Preliminary assessment of PBDE exposure from food in Norway

Helle Knutsen[1], Christina Bergsten[2], Cathrine Thomsen[1], Are Sletta[2], Georg Becher[1], Jan Alexander[2], Helle M Meltzer[1]

[1]Norwegian Institute of Public Health
[2]Norwegian Food Safety Authority

Introduction

PBDEs are present in several kinds of food, and especially high levels have been found in oily seafood. Food is believed to be a major contributor to human exposure, and different dietary habits may to some extent be reflected in the variable levels that have been found in human serum and milk samples. The aim of this study was to estimate the dietary intake of PBDEs in Norway based on food frequency questionnaires and levels of PBDEs in food.

Materials and Methods

The levels of BDE 47, 99, 100, 153, and 154 were measured in 33 food items in 2002-2004. In order to make a complete calculation of intake from all foods, the PBDE levels were estimated in 24 additional food items, based on fat content and level in related food.

In NORKOST 1997, a sample of 2672 persons 16 to 79 years participated. The quantitative food frequency questionnaire was distributed and collected in four different periods spread through the year. The survey captures information about the usual diet during the prior year among the participants[1].

The Norwegian Fish and Game Study, part A, was carried out in November 1999 with nation-wide randomly chosen individuals. 6015 adults answered a food frequency questionnaire, which included 27 questions about the consumption of fish and shellfish during the last year. The findings provided information about fish and game consumption in the general population[2].

Food frequencies were converted into consumption (grams/day) by multiplying with standard portion sizes, and PBDE intake was calculated by multiplying consumption with levels (lower bound) in food.

Results and discussion

The summarized levels of the mean PBDE content in the analysed food items are shown in figure 1A and 1B. The highest levels were found in fish, and especially in halibut, cod liver and cod liver oil.

The estimated intake of PBDEs based on the survey NORKOST 1997 was 48.6 ng/day (median, table 1), of which 29.4 ng/day (60%) came from seafood. One of the weaknesses regarding the survey NORKOST 1997 is that the questionnaire only includes four questions regarding fish consumption ("How often do you eat oily fish, lean/semi-oily fish, freshwater fish and shellfish?"). Thus, the data do not give detailed information about the consumption of specific fish species. Therefore, a second calculation was made based on data from the Norwegian Fish and Game Study, part A. The median intake of PBDEs from fish and shellfish in this study was 55 ng/day. When the intake based on the NORKOST 1997 survey, excluding fish, was combined with the fish-intake from the Fish and game study, the estimated median intake of PBDE was 74.2 ng/day, and 170.5 ng/day for the high consumers (95th percentile) (table 1).

