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**The use of a food consumption database with packaging information to estimate exposure to food packaging migrants- expoxidised soya bean oil and styrene monomer.**

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## The use of a food consumption database with packaging information to estimate exposure to food packaging migrants- expoxidised soya bean oil and styrene monomer

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### Abstract

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There is no set protocol for completing refined exposure assessments to food packaging migrants in the EU. One novel method that could be used to provide more realistic exposure assessments and also reduce uncertainty in the exposure estimation could be the use of food consumption surveys that also have packaging information. The aim of the current study was to estimate exposure to two food packaging migrants [expoxidised soya bean oil (ESBO) and styrene monomer] using a food consumption database that collected packaging information. The Irish National Children's Food Survey (NCFS) was completed in 2003-04 and collected information on the type and the amount of food consumed by 594 Irish children aged 5-12 years, in addition to the type of packaging used for these foods. The Irish Food Packaging Database (IFPD) was completed in parallel to this food consumption survey and recorded exact information on the contact layer used for the packaging (Duffy et al. 2006a). In a database that combined information from the NCFS and the IFPD, the packaging materials that could contain the target migrants were identified. If a food was packaged in a material that could contain the migrant, it was assumed that the migrant was present in the food. For the exposure assessment of ESBO the 90<sup>th</sup> percentile migration values of ESBO in foods derived from the literature were used (Castle 1990; EFSA 2006). This was similar to a method as used by the European Food Safety Authority (EFSA) in their exposure assessment of ESBO for adults (EFSA 2006). Two scenarios of styrene exposure were undertaken in this study. In the first scenario the 90<sup>th</sup> percentile migration value for styrene found in foods was used, while in the second scenario the maximum level of styrene found in foods was used. These migration values were derived from the literature (Flanjak and Sharrad 1984; Lickly et al. 1995; Tawfik and Huyghebaert 1998; Bradley and Castle 2003). The mean intake of ESBO for Irish children was 0.023 mg per kg body weight (bw) per day, which is well below the tolerable daily intake (TDI) of 1 mg/kg bw/day set by the

1  
2 Scientific Committee for Food (SCF) (1999). The food group that contributed most to  
3 ESBO intake was tomato sauces packed in glass jars with polyvinyl chloride (PVC) lined  
4 metal lids (46.8%). For styrene, the mean intake was 0.122  $\mu\text{g}/\text{kg}$  bw/day when using the  
5 90<sup>th</sup> percentile migration values and 0.169  $\mu\text{g}/\text{kg}$  bw/day when using the maximum  
6 migration values. These estimated intakes are below the provisional maximum tolerable  
7 daily intake (PMTDI) of 40  $\mu\text{g}/\text{kg}$  bw/day, which was established by the Joint  
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Scientific Committee for Food (SCF) (1999). The food group that contributed most to ESBO intake was tomato sauces packed in glass jars with polyvinyl chloride (PVC) lined metal lids (46.8%). For styrene, the mean intake was 0.122  $\mu\text{g}/\text{kg}$  bw/day when using the 90<sup>th</sup> percentile migration values and 0.169  $\mu\text{g}/\text{kg}$  bw/day when using the maximum migration values. These estimated intakes are below the provisional maximum tolerable daily intake (PMTDI) of 40  $\mu\text{g}/\text{kg}$  bw/day, which was established by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) (World Health Organisation 1984). Therefore, the estimated intakes of the two migrants are not of concern for Irish Children and uncertainty is reduced in the assessment due to the fact that information is available on the type of foods consumed the type of packaging used for these foods.

### Introduction

There are numerous chemicals used in food contact materials, which includes food packaging materials, that have the potential to migrate. These chemicals include monomers and starting substances, catalysts, additives, solvents and suspension media. European Commission Directive 2002/72/EC establishes a 'positive list' of approved monomers and starting substances (European Commission 2002), many of which have restrictions placed on their use (e.g. a specific migration limit (SML), or a maximum permitted quantity of the substance in the finished material or article (QM)). There is also an incomplete list of additives used in the manufacture of food contact plastics contained in European Commission Directive 2002/72/EC and subsequent amendments. It is not a 'positive list', but rather a list of additives approved by the European Commission, Scientific Committee on Food (now the responsibility of the European Food Safety Authority (EFSA)). By the end of 2006, industry has to submit dossiers to EFSA for those plastics additives that have not yet been evaluated at an EU level. After this date the Commission will establish a positive list for plastics additives. EFSA is also responsible for completing exposure assessments in the EU and these assessments are performed on an *ad hoc* basis using available data either provided by a petitioner or obtained from various sources (European Food Safety Authority 2005a). Exposure assessments comprise one part of the risk assessment process (the other parts include hazard identification, hazard characterisation and risk characterisation). Traditionally, exposure assessments were completed using EU assumptions that 1kg of food packaged in the material of interest is consumed per person per day over a lifetime and the substance of interest migrates into the food at the maximum permitted level. There are ongoing efforts to try to refine this traditional exposure assessment methodology.

