Analysis of the Lipid Fractions of Coffee Creamers, Cream Aerosols, and Bouillon Cubes for Their Health Risk Associated Constituents

Lenka KARŠULÍNOVÁ, Blanka FOLPRECHTOVÁ, Marek DOLEŽAL, Jana DOSTÁLOVÁ and Jan VELÍŠEK

Department of Food Chemistry and Analysis, Faculty of Food and Biochemical Technology, Institute of Chemical Technology in Prague, Prague, Czech Republic

Abstract

Karšulínová L., Folprechtová B., Doležal M., Dostálová J., Velíšek J. (2007): **Analysis of the lipid fractions of coffee creamers, cream aerosols, and bouillon cubes for their health risk associated constituents**. Czech J. Food Sci., **25**: 257–264.

Fifteen coffee creamers, 10 cream aerosols, and 5 bouillon cubes from the retail market were analysed, principally for their contents of *trans*-fatty acids that are known to increase the risk of coronary heart disease, and for their contents of 3-chloropropane-1,2-diol (3-MCPD) fatty acid esters that possibly have a bioaccumulation potential. The contents of *trans*-fatty acids in coffee creamers, cream aerosols and bouillon cubes were in the range of 0.2–32.8%, < LOD – 6.0%, and 0.5–2.1% of total fatty acids, respectively. All samples contained high levels of 3-MCPD fatty acid esters that were determined after releasing the free 3-MCPD by methanolysis. The 3-MCPD levels in coffee creamers, cream aerosols, and bouillon cubes were in the range of 130–730 μg/kg (540–4480 μg/kg fat), 50–730 μg/kg (220–2880 μg/kg fat), and 380–670 μg/kg (2650–4840 μg/kg fat), respectively. The results showed that the refined and hydrogenated oils may represent a certain risk. The highest levels of 3-MCPD esters were found in a sample of refined palm oil (4170 μg/kg). Currently, there is no information available on how these 3-MCPD esters are metabolised, to which extent they are hydrolysed or biosynthesised in the body, to which extent they are deposited in tissues, and how they influence the properties and functions of tissues (if they really do it).

Keywords: coffee creamers; cream aerosols; bouillon cubes; fatty acids composition; *trans*-fatty acids; chloropropanols; 3-chloropropane-1,2-diol; 3-MCPD; 3-MCPD esters; contaminants

The nutritive value of foods relates to both the qualitative and quantitative composition of the food nutrients. Fats play an extremely important role because of the impact they may have on human health (Dietary Guidelines for Americans 2005). *Trans*-fatty acids (commonly termed trans fats) occur, in small quantities, in meat and dairy products from ruminants. Most *trans*-fatty acids (TFA) consumed today, however, are industrially created as a side product of partial hydrogenation of plant oils. TFA can thus be found in a list of foods including vegetable shortenings, margarines, crackers, cereals, candies, donuts (doughnuts), baked goods, cookies, granola bars,

Supported by the Ministry of Education, Youth and Sports of the Czech Republic (a part of the Projects No. MSM 6046137305 and MŠMT.NPV 2.5.01).

French fries (chips), snack foods, salad dressings, fried foods, and many other processed foods. The consumption of TFA increases the risk of coronary heart disease. For these reasons, health authorities worldwide recommend that consumption of TFA be reduced to trace amounts. The intake of TFA was limited to < 2% of the total energy content (Eurodiet 2000) and < 1% (WHO 2004), respectively. TFA from partially hydrogenated oils are generally considered a higher health risk than those occurring naturally (Mozaffarian *et al*. 2006). TFA are strictly regulated in a few countries, they must be disclosed on the product labels in many others, and are the central issue in several ongoing lawsuits (particularly against fast food outlets). For example, the content of TFA higher than 0.5 g per serving must be labelled on the food products after January 1st, 2006 in USA (Guidance for Industry and FDA 2005), and WHO (2004) even recommends to decrease the levels of TFA in the existing food products. Many companies are voluntarily removing TFA from their products, or establishing trans-free product lines.

