0.4 | 0.001 | 0.1 | 0.007 | 0.4 | 0.01 | 0.4 | 0.28 | 14 |
| K | 0.043 | 2.2 | 2.730 | 137 | 0.028 | 1.4 | 0.037 | 1.8 | 0.008 | 0.4 | 0.013 | 0.7 | 0.00 | 0.2 | 2.86 | 143 |

***Table 3.***Contd

| Cluster Diet | Food category | | | | | | | | | | | | | | Total from all food sources | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Wheat | | Soya [b] | | Nuts and oilseeds | | Meat[c] | | Animal oils and fats | | Beer [d] | | Other foodse | | | |
| | Intake[a] | % PTMDI | Intake[a] | % PTMDI | Intake[a] | % PTMDI | Intake[a] | % PTMDI | Intake[a] | % PTMDI | Intake[a] | % PTMDI | Intake[a] | % PTMDI | Intake | % PTMDI |
| L | 0.039 | 2.0 | 3.224 | 161 | 0.100 | 5.0 | 0.025 | 1.3 | 0.006 | 0.3 | 0.011 | 0.6 | 0.01 | 0.5 | 3.41 | 171 |
| M | 0.088 | 4.4 | 3.126 | 156 | 0.037 | 1.8 | 0.070 | 3.5 | 0.033 | 1.6 | 0.035 | 1.8 | 0.01 | 0.5 | 3.40 | 170 |

GEMS/Food: Global Environment Monitoring System-Food Contamination Monitoring and Assessment Programme; PTMDI: provisional maximum tolerable daily intake.

[a] Weighted average concentration as reported in Table 2 for the food category or subcategory considered and food consumption in the new 13 GEMS/Food Consumption Cluster Diets.

[b] Soy sauce and oil of soya beans.

[c] Meat from cattle, pigs and sheep.

[d] From barley, maize, millet and sorghum.

[e] Others foods from all the following food category or subcategory (sugar confectionery, cocoa beans, spices, fish marine and freshwater, and cheeses from raw milk and processed) contributed less than 1% of the PTMDI of 2 µg/kg bw per day.

## 6. COMMENTS

*Toxicological data*

At its present meeting, the Committee evaluated two new short-term studies on the reproductive effects of 3-chloro-1,2-propanediol in rats.

In the first study, effects on fertility and sperm parameters were examined in male rats given 3-chloro-1,2-propanediol by oral gavage at doses ranging from 0.01 to 5 mg/kg bw per day for 28 days. The NOEL for effects on fertility was 1 mg/kg bw per day, in accordance with the results of earlier studies. With respect to the findings on sperm count, the nature of the dose–response relationship was unusual and was not in conformity, quantitatively, with results from earlier studies. The Committee considered that the data on sperm motility did not show any effect of treatment; the proportion of motile sperm in all treated groups was within 10% of the control value. On the basis of these considerations, the Committee concluded that this study should not be used as the pivotal study for risk assessment.

In the second new study it was shown that administration of 3-chloro-1,2-propanediol at doses of up to 25 mg/kg bw per day by gavage to pregnant rats on days 11 to 18 of gestation did not affect testicular organogenesis in the fetuses.

In a new study of neurotoxicity, rats given repeated oral doses of 3-chloro-1,2- propanediol at doses of up to 30 mg/kg bw per day for 11 weeks did not show neuromotor deficits. Previous studies in rats and mice had indicated that high daily doses (mice, 25–100 mg/kg bw; rats, 50–100 mg/kg bw) given intraperitoneally were associated with dose-related lesions of the central nervous system.

*Occurrence*

Acid-HVPs are widely used in seasonings and as ingredients in processed savoury food products. They are used to flavour a variety of foods, including many processed and prepared foods, such as sauces, soups, snacks, gravy mixes, bouillon cubes. As a result of those uses, 3-chloro-1,2-propanediol had been identified in many foods and food ingredients, most notably in acid-HVP and soy sauces.

