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## **Analysis of 3-monochloropropane-1,2-diol (3-MPCD) in the UK diet: 2001 Total Diet Study**

### **Summary**

3-Monochloropropane-1,2-diol (3-MCPD) is one of a group of chemical contaminants known as chloropropanols. It occurs at low levels in many foods and food ingredients as a result of processing or storage conditions.

A survey of the levels of 3-MCPD in samples from the 2001 Total Diet Study, (TDS), has been completed. No 3-MCPD was detected in 14 of the 20 food groups analysed. The highest level of 3-MCPD found at 33 micrograms/kg was group 2 (miscellaneous cereals), followed by group 7 (fish) at 19 micrograms/kg and group 1 (bread) at 11 micrograms/kg. Levels of 3-MCPD of between 4 micrograms/kg and 6 micrograms/kg were found in groups 5 (meat products), 6 (poultry) and 8 (oils and fats).

The results of this survey were used in conjunction with consumption data from the National Diet and Nutrition Survey (NDNS) to conduct dietary exposure intake estimates for UK consumers. For average consumers the dietary intake of 3-MCPD is 0.10 micrograms/kg per bodyweight (bw) per day for adults, 0.18 micrograms/kg bw/day for young people aged 4 to 18 and 0.28 micrograms/kg bw/day for toddlers aged 1.5 to 4.5 years. For high level consumers it is 0.21 micrograms/kg bw/day for adults, 0.38 micrograms/kg bw/day for young people aged 4 to 18 and 0.58 micrograms/kg bw/day for toddlers aged 1.5 to 4.5 years.

These estimates are all well below the Total Dietary Intake (TDI), of 2 micrograms/kg bw/day recommended by the European Union Scientific Committee on Food (SCF), and Joint FAO/WHO Expert Committee on Food Additives (JECFA), and therefore do not pose any cause for concern. The estimated exposure for young people and toddlers is higher

than for adults and this can be accounted for by the greater amount of food that these age groups consume per unit of bodyweight. Consumers are therefore advised that they do not need to change their diet as a result of these findings.

## **Background**

3-Monochloropropane-1,2-diol (3-MCPD) is one of a group of chemical contaminants known as chloropropanols. It occurs at low levels in many foods and food ingredients as a result of processing or storage conditions. 3-MCPD was originally identified as a contaminant of the savoury ingredient acid-hydrolysed vegetable protein (acid-HVP)<sup>1</sup>, which is produced by treating proteins from vegetables, such as soya beans with hydrochloric acid. In acid-HVP, components of fats and oils in the starting materials are chlorinated at high temperature to form chloropropanols. 3-MCPD has now been identified in many other foods and food ingredients, most notably soy sauce<sup>2-8</sup>. 3-MCPD is also formed during the heating of cereal grains for the production of bread and other cereal products. In this process glycerol is reported to be a major precursor of 3-MCPD<sup>9</sup>.

In 2001, SCF set a TDI for 3-MCPD of 2 micrograms/kg bw<sup>10</sup>. This is the amount of 3-MCPD, expressed on a bodyweight basis, which can be consumed daily over a lifetime without appreciable harm to health. JECFA also recommended a provisional maximum tolerable daily intake (PMTDI) of 2 micrograms/kg bw<sup>11</sup>. Commission regulation (EC) No 466/2001 came into force on 5 April 2002<sup>12</sup>. This set a regulatory limit of 0.02 mg/kg for 3-MCPD in soy sauce and acid-HVP based on 40 per cent dry matter content corresponding to 0.05 mg/kg in the dry product.

Previous work on 3-MCPD has focused on its presence in specific foods and food groups, in particular soy sauce<sup>2-8</sup>. The surveys of soy sauce and related products carried out by the Food Standards Agency have shown a marked reduction in the number of samples contaminated with 3-MCPD at levels above the 0.02 mg/kg limit. From 25 soy sauce samples being at or above 0.02 mg/kg in 2000, this decreased to 6 samples being at or above this level in 2002.

In February 2001 the Agency published the results of two surveys of 3-MCPD levels in food ingredients and selected food groups. Full details of these surveys can be found on

our website<sup>4-5</sup>. <http://www.food.gov.uk/science/surveillance/fsis-2001/3-mcpding>,  
<http://www.food.gov.uk/science/surveillance/fsis-2001/3-mcpdset>

The EU Scientific Co-operation (SCOOP) task 3.2.9, which collated chloropropanol occurrence data and intake estimates from a number of EU countries, was completed in June 2004. It also identified categories of products most likely to contain 3-MCPD. It showed chloropropanols concentrations were found to be at their highest in soy sauce and soy sauce related products than in any other food or ingredient group. Dietary exposure estimates for 3-MCPD were all below the limit of 2 micrograms/kg bw/day for all consumers, except children who consumed a high level soy sauce, where intakes may have been at the TDI or exceed it<sup>13</sup>.