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3 In recent years there has been a need to complete safety assessments for a number of  
4 chemical migrants from food contact materials and exposure assessments have been part  
5 of these safety assessments. For example, following reports of the presence of 2-  
6 isopropylthioxanthone (ITX) in foods packaged in cartons, the European Commission  
7 requested that EFSA provide scientific advice with respect to possible health risks  
8 associated with this substance by April 2006 (European Food Safety Authority 2005b).  
9 In addition, regarding high levels of epoxidised soybean oil (ESBO) in baby foods,  
10 EFSA released an opinion on the exposure assessment of infants (European Food Safety  
11 Authority 2004) and adults (European Food Safety Authority 2006). Although exposure  
12 assessments feature prominently in the safety assessment of chemical migrants, there is  
13 no set protocol on how to complete these exposure assessments and most methodologies  
14 are determined by the availability of data.  
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26 One data source that can facilitate the exposure assessment of food packaging materials  
27 is the use of a food consumption database that also has packaging information. The Irish  
28 National Children's Food Survey (NCFS) is the first of this type of database (Irish  
29 Universities Nutrition Alliance 2005). In the NCFS information was collected on the  
30 type of food consumed and also on the packaging used for this food (e.g. glass, plastic,  
31 metal etc.). Therefore, when this data is used in the exposure assessment of packaging  
32 migrants in foods it removes the uncertainty regarding the type of food consumed, the  
33 amount of food consumed and the packaging used for this food. Because food  
34 consumption surveys are not designed to analyse the concentration of a particular  
35 migrant in a food, there will still be some uncertainty regarding the presence of the  
36 migrant in the food and the level of the migrant in the food when using this data.  
37 However, this data permits the most accurate exposure assessment to packaging migrants  
38 currently available for Irish children as it reduces the overall uncertainty in the exposure  
39 calculation.  
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52 To demonstrate the use of the NCFS for estimating exposure to food packaging migrants  
53 two sample migrants were chosen on which to complete exposure assessments: (1)  
54 ESBO; and (2) styrene monomer. These sample migrants were chosen because their  
55 presence in foods was previously an issue of safety concern (Ministry for Agriculture,  
56 Food and Fisheries 1999a; European Food Safety Authority 2004, 2006). This use of  
57 food consumption data at an individual level with a fixed value for the concentration of  
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2 the migrant present in the food is an example of a simple distribution approach to  
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4 estimating exposure to a food packaging migrant.  
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### 7 **Epoxidised Soya Bean Oil (ESBO)**

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9 ESBO is an additive used in the manufacture of food packaging. It is used as a plasticiser  
10 as well as a stabiliser for plastic polymers such as polyvinyl chloride (PVC). It is used, in  
11 particular, in closure gaskets for metal lids used to seal glass jars and bottles. It forms an  
12 airtight seal, which is needed to prevent microbial contamination and in jarred baby  
13 foods it can be employed at up to 40% of the formulation weight of the gasket (European  
14 Food Safety Authority 2004). Due to the high levels in gaskets in contact with foods  
15 there is potential for migration into the food, especially fatty food, during both  
16 sterilisation and storage. In the past two years the Scientific Panel on Food Additives,  
17 Flavourings, Processing Aids and Materials in Contact with Food (AFC) of EFSA has  
18 published two opinions on exposure to ESBO from food contact materials (European  
19 Food Safety Authority 2004, 2006). The first opinion examined exposure of infants to  
20 ESBO, while in 2006 the exposure of adults to ESBO was examined. The results of these  
21 opinions suggest that adult exposure does not exceed the tolerable daily intake (TDI) of 1  
22 mg per kilogram body weight per day, whereas infant exposures could exceed the TDI  
23 by 4-5 fold (European Food Safety Authority 2004, 2006). As EFSA provided opinions  
24 on exposure of infants and adults to the food packaging migrant EBSO, one of the aims  
25 of the present study was to estimate exposure of Irish children to ESBO.  
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### 41 **Styrene Monomer**