Several findings document that a wide variety of both unprocessed and processed foods and various food ingredients contain high levels of the processing contaminant 3-chloropropane-1,2-diol[1] (better known as 3-MCPD) and, especially, high levels of lipophilic 3-MCPD fatty acid esters (Svejkovská *et al*. 2004; Hamlet & Sadd 2004; Doležal *et al*. 2005; Divinová *et al*. 2007). The amounts ranging from < 300 µg/kg to 2462 µg/kg have been found, for example, in refined edible oils including refined olive oils (Zelinková *et al*. 2006). Recent identification of 3-MCPD esters in human breast milk (Zelinková *et al*. 2007) suggests possible bioaccumulation of the esterified 3-MCPD. Considering the high amounts of lipophilic 3-MCPD esters in various foods, notably in refined edible oils, we hypothesised on a potential transfer of these chemicals into breast milk in a similar way as is known for persistent organic contaminants.

For coffee creamers, cream aerosols, bouillon cubes, and many other foods containing refined and/or hydrogenated vegetable fats, no data on their suspected constituents, TFA and 3-MCPD fatty acid esters, are available, hence the analysis of these three products that were chosen as representatives of foods containing refined and/or hydrogenated fats.

MATERIAL AND METHODS

Chemicals. 3-Chloropropane-1,2-diol (98%), hexane for organic trace analysis and tetrahydrofurane p.a. (99.5%) were obtained from Merck (Darmstadt, Germany), phenylboronic acid and sulphuric acid for organic trace analysis (> 95%) were products of Fluka Chemie (Buchs, Switzerland), 3-chloropropane-1,2-diol-d_5 (99.4%) was provided by Dr. Ehrenstorfer (Augsburg, Germany), acetone p.a. (99.5%), methanol p.a., and butane-1,3-diol p.a. were products of Lach-Ner (Neratovice, Czech Republic), diethyl ether p.a. (99.7%), petroleum ether p.a. (b.p. 40–60°C), sodium bicarbonate (99.5%), and sodium chloride p.a. (99.9%) were products of Penta (Chrudim, Czech Republic), and silver nitrate p.a. was produced by Safina (Vestec, Czech Republic). All other reagents and solvents used were of analytical purity.

Materials. Coffee creamers, cream aerosols, and bouillon cubes were obtained from the local retail market in Prague in 2006. Nine virgin seed oils (almond, soybean, rapeseed, sunflower, sesame, hazelnut, peanut, and pumpkin oils), four virgin olive oils (extra virgin and virgin oils), five refined seed oils (maize, soybean, sunflower, and rapeseed oils) and five refined olive oils (olive oils and olive pomace oils) were obtained from retail outlets in Prague (Zelinková *et al*. 2006). Three refined palm kernel oils, two refined coconut oils, and four refined palm oils were supplied by Setuza a.s. (Ústí n. L., Czech Republic) and Cargill B.V. (The Netherlands).

Methods. Free 3-MCPD and its esters were determined according to the modified GC/MS procedure of Divinová *et al*. (2004) described in detail by Divinová *et al*. (2007). Three parallel determinations

[1]In view of its toxicity, the European Commission's Scientific Committee on Food (SCF) has proposed a provisional Total Daily Intake (TDI) level of 2 µg/kg body weight/day for the amount of 3-MCPD that can be consumed daily over a lifetime without appreciable harm to health (SCF 2001). TDI was adopted on 8 March 2001 and applies from 5 April 2002. Similarly, the Joint FAO/WHO Expert Committee on Food Additives (JECFA) set a provisional maximum tolerable daily intake (PMTDI) of 2 µg/kg body weight/day in 2001 (JECFA 2001). A regulatory limit of 20 µg/kg, based on a 40% dry matter content, has been adopted for 3-MCPD in acid-HVP and soy sauce and came into force in the European Union in 2002 (EC 2001).

of each sample were made. The determination of fat in coffee creamers and cream aerosols (5 g) was carried out using the method of Röse and Gottlieb (AOAC 1975) with slight modifications (reextraction with ethanol/diethyl ether mixture). The fat content in bouillon cubes (10 g) was determined by the Soxhlet method using 150 ml of light petroleum ether (8 h). The solvent was evaporated on a rotary vacuum evaporator and the residue was dried in an oven at 103–105°C (IUPAC 1964). The water content was determined by drying the samples at 103–105°C. Two parallel determinations with each sample for the determination of fat and water content and fatty acid composition were made.