A Food Standards Agency research project considering the factors that influence the formation of 3-MCPD in foods has recently been completed. The results of this project could be used to inform the food industry of measures to be taken to further reduce levels of 3-MCPD.

This survey aimed to provide information on the total amount of 3-MCPD in the UK diet as a whole. This enabled the dietary exposure of 3-MCPD for the UK population to be estimated, as well as helping to inform future discussions in the EU and Codex Committee on Food Additives and Contaminants (CCFAC).

## **Methodology**

### Samples

The Total Diet Study is a continuous market basket-type survey in which foods representing the average UK diet are purchased, prepared and combined into groups of similar foods for analysis<sup>14</sup>. The types and quantities of food sampled are based on analysis of food consumption recorded in the DEFRA Expenditure and Food Survey<sup>15</sup> and from trade statistics. The quantities of food are updated annually to reflect changing eating habits in the UK. The TDS has been run on a continuous annual basis since the early 1960s and allows the Agency to estimate the population's average exposure to chemical contaminants as well as intakes of some nutrients. A breakdown of the foods included in each of the groups is given in Annex 1.

Every year British Market Research Bureau (BMRB) International selects 24 different towns throughout the UK from which the food samples are to be bought. Every two weeks instructions and equipment are despatched to trained shoppers, who despatch the food to the Institute of Food Research (IFR), Norwich. At IFR the food samples are prepared, and where necessary, cooked according to normal domestic practice. A portion of each food, relative to its contribution to the UK diet, is then combined with similar foods into groups. A homogenous composite sample is then prepared for each group, frozen and stored at – 18°C until required.

### Analysis

Analysis of the 2001 TDS samples for 3-MCPD was conducted by RHM Technology using an UKAS accredited method with a limit of quantification of 0.01 mg/kg<sup>16-18</sup>. Further details of the method together with the quality assurance procedures employed and measurement uncertainty are given in Annex 2.

### Dietary Exposure Estimates

3-MCPD occurrence data from the analysis of 2001 TDS samples was used together with consumption data from the National Diet and Nutrition Survey of adults aged 16 to 64 years<sup>19</sup>, the National Diet and Nutrition Survey of Young People aged 4-18 years<sup>20</sup> and the National Diet and Nutrition Survey of toddlers aged 1.5-4.5 years<sup>21</sup>, to provide dietary exposure estimates.

The estimated mean and high level consumer, (97.5<sup>th</sup> percentile), dietary exposures were estimated for each set of consumption data per food group and for all food groups combined.

## Results

### 3-MCPD levels

Table 1 contains the mean concentrations of 3-MCPD found in each of the 20 food groups. No 3-MCPD was detected in 14 of the 20 food groups analysed. The highest level of 3-MCPD found, 33 micrograms/kg was the miscellaneous cereals food group, followed by the fish group at 19 micrograms/kg and group 1 (bread) at 11 micrograms/kg. Levels of 3-MCPD of between 4 micrograms/kg and 6 micrograms/kg were found in groups 5 (meat products), 6 (poultry) and 8 (oils and fats). Measurement uncertainty and method performance data is given in Table 2.

### Exposure estimates

Table 3 contains the mean and high level consumer estimates of dietary exposure to 3-MCPD for adults, young people (split by age) and children. For mean consumers this is 0.10 micrograms/kg bw/day for adults, 0.18 micrograms/kg bw/day for young people aged 4 to 18 and 0.28 micrograms/kg bw/day for toddlers aged 1.5 to 4.5 years. For high level consumers this is 0.21 micrograms/kg bw/day for adults, 0.38 micrograms/kg bw/day for young people aged 4 to 18 and 0.58 micrograms/kg bw/day for toddlers aged 1.5 to 4.5 years. These exposures are well below the TDI of 2 micrograms/kg bw/day.

## Discussion

The highest level of 3-MCPD was found in the miscellaneous cereals group, which comprises flour, buns, cakes, pastries, sweet & savoury biscuits, breakfast cereals and other cereal products such as rice and pasta. This is consistent with previously reported data identifying cakes and biscuits as foods containing 3-MCPD<sup>4-5</sup>. 3-MCPD found in the bread group is consistent with findings reported elsewhere<sup>4-5</sup>.