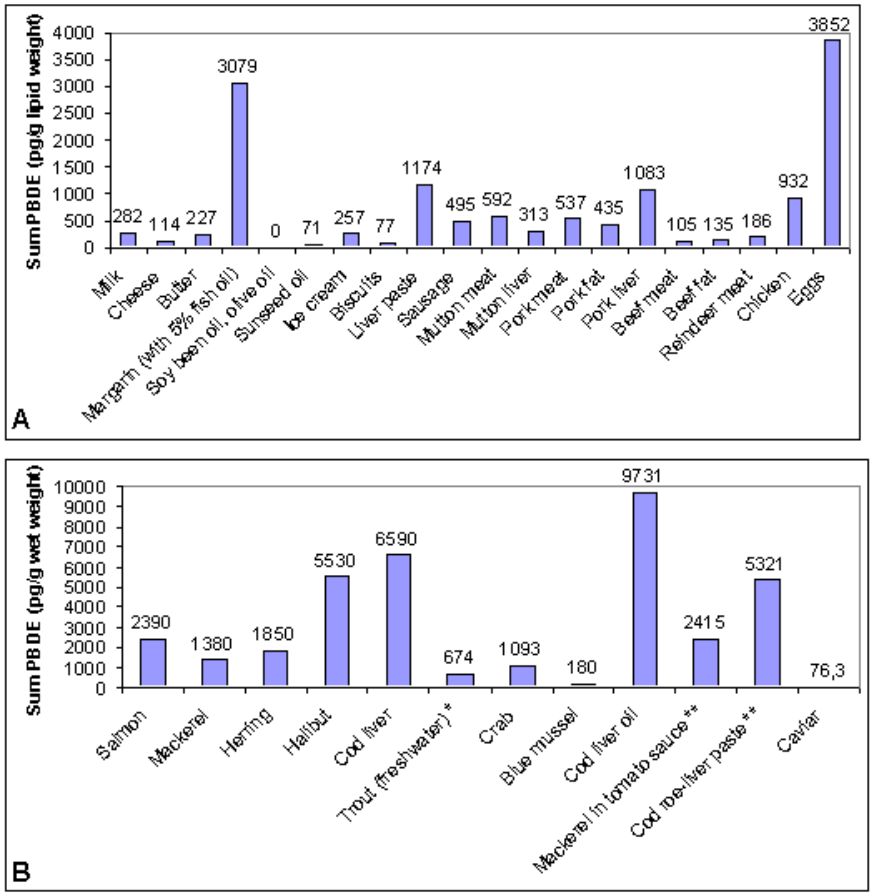

Figure 1.The sum of BDE 47, 99, 100, 153, and 154 in Norwegian foods. *Please note different scaling of the axes in panel A and B. A: Levels in agricultural products are shown per lipid weight. B: Levels in seafood are shown on wet weight basis. *: Only BDE 47, 99, and 153. **: Only BDE 47 and 99. The levels in salmon, mackerel, herring, halibut, cod liver, crab and blue mussels are from C. Bethune[3].*

Fish oil supplements are widely used in Norway. The Norwegian Directorate for Health and Social Affairs recommends a daily use of fish oil supplements to the whole population in order to secure a sufficient intake of vitamin D and omega-3 fatty acids. The recommended intake of one teaspoon (5 ml) of cod liver oil is equal to about 5g of fish oil. However, the actual intake of fish oil is not a question in the two food surveys. We thus conducted a theoretical calculation of the additional intake of PBDE from cod liver oil, provided that the whole population followed the recommendations on fish oil supplements. 5g cod liver oil would alone add 48.7 ng to the daily intake, indicating a median intake of PBDE of 123 ng/day and 220 ng/day for the 95 perc.

Table 1: Estimated dietary intake of PBDE in Norway

	Mean ng/day	**Median** ng/day	**95th perc** ng/day
NORKOST 1997	62.5	48.6	149.0
NORKOST, excluding fish, shellfish and game	20.8	19.2	36.7
The Norwegian Fish and Game study, part A	64.2	55.0	151.3
Total[a], NORKOST + Fish and Game study		74.2	170.5[b]
Total[a], NORKOST + Fish and Game + fish oil supplement[c]		122.9	219.2

[a]Norkost excluding intakes from fish, shellfish and game + intakes from fish, shellfish and game based on the Fish and Game Study. [b] High intake = Median intake based on Norkost excluding intakes from fish, shellfish and game + 95th percentile intake from fish, shellfish and game based on the Fish and Game Study. [c]An additional daily intake of 5 g of fish oil supplement, which is the recommended amount.

The calculated exposure levels from food in Norway are higher than those reported in other Scandinavian countries (Table 2). This may be due to higher fish consumption in Norway (70 g fish/day in average). On the other hand, the intake is lower than in Catalonia (Spain), where the reported fish-consumption was as high as 92 g/day, and more PBDE-congeners were included. The Norwegian intake was also lower than that found in the UK

Table 2: Published dietary exposures to BDE (47, 99, 100, 153, 154) in Europe

Study	Total intake (ng/day)
2001 Market basket, Sweden [4]	51 (medium bound)
2003 Food frequency, lactating women, Uppsala, Sweden [5]	27 [b]
2003 24 h recall, 3 days, Catalonia, Spain [a 6]	81.9 (lower bound) 97,3 (medium bound)
2004 Duplicate diet, UK [7]	90,5 (lower bound)
2004 Market basket, Finland [8]	44 (lower bound)

[a]Provides no specific information on congeners: tetra, penta, hexa, hepta and octa BDE are included. [b]Provides no information of upper, medium or lower bound.