Determination of fatty acids composition. The analysis of fatty acids composition was made after derivatisation using a base-catalysed reaction with KOH-methanol as the reagent and extraction with hexane (Nollet 1996). The GC analysis was carried out on an Agilent Technologies 6890N gas chromatograph (Agilent Technologies, Palo Alto, USA) equipped with a flame ionisation detector and a capillary column Supelco SP 2560 (100 × 0.25 mm i.d., thickness of 0.2 μm, Supelco, Bellefonte, USA). The injector was held at 240°C (split, 75:1), the column temperature was programmed from 175°C to 240°C at the rate of 4°C/min. The fats containing butyric acid were analysed using the column temperature programmed from 90°C to 200°C at the rate of 6.9°C/min, and from 200°C to 240°C at the rate of 2°C/min. Helium, at the flow rate of 0.8 ml/min, was used as the carrier gas, 1 μl sample was injected. The results are expressed in relative percentages of each fatty acid and calculated by internal normalisation method using the chromatographic peak areas.

RESULTS AND DISCUSSION

Fifteen samples of coffee creamers, 10 samples of cream aerosols, and 5 samples of bouillon cubes obtained from the retail market were analysed for their contents of fat and water (Table 1). Table 1 also contains the types of fat given by the producers on the package labels. Groups of retail market products were selected to focus on foods produced by different producers and from different raw materials, as well as on various grades of fats that might contain *trans*-fatty acids (TFA) and 3-MCPD esters. The fats blended into the products were very variable in their compositions and were mainly made up from refined vegetable oils that had undergone hardening, by hydrogenation in most cases, to elevate their melting points and enhance their resistance to autoxidation. The fat isolated from bouillon cubes (12 samples) was recently analysed by Caponio *et al*. (2002). It was found that the levels of oxidative and hydrolytic changes were rather high and similar to those reported for low quality oils. The analyses of TFA (elaidic acid) yielded particularly high values (up to over 20%) and differentiated the cubes on the basis of the type of the fat added.

According to the producers, 2 cream aerosols (sample No. 20 and sample No. 21) contained milk fat but all other samples were composed of either so-called vegetable fat (or coconut fat) or hardened (hydrogenated) unspecified vegetable fat (palm or coconut fat).

The fat content in coffee creamers varied between 16.3% and 35.5%, being the lowest in sample No. 15 and the highest in sample No. 10. The fat content of cream aerosols varied between 21.7% (sample No. 17) and 33.5% (sample No. 22). Bouillon cubes had the content of fat between 7.8% (sample No. 29) and 25.2% (sample No. 27).

The composition of fatty acids of the analysed fats was in accordance with that labelled on the food products analysed. The compositions of fatty acids of all food products analysed were not favourable for the prevention of cardiovascular diseases. All samples of coffee creamers had a very low polyunsaturated fatty acid (PUFA) content (0.1–5.7%). Nine samples of coffee creamers had the saturated fatty acids (SAFA) content > 80% and contained high levels (up to 18.0%) of the most atherogenic myristic acid. The content of TFA higher than 10% was found in 2 samples only. The composition of fatty acids of cream aerosols was very similar to that of coffee creamers, i.e. the samples showed low contents of PUFA (0.3–8.7%) and high contents of SAFA (6 samples > 80%). The contents of TFA were in the range of not detected to 6.0%.

As expected, the dry matter content was very high in the samples of coffee creamers, being the lowest in sample No. 1 (95.4%) and the highest in sample No. 14 (98.1%). Cream aerosols had an average dry matter content of about 32%, ranging from 31.7% (sample No. 18) to 39.3% (sample No. 22). Very high dry matter contents were also found in bouillon cubes (94.9% in sample No. 30 and 98.4% in sample No. 27).

