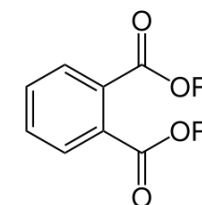


PHTHALATES AS ENVIRONMENTAL CONTAMINANTS IN FOOD

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What are phthalates?

Substances used predominantly as plasticizers (plus adhesives, caulk, nail polish, paint etc): ca. 400 ktpa



Phthalate structure

R, R' = CH₃C₁₀H₂₁

- Are they POPs?
 - Widespread in the environment
 - Biodegradable (soil/water t_{1/2} days – weeks)
 - Some persistence, but limited

Phthalate	Study	Endpoint	Value*
Di-n-butyl phthalate (DBP)	Developmental tox in rats	Germ cell development	2 mg/kg BWd ⁻¹
Benzyl butyl phthalate (BBP)	Developmental/ testicular tox in rats	Sperm conc'n AGD (F1, F2)	20 mg/kg BWd ⁻¹ 50 mg/kg BWd ⁻¹
Bis-(2-ethylhexyl) phthalate (DEHP)	Developmental/ testicular tox in rats	Germ cell depletion Reduced testis weight	5 mg/kg BWd ⁻¹ 5 mg/kg BWd ⁻¹
Diisononyl phthalate (DiNP)	Liver/ kidney tox in rats	Spongiosis hepatitis	15 mg/kg BWd ⁻¹
Diisodecyl phthalate (DiDP)	Liver tox in dogs Developmental tox in rats	Microscopic lesions F2 offspring survival ↓	15 mg/kg BWd ⁻¹ 30 mg/kg BWd ⁻¹

* all NOAEL except DBP (LOAEL)

DEHP Log K_{ow} 5 – 8
(true value probably
ca. 7.5)

- Bioaccumulation Factors
 - mussels ca. 2,500 (28d @ 4-42 µg/l)
 - freshwater lamprey 10,600 (27d @ 1 µg/l)
 - snail 17,500 (27d @ 1 µg/l)

Occurrence in food - history

- Investigations by MAFF in the 1990s
 - Packaging 1995
 - Total Diet Study 1996
 - Levels in Infant Formulae 1996, 1998
- No health concerns raised
- Moved to Food Contact Materials remit (low priority)
- 2005 EFSA AFC opinion on phthalates as FCM (looked at all sources) – exposure to DBP and DEHP may be in range of TDI (limited data); restrictions on use of 5 phthalates as:
 - plasticizers (ban/SML)
 - technical support agents (SML)(Commission Directive 2007/19/EC)



CONTAM reviewed, concluded need for more data

March 2007

Phthalate issue to Environmental Contaminants WG

- Need for analytical capability survey
- Need for more data

FSA phthalate project

- Commissioned February 2008
 1. Develop and validate methods for phthalate diesters, monoesters and total phthalate in 3 food matrix types (fat / carb / protein)
 - Cheese (high fat)
 - Orange juice (high carbohydrate)
 - Pork mince (high protein)
 2. Measure levels in Total Diet Study samples (2007)
 3. Investigate means of distinguishing sources
 4. 'Snapshot' survey of levels in individual foods

Compounds measured (based on standards available)

Dimethyl phthalate (DMP) Diethyl phthalate (DEP) Diisopropyl phthalate (DiPP) Diallyl phthalate (DAP) Diisobutyl phthalate (DiBP) Di-n-butyl phthalate (DBP) Di-n-pentyl phthalate (DPP) Di-n-hexyl phthalate (DHexP) Benzyl butyl phthalate (BBP) Dicyclohexyl phthalate (DCHP)	Di-(2-ethylhexyl) phthalate (DEHP) Di-n-heptyl phthalate (DHepP) Di-n-octyl phthalate (DOP) n-Octyl-n-decyl phthalate (nOnDP) Diisononyl phthalate (DiNP) Diisodecyl phthalate (DiDP) Di-n-decyl phthalate (DDP)	Monoisopropyl phthalate (MiPP) Monoisobutyl phthalate (MiBP) Mono-n-butyl phthalate (MBP) Monobenzyl phthalate (MBnzP) Monocyclohexyl phthalate (MCHP) Mono-n-pentyl phthalate (MPP) Mono-2-ethylhexyl phthalate (MEHP) Mono-n-octyl phthalate (MOP) Monoisononyl phthalate (MiNP)
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Methodology

1. Extraction into MeCN/DCM, evaporation to dryness
2. Uptake into MeCN (no further cleanup)
3. Analysis by GC-MS (40-450 amu)
4. (For total as DMP, extract treated with MeOH/KOH and BF₃/EtOEt then SEC)

Total Diet Study – results (µg/kg)