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43 Styrene is a monomer used to make polystyrene plastics and polystyrene is used to  
44 package dairy products, meats, eggs and takeaway foods (Duffy et al. 2006). In terms of  
45 styrene monomer, exposure occurs via inhalation and dietary intake. Styrene may be  
46 naturally present in food [e.g. cinnamon, beef, and coffee beans (Steele et al. 1994)] or  
47 enter the food via migration from food contact materials. Migration of styrene may occur  
48 because some residual styrene can remain in the finished packaging material. Although  
49 styrene has low acute toxicity after inhalation or ingestion, it is classified as harmful by  
50 inhalation and irritating to skin and eyes. Very high exposure to styrene induces  
51 dizziness, drowsiness, headaches and potentially unconsciousness (Filser et al. 2002). In  
52 1987 the International Agency for Research in Cancer (IARC) classified styrene as  
53 'group 2B' (possibly carcinogenic to humans) and maintained this classification in 1994  
54 (Polystyrene Packaging Council 2005). The use of styrene as a monomer in food contact  
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2 plastics is currently authorised under European Commission Directive 2002/72/EC  
3 without a SML [although an overall migration limit (OML) of 60 mg/kg still applies]  
4 (European Commission 2002).  
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9 In practice the tainting properties of styrene monomer in foodstuffs and the pungent  
10 odour act as a restriction on the level at which styrene is tolerated by the consumer in  
11 most foods (International Life Sciences Institute 2002). An EU risk assessment of  
12 styrene is currently being completed in the UK. However, it may take some years before  
13 this assessment is completed, as it is quite extensive. Previous dietary exposure  
14 assessments have been completed for styrene. For example, in the UK the intake of  
15 styrene was calculated using the UK Total Diet Study (TDS) samples (Ministry for  
16 Agriculture, Food and Fisheries 1999a) and more recently styrene exposure was  
17 estimated using a probabilistic exposure assessment tool, which incorporated  
18 concentration data from the UK TDS (Holmes et al. 2005). The results of these exposure  
19 assessments were orders of magnitude less than the provisional maximum tolerable daily  
20 intake (PMTDI) of 40 µg/kg bw/day set by the Joint FAO/WHO Expert Committee on  
21 Food Additives (JECFA) (World Health Organisation 1984). The aim of the present  
22 study was to estimate exposure of Irish children to styrene.  
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35 Therefore, the overall aim of this study was to estimate exposure to one additive (ESBO)  
36 and one monomer (styrene) from food packaging materials using a food consumption  
37 database that contained food packaging information. As these exposure assessments  
38 were completed on children this study provides novel information regarding exposure in  
39 this sub group of the population who have not been previously studied for their exposure  
40 to these target migrants.  
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## 48 **Materials and methods**

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51 A dataset that was created from information on food consumption data from the NCFS  
52 (Irish Universities Nutrition Alliance 2005), food packaging information from the IFPD  
53 (Duffy et al. 2006) and migration data from the literature (Flanjak and Sharrad 1984;  
54 Castle 1990; Lickly et al. 1995; Tawfik and Huyghebaert 1998; Bradley and Castle 2003;  
55 EFSA 2006) was used to estimate exposure of Irish children aged 5-12 years. This  
56 dataset documented the types and amounts of food consumed by 594 Irish children over  
57 a seven-day period, in addition to the packaging used for these foods.  
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### *Epoxidised Soya Bean Oil (ESBO)*

In the EFSA exposure assessment of ESBO for adults, the main food packaging types identified as potentially contributing to ESBO exposure were glass jars with metal lids lined with PVC gaskets and thin plasticised PVC cling films, in which ESBO is used as a stabiliser (European Food Safety Authority 2006). Foods packaged in these materials were identified in the current database and it was assumed that ESBO was present in these materials and that it migrated into the food (i.e. the probability of presence of ESBO in foods packaged in glass jars with metal lids and PVC cling films was 100%). In their exposure assessment, EFSA did not include non-fatty foods because ESBO has a low solubility in foods with no fat and therefore is not expected to migrate into such foods (EFSA 2006). However, EFSA did not clarify whether foods were classified as fatty according to European Council Directive 85/875/EC (European Council 1985), or on the amount of fat per 100g of food, or some other measurement parameter. Therefore, in the current exposure assessment, all foods that were classified as fatty according to European Council Directive 85/572/EC and packaged in one of the two materials were included in the assessment. In addition, many sauces that were classified as acidic or aqueous and packaged in glass jars with metal lids were also included in the exposure assessment as these foods contained some fat (e.g. curry sauce, tikka masala sauce and tomato based sauces).

As concentration data were not available for all foods packaged in one of the two packaging types (i.e. glass jars with metal lids or PVC cling films), foods were classified into a number of “food packaging groups”. These food packaging groups were designed to reflect the food type and the packaging type used for the food. Table 1 lists these food packaging groups and the migrant concentration data used for each of these groups in the exposure assessment. In the EFSA exposure assessment, the AFC panel noted that due to the variability of the migration value in foods from glass jars with PVC lined lids, a migration value covering 90% of the samples for each category could be used as a conservative estimate of the concentration for estimating chronic exposure of adults to ESBO. Therefore these values covering 90% of samples were also used in the current exposure assessment for children (Table 1). There were few survey data available for the migration of ESBO from PVC films, and therefore, in the EFSA assessment migration values for ESBO in PVC films were extrapolated from work completed on the plasticiser di(2-ethylhexyl)adipate (DEHA) (EFSA 2006). In the current study data on the migration

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2 of ESBO from PVC cling films were used (Castle et al. 1990). From this data, the 90<sup>th</sup>  
3 percentile concentration for each food group was calculated and used in the exposure  
4 assessment to ensure conservative results.  
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9 [Insert table 1 about here]  
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### 11 12 *Styrene monomer*