Free 3-MCPD was not detected in any sample analysed (the LOD for the method used to deter-

Table 1. Type of fat and contents of fat and dry matter in analysed samples

Sample No.	Fat type	Fat		Dry matter	
		(%)	RSD	(%)	RSD
Coffee creamers					
1	vegetable fat	17.5	2.29	95.4	0.10
2	hardened palm fat	13.3	1.50	96.7	0.10
3	hardened vegetable fat	17.5	5.14	97.4	0.10
4	vegetable fat	28.0	1.43	96.6	0.00
5	vegetable fat	18.4	2.72	98.3	0.00
6	vegetable fat	23.2	0.00	96.6	0.00
7	hydrogenated vegetable fat	20.8	0.00	96.2	0.31
8	hardened vegetable coconut fat	20.0	0.50	96.5	0.31
9	hydrogenated vegetable fat	18.3	0.00	97.1	0.10
10	coconut fat	35.5	0.56	96.9	0.00
11	vegetable coconut fat	32.9	0.61	96.8	0.00
12	hardened vegetable coconut fat	35.0	0.29	97.6	0.10
13	vegetable fat	18.5	2.16	97.5	0.10
14	vegetable fat	23.6	0.00	98.1	0.00
15	vegetable fat	16.3	3.07	97.7	0.10
Cream aerosols					
16	hardened vegetable fat	26.2	1.83	32.0	0.41
17	hydrogenated vegetable fat	21.7	1.11	32.6	0.25
18	hardened vegetable fat	23.5	0.77	31.7	0.06
19	hardened vegetable fat	29.0	0.52	31.8	1.23
20	milk fat	24.5	0.78	34.7	0.03
21	milk fat	28.0	0.54	39.0	0.05
22	hardened vegetable fat	33.5	2.06	39.3	0.23
23	vegetable oil, hardened vegetable oil	27.6	1.99	34.4	0.29
24	hardened vegetable oil	30.3	1.25	33.7	0.06
25	hardened vegetable fat	25.8	1.09	38.0	0.03
Bouillon cubes					
26	vegetable fat, sunflower oil	23.3	0.08	97.25	0.01
27	hardened vegetable fat	25.2	0.42	98.38	0.01
28	hardened vegetable fat	10.6	0.64	93.88	0.03
29	hardened vegetable fat	7.8	0.08	95.30	0.04
30	hardened vegetable fat	14.1	0.17	94.85	0.05

RSD = relative standard deviation (%)

mine the free 3-MCPD was 3 µg/kg sample). As expected, the levels of 3-MCPD released from its esters with fatty acids, when expressed as free 3-MCPD (so-called bound 3-MCPD given in Table 4), found in fats isolated from the samples, were relatively high. The limit of detection (LOD) and the limit of quantification (LOQ) of the bound 3-MCPD were 100 µg/kg oil and 300 µg/kg oil, respectively. The results obtained with coffee creamers varied between 540 µg/kg fat (sample No. 4) and 4480 µg/kg fat (sample No. 2), i.e. 150–590 µg/kg sample. In cream aerosols the levels of bound

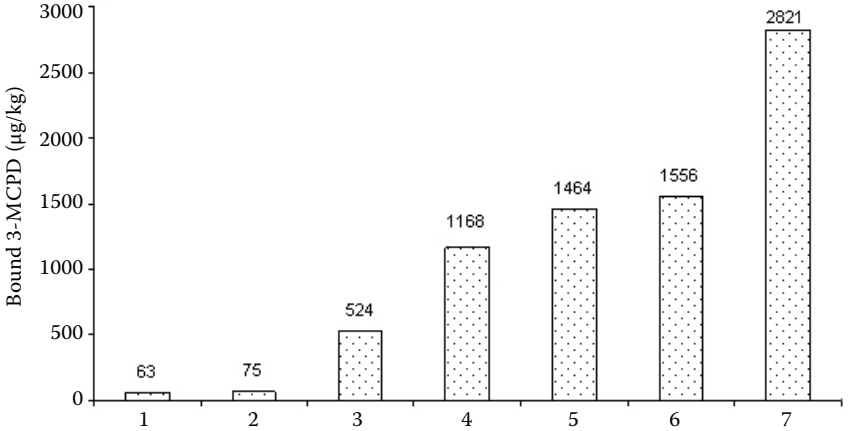
Table 2. Fatty acid composition (% of total fatty acids) of fats of coffee creamers