As illustrated in figure 2, as much as 74 % of the median dietary PBDE exposure comes from fish and fish products, and the majority of this comes from oily and semi-oily fish.

Fish liver and roe contributes with 15% of the estimated total intake. This may represent an overestimation, because the proportion of cod-liver paste of the total fish used as bread-spread has probably been calculated higher than the actual consumption. Bread and cakes contributes with 9% of the calculated intake. Margarine with 5% fish oil has been used as the fat source in bread in the present calculations, and although hydrogenated fish oil still is used in the baking industry, this may also represent an overestimation.

Altogether, this may imply that this preliminary calculation of the PBDE-intake in Norway to some extent is overestimated. However, this will not change the conclusion that seafood is the major dietary PBDE source in Norway.

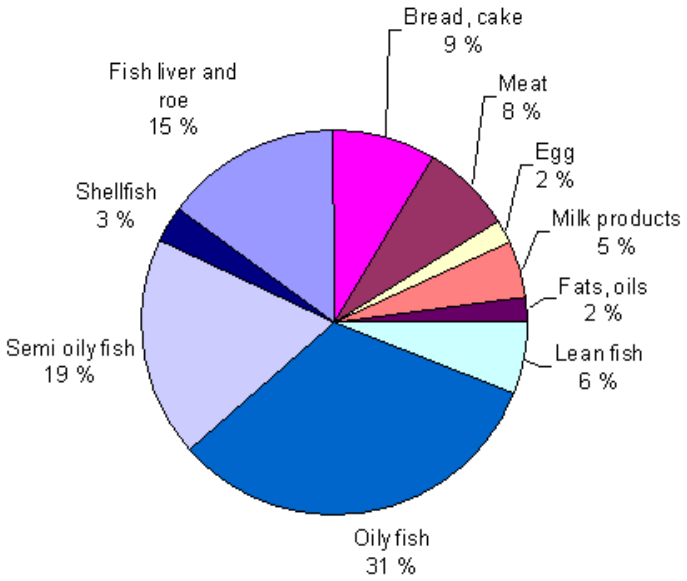

Figure 2.Distribution of PBDE intake from different food-groups. *Fish and shellfish contributes with 74% of the total intake, and 50% of the calculated intake comes from oily and semi oily fish.*

References

1. Johansson, L. and Solvoll, K. (1999) Norkost 1997, The National Council on Nutrition and Physical Activity

2. Meltzer, H. M., Bergsten, C., and Stigum, H. (2002) Fisk- og Viltundersøkelsen. SNT Rapport 6.

3. Bethune, C., Nielsen, J., and Julshamn, K. (2004) *Organohalogen Compounds* 66: 3861-3866.

4. Darnerud, P. O., Eriksen, G. S., Johannesson, T., Larsen, P. B., and Viluksela, M. (2001) *Environ.HealthPerspect*. 109: Suppl 1, 49-68

5. Lind, Y., Darnerud, P. O., Atuma, S., Aune, M., Becker, W., Bjerselius, R., Cnattingius, S., and Glynn, A. (2003) *Environ.Res*. 93: 186-194

6. Bocio, A., Llobet, J. M., Domingo, J. L., Corbella, J., Teixido, A., and Casas, C. (2003) *J.Agric.Food Chem*. 51: 3191-3195

7. Harrad, S., Wijesekera, R., Hunter, S., Halliwell, C., and Baker, R. (2004) *Environ.Sci.Technol*. 38: 2345-2350

8. Kiviranta, H., Ovaskainen, M. L., and Vartiainen, T. (2004) *Environ.Int*. 30: 923-932