13 For the styrene exposure assessment, polystyrene was identified as the main source of  
14 styrene monomer. All foods packaged in polystyrene were identified in the database and  
15 it was assumed that if a food was packaged in polystyrene then styrene monomer was  
16 present in the food (i.e. the probability of presence of styrene in these foods was 100%).  
17 The migration concentration of styrene in foods was derived from the literature (Table  
18 2). A number of food groups were developed as the migration of styrene from packaging  
19 differs according to the food type. Two conservative exposure scenarios for styrene were  
20 completed, one in which the 90<sup>th</sup> percentile migration value for each food group was  
21 used and one in which the maximum migration value for each food group was used.  
22 Table 2 lists the food groups that were created, the level of styrene in these groups and  
23 the data sources from which these food groups and concentration values were developed.  
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36 [Insert table 2 about here]  
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39 As some foods consumed in the NCFS did not have their exact packaging information  
40 documented, they were examined and assessed regarding the probability that they may  
41 have been packaged in one of the materials that contained one of the target migrants. The  
42 probability of whether these foods were packaged in a material that could contain the  
43 migrant was based on expert opinion, which erred on the side of conservatism. For  
44 example, sausages that could have been packaged in PVC cling film were assumed to be  
45 packaged in PVC cling film. This was similar for foods that could have been packaged  
46 in polystyrene, for example, for foods such as pot noodles, mousse desserts and fresh  
47 chickens. Once the probability of presence of ESBO and styrene monomer in the foods  
48 and the concentration at which these migrants could be present in the foods was  
49 established then the basic exposure equation was completed:  
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Exposure =  $\sum$  amount of food consumed x amount of chemical present in the food

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This calculation was completed for every eating event of each child in the consumption database. The average daily intake of the migrants for each of the 594 children were calculated. These values were analysed to calculate the overall mean intake and the upper percentile intakes for children. The body weight of each child was also used to calculate intakes per kilogram body weight. Analyses were completed using the CREMe® Software v.2.0.2 (CREMe Software 2006).

## Results

The mean intake of ESBO in Irish children was estimated at 0.687 mg/day with upper percentiles of 2.186 mg/day (95<sup>th</sup> percentile) and 2.733 mg/day (97.5<sup>th</sup> percentile) (Table 3). When actual body weights of children in the survey were incorporated into the equation the estimated mean intake was 0.023 mg/kg bw/day, while the upper percentiles were 0.077 mg/kg bw/day (95<sup>th</sup> percentile) and 0.098 mg/kg bw/day (97.5<sup>th</sup> percentile). Exposure to ESBO from each of the food packaging groups is presented in Table 4. Tomato sauce in glass jars (46.8%) and meat in PVC cling film (35.9%) were the highest contributors to ESBO intake. For some of the food groups, which were used in the EFSA exposure assessment, there were no eating events of these groups in the NCFS (e.g. fish in oil packaged in a glass jar, vegetables packaged in a glass jar, cheese in oil packaged in a glass jar). Therefore, exposure to ESBO from these groups in the current exposure assessment was zero. Figure 1 shows the distribution of ESBO intakes among the 594 children in the NCFS and the cumulative distribution.

[Insert Table 3 about here]

[Insert Table 4 about here]

[Insert Figure 1 about here]

In the first exposure scenario for styrene, the 90<sup>th</sup> percentile migration concentrations were used. In this instance, the estimated mean intake was 3.7 µg/day or 0.12 µg/kg bw/day. The upper percentiles for the intake per kilogram body weight ranged from 0.33 µg/kg bw/day (95<sup>th</sup> percentile) to 0.39 µg/kg bw/day (97.5<sup>th</sup> percentile). When the maximum migration concentrations were used the estimated mean intake of styrene was 5.16 µg/day or 0.17 µg/kg bw/day. The upper percentiles ranged from 14.24 µg/day (95<sup>th</sup>

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2 percentile) to 17.72  $\mu\text{g}/\text{day}$  (97.5<sup>th</sup> percentile) or 0.47  $\mu\text{g}/\text{kg bw}/\text{day}$  (95<sup>th</sup> percentile) to  
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4 0.57  $\mu\text{g}/\text{kg bw}/\text{day}$  (97.5<sup>th</sup> percentile) (Table 5). When styrene intake per food group was  
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6 examined for the scenario that used the maximum migration concentrations, the food  
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8 group that contributed most to styrene intake was the “other styrene group  
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10 (fatty)” (71.6%) (Table 6). This group included all fatty foods (as classified in European  
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12 Council Directive 85/572/EEC) packaged in polystyrene that did not belong to one of the  
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14 other food groups, for example all fresh and processed meats were classified as “other  
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16 styrene group (fatty)”. It should be noted that for some food groups listed in Table 2  
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18 there were no records of these foods packaged in styrene in the NCFS, therefore  
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20 exposure to styrene from these groups was zero (i.e. cheese, ice-cream, juice and other  
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22 simulant B (acidic)). Figure 2 shows a distribution of styrene intakes in the 594 children  
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24 in the NCFS and the cumulative distribution. There are two distributions on this graph,  
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26 one that represents the distribution of intakes when using the 90<sup>th</sup> percentile migration  
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28 concentration values and one that represents the distribution of intakes when using the  
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30 maximum migration concentration values.