Fatty acid composition	Sample No.														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
C4:0	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C6:0	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C8:0	7.1	< 1	6.6	6.7	< 1	4.1	6.9	3.4	6.9	7.0	4.3	2.4	< 1	7.0	< 1
C10:0	5.8	< 1	5.6	5.5	< 1	3.6	5.6	2.8	5.6	5.7	3.6	2.0	< 1	5.6	< 1
C12:0	45.4	4.5	44.3	44.7	1.1	30.9	44.7	21.6	45.2	44.6	32.4	15.9	< 1	44.8	2.1
C14:0	17.3	2.5	18.0	17.9	1.4	11.9	17.9	9.1	18.0	17.3	12.8	7.0	1.2	17.6	1.2
C16:0	11.0	36.3	10.2	11.1	41.0	21.3	11.5	27.3	11.1	11.6	20.7	32.5	41.8	11.2	18.8
C18:0	12.1	7.9	11.9	12.0	10.7	12.1	11.5	10.1	12.0	12.3	12.6	10.4	8.4	10.7	12.7
C18:1*t*	< 1	10.8	< 1	< 1	5.0	3.8	< 1	1.9	< 1	< 1	3.7	1.8	5.6	< 1	31.5
C18:1*c*	< 1	29.8	< 1	< 1	31.2	9.4	< 1	17.5	< 1	< 1	7.8	21.7	32.5	1.7	22.7
C18:2*c*	< 1	3.6	< 1	< 1	5.3	1.6	< 1	3.2	< 1	< 1	< 1	4.4	4.7	< 1	1.8
TFA	0.2	11.7	0.5	0.2	5.2	3.8	0.5	2.3	0.2	0.6	3.7	2.3	6.5	0.4	32.8
SAFA	99.2	53.1	97.3	98.7	55.1	84.4	98.6	74.6	99.3	98.9	87.0	70.8	52.6	97.6	36.1
MUFA	0.2	40.7	0.4	1.0	36.4	13.3	0.4	19.5	0.2	0.5	11.6	23.5	38.3	2.1	54.3
PUFA	0.1	4.6	0.2	0.3	5.7	1.7	0.2	3.7	0.1	0.2	1.0	5.0	5.6	0.3	3.2
Others	0.5	1.6	2.1	nd	2.9	0.6	0.8	2.2	0.4	0.4	0.5	0.7	3.6	nd	6.4

TFA = *trans*-fatty acids (sum of *trans*-isomers of octadecenoic, octadecadienoic and octadecatrienoic acids), SAFA = saturated fatty acids, MUFA = monounsaturated fatty acids (including *trans*-isomers of octadecenoic acid), PUFA = polyunsaturated fatty acids (including *trans*-isomers of octadecadienoic and octadecatrienoic acids), nd = not detected

3-MCPD varied between 220 µg/kg fat (sample No. 20) and 2880 µg/kg fat (sample No. 17), i.e. 10–660 µg/kg sample. Similar levels of bound 3-MCPD were found in the bouillon cubes, varying between 2650 (sample No. 27) and 4840 µg/kg fat (sample No. 29), i.e. 209–318 µg/kg sample.

