Mass Transfer of Dichloromethane from EU Retail Roast and Ground Decaffeinated Coffee into Prepared Beverages

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Main Uses of Dichloromethane

- As a solvent in closed systems in industry for the production of:
- pharmaceuticals (antibiotics and other APIs, vitamins)
- fine chemicals,
- polymers (polycarbonates),
- drug & herb extracts, decaffeinated coffee, etc. in the pharma & food industry
- Solvent in special adhesives, road marking paint and cleaning fluids
- Laboratory solvent
- Estimated production: ~ 200.000 MT/year

Dichloromethane in decaffeination

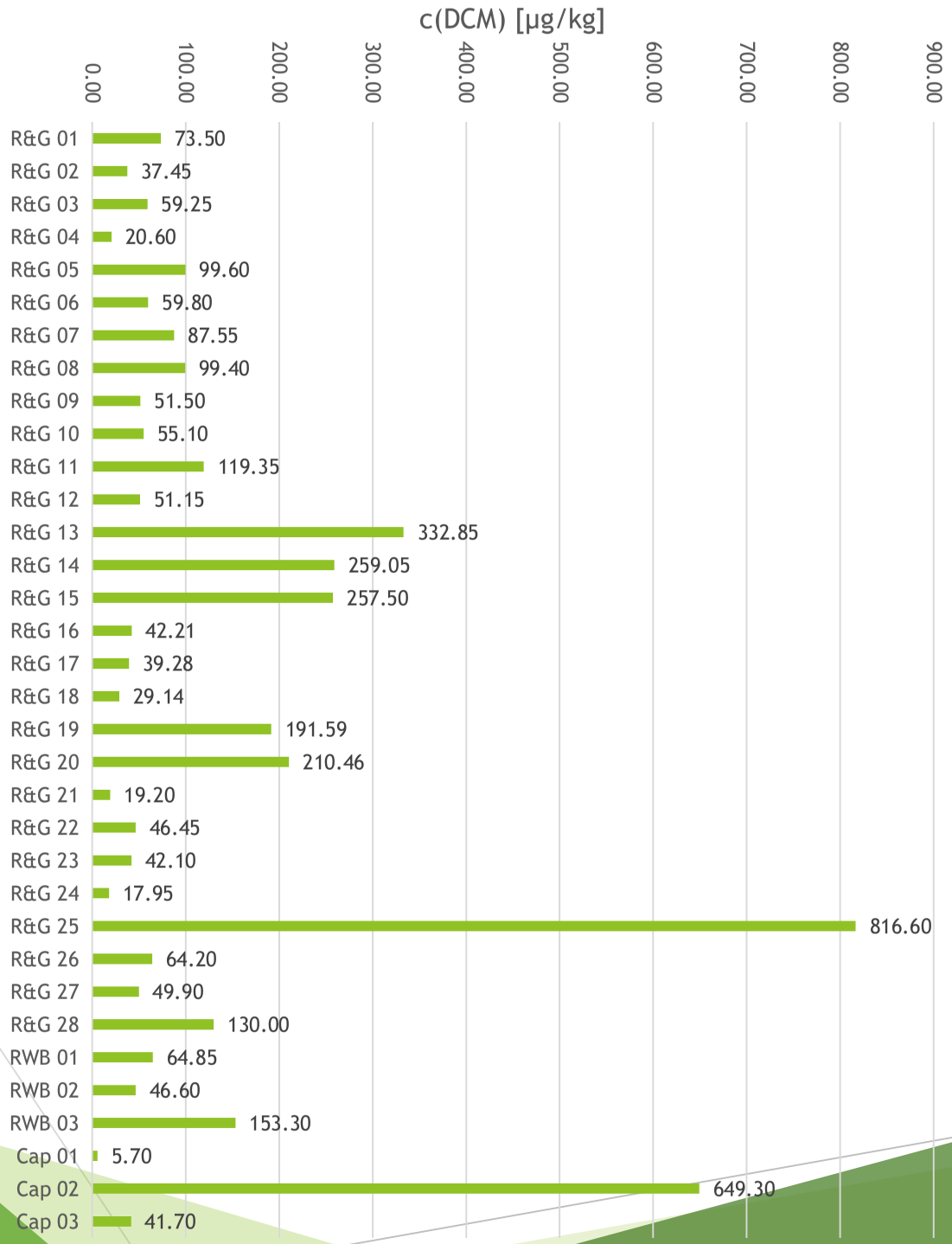
- DCM is widely used as an extraction agent in the decaffeination process of green coffee beans due to:
- Low boiling point (39°C) – easy to remove after the process
- Highly selective towards caffeine
- Relatively low amounts of energy required
- It appears to be the most widespread
- Very little consumption if compared to other industrial uses

Materials and Methods

- 34 commercial decaffeinated coffee samples
- 28 roasted and ground coffee samples
- 3 whole coffee beans
- 3 coffee capsules
- Analyses performed using Headspace-GC-MS on samples of 2 specific brewing methods: Drip Coffee and French Press

Results

- DCM concentrations in coffee samples well below EU (2 mg/kg) and USA (10 mg/kg) limits.
- Average DCM content: 0.127 mg/kg; Median: 0.059 mg/kg.
- Drip Coffee: Average DCM transfer rate 24.7%, Median 26.8%.
- French Press: Average DCM transfer rate 41.9%, Median 43.1%.