31 [Insert Table 5 about here]

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33 [Insert Table 6 about here]

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36 [Insert Figure 2 about here]

## 37 38 39 40 41 **Discussion**

42 The use of a food consumption database, which also contains packaging information, has  
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44 proved very useful in the estimation of exposure to food packaging migrants for a  
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46 number of different scenarios in this study. By using a database that contains this  
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48 information a large amount of the work, currently required in the exposure assessment  
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50 methodology to link food consumption information with packaging information, was  
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52 eliminated. It also eradicated the need to use upper percentile values for the consumption  
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54 level of foods, as individual exposure assessments were completed.

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57 Regarding ESBO, the Scientific Committee for Food (SCF) has classified it in list 2  
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59 (substances for which the committee has established a TDI or a temporary TDI (t-TDI)),  
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where it has a TDI of 1 mg/kg body weight. In the EU there is no SML for ESBO but the  
OML of 60 mg/kg food is applicable. From previous studies it was observed that the

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2 migration from ESBO alone approaches or even exceeds this limit in some samples  
3 (Hammarling et al. 1998; Ministry for Agriculture, Food and Fisheries 1999b; Fantoni  
4 and Simoneau 2003). Although ESBO is neither carcinogenic nor genotoxic the AFC  
5 panel of EFSA recommended that a SML be developed for ESBO in baby foods. They  
6 also decided not to change the TDI for ESBO as there is an inbuilt safety factor of 100-  
7 fold (thereby, an intake that exceeds the TDI by 4- 5 fold does not imply there will be  
8 adverse health effects in infants) (European Food Safety Authority 2004). Due to  
9 differing food consumption patterns throughout life, a significant variation in ESBO  
10 exposure is expected according to life stage. Infants are likely to have the highest  
11 exposures as the highest food intakes on a body weight basis is likely to occur within the  
12 first year of life, and also due to the consumption of commercial infant foods packaged  
13 in glass jars (European Food Safety Authority 2004). It was stated in the EFSA 2004  
14 opinion that adult exposures are likely to be much lower than infant exposures, both due  
15 to the lower contribution from target foods, particularly jarred foods, to their total diet,  
16 and also due to the generally lower levels of ESBO in closures used in packaging adult  
17 foods (European Food Safety Authority 2004). When a conservative exposure  
18 assessment to ESBO on adults was completed the potential high exposure of adults was  
19 estimated at 0.84 mg/kg bw/day (0.64 mg/kg bw/day from glass jars + 0.2 mg/kg bw/day  
20 from cling film) (European Food Safety Authority 2006). Exposure for infants was  
21 calculated at 0.34-4.65 mg/kg bw/day (European Food Safety Authority 2004).