Detectable levels of 3-MCPD were found in the fish, meat products, poultry and oils and fats groups. The TDS meat products group consists of fresh bacon/ham (grilled), pre-cooked ham, canned meats, sausages (baked), pies, and other meat products such as burgers (baked). Of these, bacon, salami, beef burgers and sausages, as well as other products, such as flavoured and coated meat products, have all previously been found to contain 3-MCPD.

The poultry group contained levels of 3-MCPD at the limit of quantification for that food group. The group consists of fresh or frozen chicken, other poultry, rabbit (all baked) and ready cooked poultry.

A low level of 3-MCPD was found in the fats and oils group. The formation of 3-MCPD by heating lipid, salt and water was reported from an Agency funded project on 3-MCPD formation<sup>9</sup>. However, the refining process used for the production of edible oils and fats should reduce the concentration of 3-MCPD found in fats and oils. With the exception of one result submitted to the SCOOP task, there is no previous information in the public domain concerning 3-MCPD levels in these products.

Very little is known about the occurrence of 3-MCPD in fish products. Although significant levels of 3-MCPD have been found in canned anchovies and some cured fish<sup>5</sup>, the mechanism of formation is not yet understood. A significant proportion of this group of samples had been cooked at temperatures sufficient to generate 3-MCPD. Fresh white and fatty fish were baked and grilled respectively; cod in batter was fried. The contribution to 3-MCPD levels from heated batter as well as coated and breaded products may be significant.

No 3-MCPD above the limit of quantification was found in the carcass meat, offal, eggs, sugars and preserves, green vegetables, potatoes, other vegetables, canned vegetables, fresh fruit, fruit products, beverages, milk, dairy or nut groups.

The good overall agreement found between the levels of 3-MCPD in the TDS food groups and data on levels in individual foods would suggest that the exposure estimates made for this survey are reliable for the general UK diet. However certain individuals or sub-groups of the UK population may have a greater exposure according to their particular diets, for instance people who regularly consume 3-MCPD containing products. Also, the estimated dietary intake of 3-MCPD by young people and toddlers is higher than for adults. This can be accounted for by the greater amount of food that children consume per unit of bodyweight.

## **Conclusion**

The estimates of dietary exposure to 3-MCPD in the UK diet are all below the TDI of 2-micrograms/kg bw/day recommended by the SCF and JECFA and therefore do not pose any cause for concern. Information generated by this study will be used to inform future discussions in the EU and Codex Alimentarius.

## **Summary of Units**

Microgram ( $\mu\text{g}$ ): one thousandth of a milligram (mg)

Milligram (mg): one thousandth of a gram

Kilogram (kg): one thousand grams

Milligrams per kilogram (mg/kg)

Kilograms bodyweight (kg bw)

Micrograms per kilogram bodyweight per day ( $\mu\text{g}/\text{kg bw}/\text{day}$ )

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The full report of this survey is held in the Elsie Widdowson Library at Aviation House, 125 Kingsway, London WC2B 6NH Tel: +44 (0) 20 7276 8181. If you would like to consult a copy, please contact the Library giving at least 24 hours notice or, alternatively, copies can be obtained from the Library; a charge will be made to cover photocopying and postage.

**Table 1 Mean concentrations of 3-MCPD in the 2001 Total Diet Study samples**

Food group	3-MCPD (µg/kg)	Limit of Quantification
1. Bread	11	2.7
2. Miscellaneous cereals	33	2.7
3. Carcass meat	ND	4.0
4. Offal	ND	4.0
5. Meat products	6	4.0
6. Poultry	4	4.0
7. Fish	19	4.0
8. Oils and fats	6	2.9
9. Eggs	ND	4.3
10. Sugars and preserves	ND	2.6
11. Green vegetables	ND	3.9
12. Potatoes	ND	3.9
13. Other vegetables	ND	3.9
14. Canned vegetables	ND	3.9
15. Fresh fruit	ND	3.9
16. Fruit products	ND	3.9
17. Beverages	ND	1.9
18. Milk	ND	2.9
19. Dairy products	ND	2.9
20. Nuts	ND	2.7

ND = not detected

**Table 2 Measurement uncertainty (MU) and method performance data ( $\mu\text{g kg}^{-1}$ )**

(a) Measurement uncertainty (MU) for the food groups and in-house reference materials (IHRM)