Purple = confirmed results; red = unconfirmed; tr = <LOQ

Food group	DEP	DiBP	DBP	BBP	DEHP	DCHP	MBP	MEHP	PA	Number +ve	Total phthalate*
Bread	-	16.6	16.2	8.1	124.6	-	tr	-	27.0	5	187
Cereals	13.4	80.8	13.8	tr	104.5	-	tr	-	140.0	5	340
Carcase meat	-	5.3	6.3	-	89.7	-	29.0	-	36.0	5	116
Offal	-	6.4	-	-	tr	98.1	-	-	-	2	144
Meat products	-	18.0	15.4	-	329.1	-	32.0	tr	-	4	163
Poultry	-	-	-	-	322.1	-	tr	54.0	130.0	2	177
Fish	-	17.6	9.3	-	789.1	7.1	52.0	tr	-	5	206
Oils and fats	-	41.3	16.0	-	105.5	-	tr	-	36.0	4	90
Eggs	-	tr	tr	-	tr	-	tr	-	35.0	1	102
Sugar & preserves	-	tr	6.7	-	115.6	-	-	-	110.0	3	67
Green vegetables	51.8	-	tr	-	tr	-	tr	-	89.0	2	202
Potatoes	-	tr	tr	-	tr	-	-	-	84.0	1	163
Other vegetables	-	8.9	3.5	-	34.8	-	-	-	99.0	4	206
Canned vegetables	-	tr	tr	-	tr	-	tr	-	84.0	1	162
Fresh fruit	tr	tr	tr	tr	tr	-	tr	-	150.0	1	90
Fruit products	-	-	tr	-	tr	-	tr	-	190.0	1	361
Beverages	-	-	2.4	-	tr	-	-	-	-	1	53
Milk	-	tr	tr	-	tr	-	-	-	66.0	1	74
Dairy products	-	tr	tr	-	140.7	-	tr	-	360.0	2	157
Nuts	tr	49.0	28.3	-	111.8	-	tr	-	270.0	4	479
Number +ve	2	9	10	1	11	2	3	-	16		

* Measured as dimethyl phthalate

Total Diet Study – exposure estimates

Food group Chemical:	Estimated <i>upper bound</i> <u>average</u> adult dietary exposure (microgram/kg bodyweight/day) to phthalates from the whole diet in 2007									
	DEP	DiBP	DBP	BBP	DEHP	DCHP	DiNP	DiDP	PA	MBP
TDI	-	-	10	500	50	-	150	150	-	-
Senior citizens										
- living at home	0.2	0.4	0.2	0.2	1.5	0.1	3.3	7.7	0.003	0.4
- in institutions	0.1	0.4	0.1	0.1	1.3	0.08	3.2	7.5	0.003	0.3
Adults	0.2	0.6	0.2	0.3	2.3	0.1	4.7	10.8	0.004	0.6
<i>Schoolchildren:</i>										
age - 4-6 years	0.4	1.1	0.5	0.6	4.2	0.3	10.3	24.0	0.007	1.0
age - 7-10 years	0.3	0.9	0.4	0.4	3.2	0.2	7.5	17.7	0.006	0.8
age - 11-14 years	0.2	0.6	0.2	0.3	2.3	0.1	4.9	11.9	0.004	0.5
age - 15-18 years	0.2	0.5	0.2	0.2	1.9	0.1	3.9	9.3	0.003	0.5
<i>Toddlers:</i>										
age 1.5-2.5	0.5	1.4	0.6	0.8	5.2	0.4	17.4	39.6	0.01	1.4
age 2.5-3.5	0.5	1.4	0.6	0.7	4.7	0.3	14.3	33.5	0.01	1.3
age 3.5-4.5	0.4	1.2	0.5	0.6	4.3	0.3	12.1	28.5	0.009	1.1

- COT statement (published May 2011):
 - Endorsed EFSA TDIs
 - Noted no significant new evidence
 - Exposure to individual phthalates well below TDIs
 - Hydrolysis to monoesters unlikely to increase risk
 - No basis for relative potency / Hazard Index approach
 - Very conservative approach based on total dietary exposure, no concern
 - Future assessment should consider non-dietary exposure

Source investigation (pilot)

Three-part approach

1. What phthalates are present in packaging?
2. How do profiles in food and packaging compare?
3. Is there a concentration profile in the food

29 packaged foods purchased – packaging screened for phthalates
Results >LOQ found in only 9 samples