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39 In the current exposure assessment it was estimated that Irish children had lower intakes  
40 of ESBO at 0.023 mg/kg bw/day compared with the EFSA estimated intake for adults  
41 and infants (EFSA 2004, 2006). Similar concentration datasets were used in the EFSA  
42 exposure assessment and the current assessment as the 90<sup>th</sup> percentile concentration  
43 value for the level of ESBO present in foods was used in both studies. However, EFSA  
44 did not use actual consumption data but instead used the 95<sup>th</sup> percentile of food intake  
45 and assumed that these food groups were packaged solely in the material of interest. By  
46 using a food consumption database, which contained precise data on the packaging used  
47 for the food, uncertainty was significantly reduced in the exposure assessment.  
48 Conservatism was still ensured in the current study as food items that did not have their  
49 packaging identified had conservative assumptions made regarding the type of packaging  
50 used for these foods. Therefore, for Irish children exposure to ESBO is not of concern, as  
51 it does not approach the TDI of 1 mg/kg bw/day.  
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2 Two scenarios of styrene exposure were completed in this study. Both scenarios used  
3 conservative migration values (i.e. the 90<sup>th</sup> percentile migration concentration values and  
4 the maximum migration values). From Figure 2 it can be seen that by using the most  
5 conservative values (i.e. maximum migration values) a larger number of individuals have  
6 a higher exposure. This scenario analysis may provide useful information if the aim of  
7 the assessment is to establish the number of individuals exceeding a recommended upper  
8 intake level using different assumptions. From this study the mean styrene intake was  
9 0.12 to 0.17 µg/kg bw/day, which is higher than was found in previous studies. In the  
10 UK total diet study exposure was estimated to range from 0.03 to 0.05 µg/kg bw/day for  
11 a 60kg person (Ministry for Agriculture, Food and Fisheries 1999a). Using the  
12 probabilistic exposure assessment methodology, median adult exposure in the UK  
13 ranged from 0.037 to 0.041 µg/kg bw/day while median youths exposure in the UK was  
14 0.048 µg/kg bw/day (Holmes et al. 2005). In another study, which was based on  
15 literature data, the styrene exposure from food was found to range from 0.003 to 0.0017  
16 µg/kg bw/day for several countries (Tang et al. 2000). In the US the exposure to styrene  
17 from food was estimated at 0.15 µg/kg bw/day (Lickly et al. 1995). From these studies it  
18 can be seen that there is a large variation in estimates of styrene intake. However, the US  
19 estimate is very similar to the estimate found in the current study. The higher exposure  
20 seen in the current study as compared with the UK studies may be due to the fact that  
21 these studies were completed for adults or older children (youths) and therefore on a per  
22 kilogram body weight basis, intakes of children should be expected to be higher.  
23 Although conservatism was built into this exposure assessment, the estimated mean  
24 intake of styrene of 0.12 to 0.17 µg/kg bw/day is still well below the PMTDI of 40 µg/kg  
25 bw/day set by JECFA (World Health Organisation 1984) and therefore styrene intake is  
26 not of concern for Irish children.  
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48 By using the above methodology the exposure assessments for two food packaging  
49 migrants were completed and the results proved that the intakes of these migrants in Irish  
50 children aged 5-12 years are not of safety concern. This data lends itself to efficient use  
51 for multiple exposure scenario analysis, and future exposure assessments can be  
52 completed using this data source once the packaging in which the migrant of concern is  
53 identified and once migration data is available for this migrant.  
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**Table 1 Epoxidised Soya Bean Oil (ESBO) concentrations per food packaging group**

<b>ESBO Food group code</b>	<b>ESBO Food Group Name</b>	<b>Concentration mg/kg P90th</b>	<b>Reference</b>
1	Fatty sauce glass jar and metal lid	30	EFSA 2006
2	Pesto sauce glass jar and metal lid	300	EFSA 2006
3	Tomato sauce glass jar and metal lid	60	EFSA 2006
4*	Fish in oil glass jar and metal lid	350	EFSA 2006
5*	Vegetables in oil glass jar and metal lid	300	EFSA 2006
6*	Cheese in oil glass jar and metal lid	150	EFSA 2006
7*	Other glass jar and metal lid	30	Assumption Castle et al. (1990)
8	Meat PVC cling film	10.8	Castle et al. (1990)
9*	Sandwiches PVC cling film	15	Castle et al. (1990)
10	Cheese PVC cling film	19.4	Castle et al. (1990)
11	Other PVC cling film	22.7	Castle et al. (1990)

\*There were no eating events of these food packaging groups in the Irish National Children's Food Survey. Therefore exposure to ESBO from these groups is zero.

**Table 2** Styrene migration values per food group used in the exposure assessment of styrene

Food group code	Food group	90th percentile concentration (mg/kg)	Max concentration (mg/kg)	References
1	Yoghurt	0.041	0.044	Flanjak and Sharrad (1984); Tawfik and Huyghebaert (1998)
2	Cream	0.018	0.021	Flanjak and Sharrad (1984)
3	Cheese	0.065	0.069	Flanjak and Sharrad (1984); Tawfik and Huyghebaert (1998)
4	Milk pudding, custard and desserts	0.022	0.032	Flanjak and Sharrad (1984); Tawfik and Huyghebaert (1998)
5	Spread and margarine	0.010	0.010	Flanjak and Sharrad (1984)
6	Takeaway foods	0.002	0.002	Bradley and Castle (2003)
7	Ice-cream*	0.023	0.024	Flanjak and Sharrad (1984); Tawfik and Huyghebaert (1998)
8	Juice*	0.005	0.005	Tawfik and Huyghebaert (1998)
9	Other- dry foods	0.000	0.000	
10	Other- simulant A (aqueous)	0.085	0.273	Lickly et al. (1995)
11	Other- simulant B (acidic)*	0.028	0.029	Tawfik and Huyghebaert (1998)
12	Other- simulant D (fatty)	0.147	0.209	Lickly et al. (1995); Tawfik and Huyghebaert (1998)

\* There were no foods from these food groups packaged in polystyrene and consumed in the National Children's Food Survey.