The results obtained are not surprising as refined olive oils analysed in our previous study contained elevated levels of 3-MCPD esters (< 300–3100 µg per kg, LOQ = 300 µg/kg, Zelinková *et al*. 2006) in comparison with virgin seed oils (< 100 to < 300 µg/kg, LOD = 100 µg/kg), virgin olive oils (< 100–1000 µg/kg), and refined seed oils (484 to 1600 µg/kg). For comparison, we have further analysed a series of refined palm and coconut oils for their bound 3-MCPD content. The results obtained, presented in Figure 1, show that the average content of 3-MCPD esters in the refined palm kernel oils ranged from 850 µg/kg to 1400 µg/kg, in coconut oils from 1418–1694 µg/kg while refined palm oils



1 – virgin seed oils
2 – virgin olive oils
3 – refined seed oils
4 – refined palm kernel oils
5 – refined olive oils
6 – refined coconut oils
7 – refined palm oils

Figure 1. Bound 3-MCPD average content of some virgin and refined vegetable oils

Table 3. Fatty acid composition (% of total fatty acids) of fats of cream aerosols and bouillon cubes

Fatty acid composition	Sample No.														
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
C4:0	< 1	< 1	< 1	< 1	2.3	2.0	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C6:0	< 1	< 1	< 1	< 1	1.8	1.5	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C8:0	3.4	3.4	3.3	3.3	1.2	1.0	5.1	3.4	3.3	5.0	< 1	< 1	< 1	< 1	< 1
C10:0	3.2	3.1	3.3	3.1	2.8	2.6	4.2	3.1	3.1	4.2	< 1	< 1	< 1	< 1	< 1
C12:0	44.6	36.2	45.6	41.3	3.5	3.3	42.1	34.9	43.2	41.2	< 1	< 1	< 1	< 1	< 1
C14:0	14.5	13.0	15.9	13.7	11.0	10.6	14.1	12.8	15.3	14.1	1.2	1.4	1.4	1.4	1.3
C16:0	9.1	12.7	9.9	9.2	30.8	31.0	9.2	12.3	9.3	9.2	59.0	45.4	46.6	45.2	47.0
C18:0	23.4	7.7	20.5	22.9	8.6	9.1	15.5	7.5	11.4	15.7	5.3	15.7	4.8	7.8	4.6
C18:1*t*	< 1	< 1	< 1	< 1	1.5	2.0	5.3	< 1	6.0	5.1	< 1	< 1	< 1	< 1	1.8
C18:1*c*	< 1	17.4	< 1	2.2	23.1	23.6	2.9	17.0	4.9	2.6	51.0	27.2	36.2	34.8	35.7
C18:2*c*	< 1	4.1	< 1	1.0	2.4	2.6	< 1	4.1	< 1	< 1	15.4	7.1	8.8	8.5	8.0
TFA	0.4	0.4	nd	nd	1.9	2.2	5.3	0.4	6.0	5.1	0.5	0.8	0.6	0.6	2.1
SAFA	98.6	76.6	99.0	94.1	67.8	66.8	91.0	74.7	86.0	90.2	65.9	64.5	53.5	55.3	53.7
MUFA	0.3	17.7	0.7	2.2	27.1	28.1	8.2	17.4	10.8	7.7	27.8	28.0	36.9	36.0	38.1
PUFA	0.4	5.0	0.3	1.2	3.5	3.0	0.5	4.9	0.8	0.4	6.3	7.5	9.6	8.7	8.2
Others	0.8	0.5	nd	2.5	1.6	0.5	0.4	3.0	2.4	1.7	0.3	0.4	0.6	0.9	0.4

TFA = *trans*-fatty acids (sum of *trans*-isomers of octadecenoic, octadecadienoic and octadecatrienoic acids), SAFA = saturated fatty acids, MUFA = monounsaturated fatty acids (including *trans*-isomers of octadecenoic acid), PUFA = polyunsaturated fatty acids (including *trans*-isomers of octadecadienoic and octadecatrienoic acids), nd = not detected

contained even higher levels (1390–4170 μg/kg) of these contaminants. Moreover, there is a certain similarity between olive, palm kernel, palm, and coconut oils as all of them have been obtained from the pulp. They have high water contents and active lipases yielding partial acylglycerols (mainly diacylglycerols) during storage, which may then become the precursors of 3-MCPD esters. Virgin olive oils are produced by thrifty procedures where temperature does not exceed 40°C while pomace olive oils are commonly obtained by physical refination (degumming and bleaching) (Firestone 2005). Deodorisation of palm oils is even done at about 230–270°C for approximately 30 min (Basiron 2005).