Recent studies have demonstrated that 3-chloro-1,2-propanediol may also be formed in other processed foods, particularly in meat products (salami and beef burgers), dairy products (processed cheese and cheese alternatives), a range of cereal products subjected to heat treatments such as baking, roasting or toasting (toasted biscuits, doughnuts, malt and malt extract), and some other foods.

Data on the occurrence of 3-chloro-1,2-propanediol in food were provided by 14 countries and by the International Hydrolyzed Protein Council. Data on 3-chloro-1,2-propanediol in soy sauces and related products for an additional country were available from the published literature.

The average concentration of 3-chloro-1,2-propanediol present in soy sauce and soy sauce-related products was much higher (8 mg/kg, with a range of 0.01 to 44.1 mg/kg) than that present in any other food or food ingredient (less than

0.3 mg/kg). Data from Japan showed that soy sauce produced by traditional fermentation contains insignificant average amounts of 3-chloro-1,2-propanediol (0.003 mg/kg) compared with soy sauce made with acid-HVP (1.8 mg/kg).

Fatty acid esters of monochloropropanols have recently been identified in a range of processed and unprocessed foods. To date, only a limited number of analyses have been reported, but the amount of esterified 3-chloro-1,2- propanediol in many of the samples is higher than the amount of free (non- esterified) monochloropropanol in the same samples. The significance of the presence of esterified 3-chloro-1,2-propanediol in food has yet to be determined.

*Dietary exposure assessment*

National dietary intake data for 3-chloro-1,2-propanediol were provided for 10 countries (Denmark, Finland, France, Germany, Ireland, the Netherlands, Norway, Sweden, Thailand, UK). The national intakes were calculated by linking data on individual consumption and body weight from national food consumption surveys with mean occurrence data obtained from food contamination surveys. The estimated average intakes from a wide range of foods, including soy sauce and soy sauce-related products, ranged from 0.02 to 0.7 µg/kg bw per day in the general population. For consumers at a high percentile (95th), including young children, the estimated intakes ranged from 0.06 to 2.3 µg/kg bw per day.

Combining the average contamination levels for soy sauce produced by traditional fermentation or with acid-HVP (from the Japanese submission) with a daily consumption figure of soy sauce of 30 g (per-capita consumption for Japan and 95th percentile of consumption from Australia) resulted in values for dietary exposures of 0.0015 and 0.90 µg/kg bw per day, respectively, assuming a body weight of 60 kg.

## *7. EVALUATION*

As no new pivotal toxicological studies had become available, the Committee retained the previously established PMTDI of 2 µg/kg bw for 3-chloro-1,2- propanediol.

The Committee concluded that, based on national estimates from a wide range of foods, including soy sauce and soy sauce-related products, an intake of 3-chloro-1,2-propanediol of 0.7 µg/kg bw per day could be taken to represent the average for the general population, and that an intake of 2.3 µg/kg bw per day could be taken to represent high consumers. In the intake estimates for average to high intake, young children are also included.

When the estimated exposures are expressed as a percentage of the current PMTDI, the results at the national level ranged from 1% to 35% for average exposure in the general population. For consumers at the high percentile (95th), the estimated intakes ranged from 3% to 85% and up to 115% in young children. The estimates are based on concentrations of 3-chloro-1,2-propanediol derived before any remedial action had been taken by government or industry.

Because the distribution of 3-chloro-1,2-propanediol concentrations in soy sauce contains a number of highly contaminated samples, regular consumption of a certain brand or specific type of product could result in intakes greater than the PMTDI by such consumers. The Committee noted that reduction in the concentration of 3-chloro-1,2-propanediol in soy sauce made with acid-HVP could substantially reduce the intake of this contaminant by certain consumers of this condiment.

*Recommendation*

The Committee noted that it has been reported that fatty acid esters of 3-chloro-1,2-propanediol are present in foods, but there were insufficient data to enable either their intake or toxicological significance to be evaluated. The Committee recommended that studies be undertaken to address this question.

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