**Table 3** Exposure of Irish children aged 5-12 years to expoxidised soya bean oil (ESBO)

	Daily ESBO exposure (mg/day)	Daily ESBO exposure (mg/kg bw/day)
Mean	0.687	0.023
Std. Deviation	0.404	0.013
Minimum	0.000	0.000
Maximum	8.420	0.385
Percentile: 90th	1.750	0.054
Percentile: 95th	2.186	0.077
Percentile: 97.5th	2.733	0.098
Percentile: 99th	3.444	0.119
Percentile: 99.9th	6.648	0.301

**Table 4** Contribution of food packaging groups to expoxidised soya bean oil (ESBO) intake in Irish children

Food group	ESBO intake (mg/day)		% of total intake
	Mean	Std. Dev	
All	0.687	0.828	100
Fatty sauce glass jar	0.063	0.213	9.2
Pesto sauce glass jar	0.019	0.229	2.7
Tomato sauce glass jar	0.322	0.726	46.8
Meat PVC cling film	0.247	0.226	35.9
Cheese PVC cling film	0.029	0.083	4.2
Other foods PVC cling film	0.007	0.086	1.1

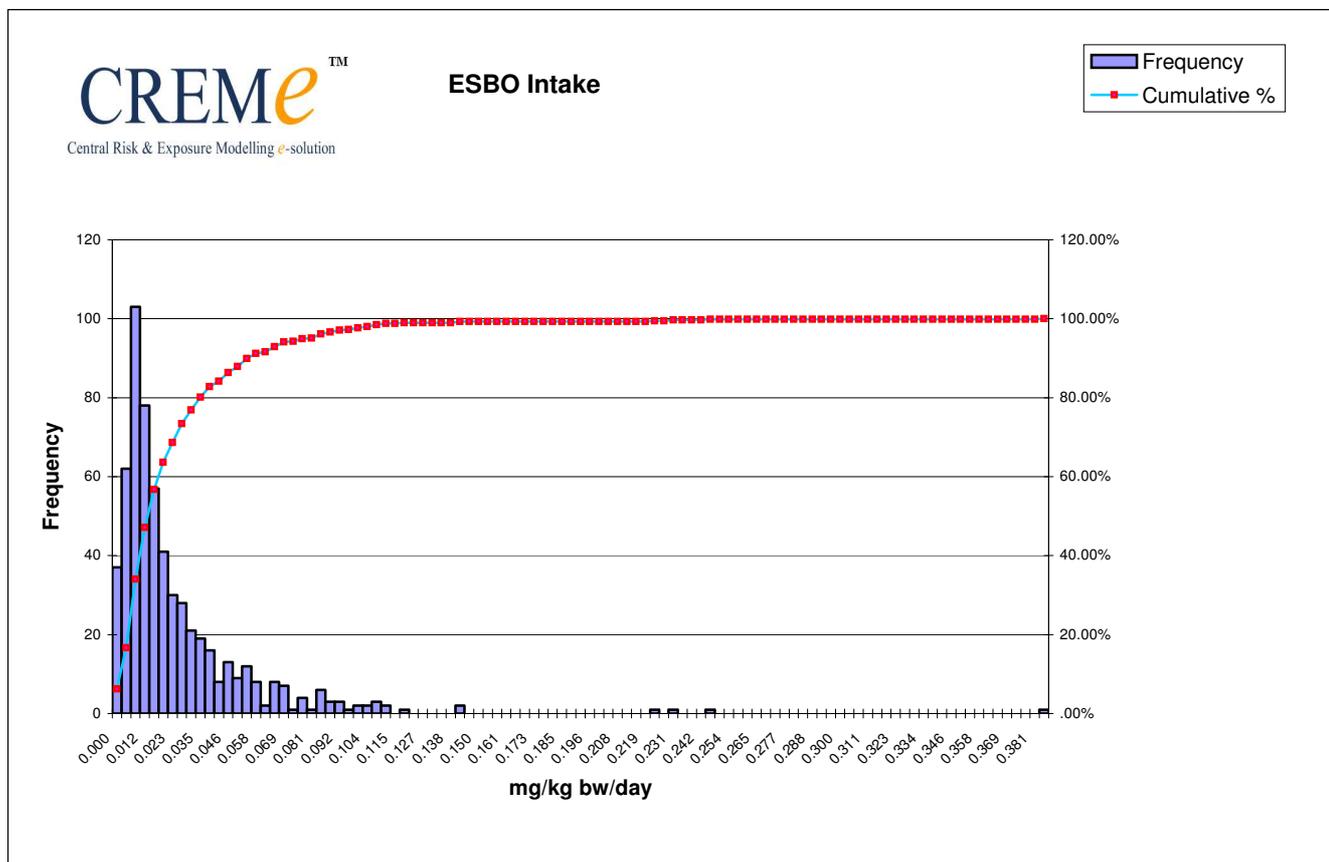
**Table 6** Contribution of food groups to styrene intake in Irish children when using maximum migration values

Food Group	Styrene Intake ( $\mu\text{g}/\text{day}$ )		% of total intake
	Mean	Std. Dev	
All	5.163	4.906	100
Yoghurt	1.033	1.451	20.01
Cream	0.005	0.026	0.10
Milk puddings, custards and desserts	0.022	0.126	0.43
Fat spread and margarine	0.002	0.017	0.04
Takeaway foods	0.001	0.008	0.02
Other styrene group (Aqueous)	0.402	2.792	7.79
Other styrene group (Fatty)	3.698	3.958	71.63