If, for example, coffee creamers are consumed by an adult weighing 70 kg and all 3-MCPD esters are totally hydrolysed in the body by digestive enzymes (lipases) to 3-MCPD, his/her TDI level of 140 μg is reached after the consumption of 237–1077 g of the product, disregarding the free 3-MCPD level in other foodstuffs (Table 4). To achieve the TDI level of 140 μg by consuming cream aerosols, 192–1273 g of the product has to be eaten a day. Somewhat curious situation exists with bouillon cubes that usually contain dried acid-hydrolysed vegetable protein (acid-HVP) as an important flavour-active ingredient. A regulatory limit of 50 μg/kg dry matter content has been adopted for 3-MCPD in acid-HVP (EC 2001) that is added to bouillon cubes. However, bouillon cubes contained 3-MCPD bound in esters in the range of 380–670 μg/kg samples due only to the addition of hydrogenated fats. One portion of bouillon prepared from the bouillon cube (5.5 g, 250 ml) with the bound 3-MCPD content of 670 μg/kg contains 3-MCPD at the level of 3.7 μg, i.e. almost 3% of the TDI.

MCPD esters are principally processing contaminants. It has been shown, for example, that appropriate manufacturing controls the levels of MCPD esters in edible oils (Zelinková *et al.* 2006) but strategies to reduce these compounds in other food products have not yet been fully explored. Identifying primary routes of 3-MCPD esters exposure, their mitigation, metabolism,

Table 4. Contents of 3-MCPD released from 3-MCPD esters and TDI achieved by the product

Sample No.	Bound 3-MCPD		Bound 3-MCPD	TDI
	µg/kg fat	RSD	µg/kg sample	per g product
Coffee creamers				
1	1660	2.8	290	483
2	4480	4.7	590	237
3	770	2.4	290	1000
4	540	2.9	150	933
5	1620	0.5	300	467
6	1840	1.6	430	326
7	820	1.8	170	824
8	2240	2.8	450	311
9	700	2.9	130	1077
10	1520	0.6	540	259
11	1910	1.3	630	222
12	2080	1.2	730	192
13	3680	1.4	680	206
14	870	4.8	200	700
15	1260	1.3	200	700
Cream aerosols				
1	2530	3.1	660	212
2	2880	1.2	620	226
3	1340	2.4	310	452
4	380	1.2	110	1273
5	220	3.4	50	2800
6	770	1.1	220	636
7	830	1.9	280	500
8	1370	1.8	380	368
9	2410	0.5	730	192
10	910	0.7	230	609
Bouillon cubes				
1	2720	0.7	630	222
2	2650	1.1	670	209
3	3650	0.6	380	368
4	4840	0.7	380	368
5	3220	1.0	450	311

and/or biosynthetic pathways and biological effects are subjects for further research.

CONCLUSION

Hardening (hydrogenation) of edible oils is considered a low risk process, however, TFA and 3-MCPD in its bound form, representing a potential hazard, can arise during this process. Hardened fats are used in a number of foods that then can contain high levels of *trans*-fatty acids and 3-MCPD esters. This contamination can be minimised by using virgin or refined vegetable oils having low levels of these contaminants.

References

AOAC (1975): Official Methods of Analysis of the AOAC, 12th Ed. Association of Official Analytical Chemists, Washington.

Basiron Y. (2005). Palm oil. In: Shahidi F. (ed.): Bailey's Industrial Oil and Fat Products. 6th Ed. Vol. 2. Wiley-Interscience, Hoboken: 333–422.

Caponio F., Gomes T., Delcuratolo D. (2002): Qualitative and quantitative characterisation of the lipid fraction of bouillon cubes. European Food Research & Technology, **215**: 200–203.