Foodstuff	Type	Packaging size	Food amount	DMP	DEP	DiBP	DnBP	DEHP	DiNP	DiDP
Tomato relish	Glass jar/gasket	0.301 g	310 g	< LOQ	< LOQ	5.2 mg/kg	< LOQ	2.8 mg/kg	10.9 mg/kg	3.9 mg/kg
Strawberry yoghurt	Plastic pot / foil lid	4.06 dm ²	500 g	< LOQ	< LOQ	< LOQ	< LOQ	< LOQ	146.5 µg/dm ²	< LOQ
Fruit drink	Paper / foil / plastic laminate	3.0 dm ²	288 ml	< LOQ	< LOQ	10.5 µg/dm ²	1.9 µg/dm ²	4.0 µg/dm ²	< LOQ	< LOQ
Southern fried chicken breast	Plastic bag	11.0 dm ²	380 g	< LOQ	< LOQ	4.0 µg/dm ²	< LOQ	10.5 µg/dm ²	< LOQ	< LOQ
Ham and cheese wrap	Plastic bag / cartonboard	4.37 dm ²	100 g	< LOQ	< LOQ	< LOQ	< LOQ	6.8 µg/dm ²	< LOQ	< LOQ
Crispbreads	Plastic liner in cartonboard box	10.8 dm ²	150 g	1.1 µg/dm ²	1.6 µg/dm ²	80.3 µg/dm ²	14.4 µg/dm ²	51.5 µg/dm ²	13.1 µg/dm ²	< LOQ
Lasagne sheets	Cartonboard box / plastic window	6.75 dm ²	500 g	1.2 µg/dm ²	< LOQ	147.1 µg/dm ²	3.9 µg/dm ²	18.3 µg/dm ²	< LOQ	< LOQ
Tofu	Foil-lined pouch	3.15 dm ²	349 g	< LOQ	< LOQ	8.4 µg/dm ²	1.6 µg/dm ²	2.2 µg/dm ²	< LOQ	< LOQ
Sage and onion stuffing	Plastic liner in cartonboard box	6.41 dm ²	100 g	< LOQ	< LOQ	15.1 µg/dm ²	2.5 µg/dm ²	14.4 µg/dm ²	< LOQ	< LOQ

Source investigation (pilot)

Calculated levels in food (assume 100% migration)

Foodstuff	DMP	DEP	DiBP	DnBP	DEHP	DiNP	DiDP
Tomato relish	< LOQ	< LOQ	5 µg/kg	< LOQ	3 µg/kg	11 µg/kg	4 µg/kg
Strawberry yoghurt	< LOQ	< LOQ	< LOQ	< LOQ	< LOQ	1200 µg/kg	< LOQ
Fruit drink	< LOQ	< LOQ	109 µg/kg	20 µg/kg	40 µg/kg	< LOQ	< LOQ
Southern fried chicken breast	< LOQ	< LOQ	116 µg/kg	< LOQ	304 µg/kg	< LOQ	< LOQ
Ham and cheese wrap	< LOQ	< LOQ	< LOQ	< LOQ	212 µg/kg	< LOQ	< LOQ
Crispbreads	43 µg/kg	63 µg/kg	3139 µg/kg	563 µg/kg	2013 µg/kg	512 µg/kg	< LOQ
Lasagne sheets	16 µg/kg	< LOQ	1961 µg/kg	52 µg/kg	244 µg/kg	< LOQ	< LOQ
Tofu	< LOQ	< LOQ	76 µg/kg	14 µg/kg	20 µg/kg	< LOQ	< LOQ
Sage and onion stuffing	< LOQ	< LOQ	967 µg/kg	160 µg/kg	922 µg/kg	< LOQ	< LOQ

Lasagne sheets selected for concentration gradient study (3 packs purchased)

Only DiBP measurable in all samples

	Layer 1 0-0.3 cm from packaging	Layer 2 0.3-0.6 cm from packaging	Layer 3 2.0-2.3 cm from packaging
Sample 1	223 µg/kg	105µg/kg	86µg/kg
Sample 2	259	111	35
Sample 3	206	104	63

Clear concentration gradient => packaging is the source

Food survey

- 261 retail samples based partly on TDS outcome
- High background, very variable LOD/LOQs
- 73 samples at least one confirmed detection
- 62 samples at least one unconfirmed detection

Food Survey Summary

Food type	Number +ve	Total	Rate	Range (µg/kg)
Baby food	3	5	60%	21.6 - 273
Cereals	28	40	70%	11.1 – 3,560
Dairy	13	19	68%	25.8 – 2,590
Fats & oils	11	17	65%	15.6 – 8,640
Fish	37	69	54%	1.5 – 2,780
Fish liver	1	2	50%	242.2
Infant formula	5	16	31%	13.1 – 208
Liver	3	11	27%	36.3 - 83.7
Meat	29	66	44%	6 – 1,880
Shellfish	5	5	100%	20.4 - 300

Detection Frequency

	All	Confirmed
DEHP	68	64
DiBP	38	12
DBP	24	5

Conclusions

- Analysis challenging due to high background levels
- Total Diet Study does not indicate a cause for concern
- Animal products and processed bread and cereals main sources
- Distinguishing origins of contamination possible but difficult to fingerprint
- Packaging sources can be proven, environmental more difficult (plus intermediate contamination during transport & processing)
- DEHP is the most commonly-occurring phthalate in food (then DiBP and DnBP)
- Levels within food groups are very variable

Next steps

- No further research for now (other priorities)
- Await discussions in Brussels
- Limits probably unnecessary BUT may be needed as a risk-management tool (Taiwan incident 2011)

Thank you

Questions?

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