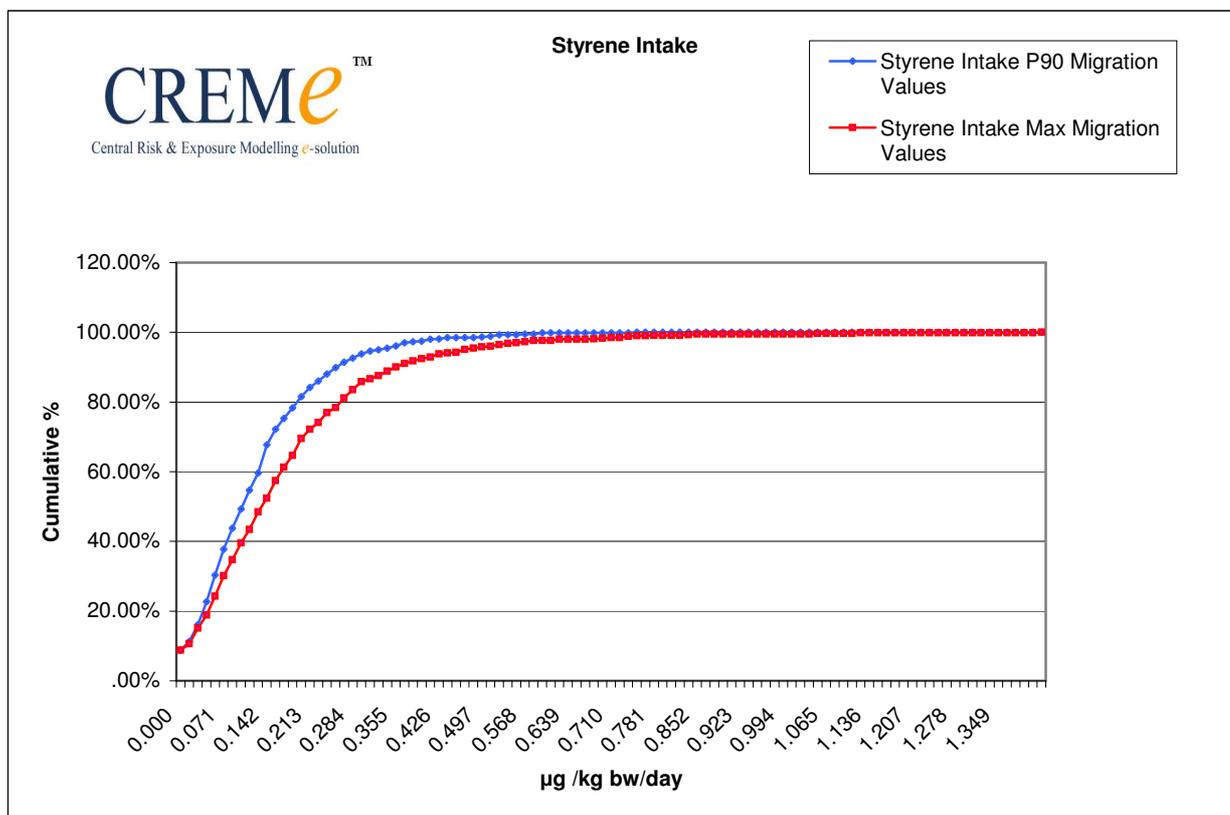
**Table 5** Exposure of Irish children aged 5-12 years to styrene

	90th Percentile migration values		Maximum migration values	
	Styrene exposure ( $\mu\text{g}/\text{day}$ )	Styrene exposure ( $\mu\text{g}/\text{kg bw}/\text{day}$ )	Styrene exposure ( $\mu\text{g}/\text{day}$ )	Styrene exposure ( $\mu\text{g}/\text{kg bw}/\text{day}$ )
Mean	3.707	0.122	5.163	0.169
Std. Deviation	3.128	0.106	4.906	0.163
Minimum	0.000	0.000	0.000	0.000
Maximum	16.900	0.741	43.945	1.422
Percentile: 90th	7.952	0.256	11.200	0.355
Percentile: 95th	9.861	0.327	14.245	0.466
Percentile: 97.5th	11.695	0.391	17.718	0.572
Percentile: 99th	14.953	0.518	22.049	0.747
Percentile: 99.9th	16.750	0.653	36.519	0.858

**Figure 1** Distribution of expoxidised soya bean oil (ESBO) intake among 594 Irish children (mg/ kg bw/day)



**Figure 2** Distribution of styrene intake in 594 Irish children using the 90<sup>th</sup> percentile migration values versus maximum migration values ( $\mu\text{g}/\text{kg bw}/\text{day}$ )



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