Divinová V., Doležal M., Velíšek J. (2007): Free and bound 3-chloropropane-1,2-diol in coffee surrogates and malts. Czech Journal of Food Sciences, **25**: 39–47.

Divinová V., Svejkovská B., Doležal M., Velíšek J. (2004): Determination of free and bound 3-chloropropane-1,2-diol by gas chromatography with mass spectrometric detection using deuterated 3-chloropropane-1,2-diol as internal standard. Czech Journal of Food Sciences, **22**: 182–189.

Doležal M., Chaloupská M., Divinová V., Svejkovská B., Velíšek J. (2005): Occurrence of 3-chloropropane-1,2-diol and its esters in coffee. European Food Research & Technology, **221**: 221–225.

Dietary Guidelines for Americans (2005): USDA, January 2005. Available at http://www.health.gov/dietaryguidelines/dga2005/document/

EC (2001): European Commission Regulation No. 466/2001. Setting maximum levels for certain contaminants in foodstuffs. Official Journal of the European Communities L77/1, 16 March. Office for Official Publications of the European Communities, Luxembourg.

EURODIET (2000): Eurodiet Reports 2000. Available at http://eurodiet.med.uoc.gr/

Firestone D. (2005): Olive Oil. In: Shahidi F. (ed.): Bailey's Industrial Oil and Fat Products. 6th Ed. Vol. 2. Wiley-Interscience, Hoboken: 303–328.

Guidance for Industry and FDA (2005): FY 2005 MDUFMA, Small Business Qualification, Worksheet and Certification. Available at http://www.fda.gov/cdrh/mdufma/guidance/2005.pdf

Hamlet C.G., Sadd P.A. (2004): Chloropropanols and their esters in cereal products. Czech Journal of Food Sciences (Special Issue), **22**: 229–262.

IUPAC (1964): Standard Methods of the Oils and Fats, Division of the I.U.P.A.C. Met. I. B., 25th Ed. Butterworths, London.

JECFA (2001): Joint FAO/WHO Expert Committee on Food Additives. 57th Meeting, 5–14 June 2001, Rome.

Mozaffarian D., Katan M.B., Ascherio A., Stampfer M.J., Willett W.C. (2006): Trans fatty acids and cardiovascular disease. New England Journal of Medicine, **354**: 1601–1613.

Nollet L.M.L. (1996): Handbook of Food Analysis. Vol. 1. Dekker, New York.

SCF (2001): Opinion of the Scientific Committee on Food on 3-monochloro-propane-1,2-diol (3-MCPD) updating the SCF opinion of 1994. Adopted on 30 May 2001.

Svejkovská B., Novotný O., Divinová V., Réblová Z., Doležal M., Velíšek J. (2004): Esters of 3-chloropropane-1,2-diol in foodstuffs. Czech Journal of Food Sciences, **22**: 190–196.

WHO (2004): Gold strategy on diet, physical activity and health, WHA57.17, Geneva. Available at www.dpaslac.org/uploads/1164807694.pdf?

Zelinková Z., Svejkovská B., Velíšek J., Doležal M. (2006): Fatty acids esters of 3-chloropropane-1,2-diol in edible oils. Food Additives & Contaminants, **23**: 1290–1298.

Zelinková Z., Novotný O., Schůrek J., Velíšek J., Hajšlová J., Doležal M. (2007): New organochlorine contaminants in breast milk: 3-chloropropane-1,2-diol fatty acid esters. Food Additives & Contaminants, **24** (in press).

Received for publication December 28, 2006
Accepted after corrections April 25, 2007

Corresponding author:

Prof. Ing. Jan Velíšek, DrSc., Vysoká škola chemicko-technologická v Praze, Fakulta potravinářské a biochemické technologie, Ústav chemie a analýzy potravin, Technická 5, 166 28 Praha 6, Česká republika
tel.: + 420 220 443 177, fax: + 420 233 339 990, e-mail: jan.velisek@vscht.cz