Food group	IHRM	mean	$S_R^a$	n	MU <sup>b</sup>
1, 2	1 (breadcrumb)	21.2	0.82	6	1.6
1-20	2 (soy sauce)	19.7	0.69	12	1.4
1-20 <sup>c</sup>	-	24.5	1.29	10	2.6

<sup>a</sup> in-house standard deviation of reproducibility from separate analyses and analysts<sup>b</sup> expanded uncertainty with a coverage factor (k) of 2<sup>c</sup> samples were spiked with 3-MCPD at  $25.0 \mu\text{g kg}^{-1}$ 

(b) Method performance data for each food group

Sample Groups	Description of classes	IHRM: 1	IHRM: 2	Spike recovery <sup>a</sup>
1, 2	Cereal products	20.9, 20.0, 20.8	18.1	-
3-7	Fish and meat	-	18.1, 17.7	24.4, 26.7
8	Oils and fats	-	17.7	24.6
9	Eggs	-	18.8	23.0
10	Sugars and preserves	-	17.9	24.7
11-14	Vegetables	-	17.9	23.5
15, 16	Fruit and fruit products	-	20	22.7
17, 17A	Beverages	-	18.3	23.8
18, 19	Milk and dairy	-	17.9	26.2
20	Nuts	-	20	24.9

<sup>a</sup> samples were spiked with 3-MCPD at  $25.0 \mu\text{g kg}^{-1}$

**Table 3 Estimated dietary exposure to 3-MCPD from food groups of the 2001 Total Diet study (all food groups combined)**

Dietary Survey	Age Range of data in years	Exposure micrograms/kg bw/day) <sup>1</sup>	
		Mean Consumer <sup>2</sup>	97.5th percentile consumer <sup>2</sup>
Adults	16-64	0.10	0.21
Young People <sup>3</sup>	4-18	0.18	0.38
Young People	15-18	0.12	0.25
Young People	11-14	0.15	0.28
Young People	7-10	0.21	0.40
Young People	4-6	0.26	0.42
Toddlers	1.5-4.5	0.28	0.58

1. Bodyweight consumption is calculated using each participant's own bodyweight.
2. Consumer estimates are based only on those people who ate the food in question.
3. To accommodate the wide range of eating habits of British young people, this group is split into 4 age ranges.

## Annex 1 MCPD analysis

### **Sample preparation.**

All food groups were analysed in duplicate. The procedure of Hamlet (1997, 1998) was modified for the analysis of all samples. The method has been validated by collaborative trial (Brereton *et al.* 2001)<sup>18</sup> and has an in-house limit of detection of  $\leq 3 \mu\text{g kg}^{-1}$ .

3-MCPD was quantified by the stable isotope internal standard method using 3-MCPD-d<sub>5</sub>. The following ions were used for quantification/identification (boldface type denotes the ions used for quantification): ***m/z* 253, *m/z* 275, *m/z* 289, *m/z* 453** (3-MCPD); ***m/z* 257, *m/z* 278, *m/z* 294, *m/z* 456** (3-MCPD-d<sub>5</sub>). The limits of detection (S/N = 3) and quantification (> 2 x limit of detection) were estimated from the response from 3-MCPD-d<sub>5</sub> added to each sample at  $10 \mu\text{g kg}^{-1}$ .

### **Quality assurance**

Samples were analysed in batches ( $\leq 12$  samples) representative of similar food groups. Each batch comprised a procedural blank, a cross-group in-house reference material (IHRM1, soy sauce) and either a spiked food group sample or a cereal in-house reference material. The cross group IHRM (soy sauce) was used to determine any batch specific error. Certified reference materials were not commercially available. The laboratory took part in an international laboratory proficiency-testing scheme for 3-MCPD conducted by the UK Central Science Laboratory (FAPAS) to ensure analytical accuracy and was accredited to ISO 17025 (United Kingdom Accreditation Service).

Accuracy and precision were monitored from the analysis of spiked samples and in-house reference materials. The criteria for acceptance were a range of 90-110 % recovery for spiked samples and > 2 standard deviations (SD) or < 3 SD of the reference values for in-house reference materials.

### **Measurement Uncertainty**

Standard uncertainty for the cereal class (groups 1 and 2) was determined from replicate determinations of IRHM1. Since no reference materials were available for the remaining food groups the standard uncertainty was determined from the spiked recovery data for each food class. The measurement uncertainty for each food group was calculated from the standard uncertainty using a coverage factor of 2 and represents a confidence level of 95 %.