c(DCM) [µg/kg]
0.00
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
R&G 01
73.50
R&G 02
37.45
R&G 03
59.25
R&G 04
20.60
R&G 05
99.60
R&G 06
59.80
R&G 07
87.55
R&G 08
99.40
R&G 09
51.50
R&G 10
55.10
R&G 11
119.35
R&G 12
51.15
R&G 13
332.85
R&G 14
259.05
R&G 15
257.50
R&G 16
42.21
R&G 17
39.28
R&G 18
29.14
R&G 19
191.59
R&G 20
210.46
R&G 21
19.20
R&G 22
46.45
R&G 23
42.10
R&G 24
17.95
R&G 25
816.60
R&G 26
64.20
R&G 27
49.90
R&G 28
130.00
RWB 01
64.85
RWB 02
46.60
RWB 03
153.30
Cap 01
5.70
Cap 02
649.30
Cap 03
41.70

Sample	Sample Type	Original R&G Coffee	Drip Coffee		French Press	
		m(DCM) [µg] in 20 g Portion	m(DCM) [µg] in 0.3 L Portion	DCM Transfer [%]	m(DCM) [µg] in 0.3 L Portion	DCM Transfer [%]
R&G 01	R&G coffee, decaf	1.47	0.315	21.4	0.519	35.3
R&G 02	R&G coffee, decaf	0.75	0.094	12.5	0.191	25.5
R&G 03	R&G coffee, decaf	1.19	0.273	23.1	0.336	28.3
R&G 04	R&G coffee, decaf	0.41	<0.075	0.0	<0.075	0.0
R&G 05	R&G coffee, decaf	1.99	0.577	29.0	0.845	42.4
R&G 06	R&G coffee, 50% caffeine	1.20	0.214	17.9	0.344	28.8
R&G 07	R&G coffee, decaf	1.75	0.464	26.5	0.626	35.8
R&G 08	R&G coffee, decaf	1.99	0.659	33.1	0.906	45.6
R&G 09	R&G coffee, decaf	1.03	0.238	23.1	0.472	45.8
R&G 10	R&G coffee, decaf	1.10	0.294	26.7	0.448	40.7
R&G 11	R&G coffee, decaf	2.39	0.714	29.9	0.956	40.1
R&G 12	R&G coffee, decaf	1.02	0.235	22.9	0.398	38.9
R&G 13	R&G coffee, decaf	6.66	2.024	30.4	4.985	74.9
R&G 14	R&G coffee, decaf	5.18	3.080	59.4	5.246	101.2
R&G 15	R&G coffee, decaf	5.15	2.213	43.0	4.011	77.9
R&G 16	R&G coffee, decaf	0.84	0.230	27.3	0.387	45.8
R&G 17	R&G coffee, decaf	0.79	0.099	12.6	0.252	32.1
R&G 18	R&G coffee, decaf	0.58	<0.075	0.0	0.102	17.5
R&G 19	R&G coffee, decaf	3.83	1.029	26.9	1.880	49.1
R&G 20	R&G coffee, decaf	4.21	1.008	23.9	2.103	50.0
R&G 21	R&G coffee, decaf	0.38	<0.075	0.0	0.125	32.4
R&G 22	R&G coffee, decaf	0.93	0.341	36.7	0.560	60.2
R&G 23	R&G coffee, decaf	0.84	0.234	27.8	0.401	47.6
R&G 24	R&G coffee, decaf	0.36	<0.075	0.0	<0.075	0.0
R&G 25	R&G coffee, decaf	16.33	6.345	38.9	9.053	55.4
R&G 26	R&G coffee, decaf	1.28	0.378	29.4	0.600	46.7
R&G 27	R&G coffee, decaf	1.00	0.362	36.3	0.438	43.9
R&G 28	R&G coffee, decaf	2.60	1.131	43.5	1.296	49.8
RWB 01	Roasted, whole beans, decaf	1.30	0.307	23.7	0.449	34.6
RWB 02	Roasted, whole beans, decaf	0.93	0.294	31.6	0.496	53.2
RWB 03	Roasted, whole beans, decaf	3.07	1.111	36.2	1.743	56.9
Cap 01	R&G coffee capsules, decaf	0.11	<0.075	0.0	<0.075	0.0
Cap 02	R&G coffee capsules, decaf	12.99	6.050	46.6	11.454	88.2
Cap 03	R&G coffee capsules, decaf	0.83	<0.075	0.0	<0.075	0.0
	Average	**2.54**	**1.08**	**24.71**	**1.72**	**41.90**
	Median	**1.19**	**0.37**	**26.79**	**0.54**	**43.14**

Conclusions (1/2)

- DCM residues in all analysed samples are well below the safety limits established by EU and USA standards.
- Brewing processes like Drip Coffee and French Press significantly reduce the DCM content in the beverage
- The study supports the safety of DCM decaffeinated coffee for consumers

Conclusions (2/2)

- Breathing normally during a 24-hour day in the vicinity of the East Chicago Marina would lead to 10 times higher exposure than 4 cups of average DCM decaf (through a pathway of inhalation which is regarded as significantly more dangerous than ingestion) – Ref. Chemical Abstracts Service Number 75-09-2
- Comparing the toxicity of dichloromethane by ingestion with that of caffeine, it is evident that the former has a lethal dose (LD50) between 1410 and 2524 mg/kg of body weight, while the latter is equal to 367.7 mg/kg of body weight. It is therefore clear that caffeine, a molecule consumed in non-decaffeinated coffee, is on average 5 times more toxic than the mean used to extract it.

References and Acknowledgments

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