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Hygienic Investigation on Plastic Food Containers in Thailand

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Ninety samples of plastic food containers (cup, dish, plate, bowl, vegetable oil bottle, *etc.*) in Thailand were surveyed according to the Japanese Food Sanitation Law. Elution tests were carried out on polyethylene, polypropylene, polycarbonate, melamine, polystyrene and polyvinyl chloride. Material tests were carried out on polystyrene and polyvinyl chloride. Many samples contained large amounts of non-volatile residues. This suggests that the plastics contain large amounts of additives, such fillers, antioxidants, plasticizers, *etc.*

Keywords — polyethylene; polypropylene; polycarbonate; melamine; polystyrene; polyvinyl chloride; vinyl chloride monomer; non-volatile residue; plastic food container

Introduction

In Thailand as well as other countries, many kinds of plastics are used as containers for foods, including boiled soup, alcoholic beverages, oily food, *etc.* Under these conditions, some additives and monomers, which might be toxic to humans, might be released into the food. However, food sanitation law for plastics is not well-established in Thailand, and basically covers only the following items.¹⁾ 1) It should be clean. 2) It should be newly manufactured. 3) It should not have contaminants which result in the release of harmful substances into the food. 4) If it is made of polyvinyl chloride, in addition to item 3), vinyl chloride monomer (VCM) content should not exceed 1 mg/kg. However, few hygienic surveys of actual containers have been carried out.

Many samples of plastics were obtained from the Food & Drug Administration, the

Association of Consumer Protection, the Department of Industry at the Ministry of Technology & Science, and private companies manufacturing plastics, and material and elution tests were carried out according to the Japanese Food Sanitation Law,²⁾ with the aim of establishing a basis for a Thai Food Sanitation Law for plastic containers.

Materials and Methods

1. **Materials** — All samples were made in Thailand, and were collected from August 1981 to July 1982.

2. **Reagents** — Vinyl chloride standard solution (1 $\mu\text{g}/\text{ml}$) was purchased from Kanto Chemical Co., Ltd., Tokyo, Japan. Other reagents were of analytical grade.

3. **Apparatus** — a) Electric muffle : Lindberg Hevi-duty, U.S.A.

b) Infrared Spectrophotometer : EPI-G2 type, Hitachi Co., Ltd., Japan.

c) Gas Liquid Chromatograph Equipped with FID : Yanaco G-2800, Yanagimoto Co., Ltd., Japan.

TABLE I. Elution Test for Cup, Dish, Plate, etc.

No.	Plastic		Phenol (ppm)	Form- aldehyde (ppm)	Consump- tion of KMnO ₄ (ppm)	Heavy metals		Non-volatile residue	
	Kind	Shape				Pb (ppm)	Cd (ppm)	H ₂ O (ppm)	4% CH ₃ COOH (ppm)
1	Melamine	Cup	ND	ND	0.47	0.001	ND	34.0	22.0
2	Melamine	Plate	ND	ND	1.90	0.016	0.245	115.0	2,037.0
3	Melamine	Dish	ND	ND	1.26	0.007	0.005	46.0	55.0
4	Melamine	Dish	ND	ND	2.05	0.005	ND	80.0	103.0
5	Melamine	Dish	ND	ND	0.63	0.086	0.003	7.0	39.0
6	Melamine	Dish	ND	ND	7.11	0.012	ND	20.0	22.0
7	Melamine	Dish	ND	ND	1.42	0.013	ND	7.0	48.0
8	Melamine	Dish	ND	ND	1.74	0.002	ND	55.0	54.0
9	Melamine	Spoon	ND	ND	0.63	0.002	ND	34.0	103.0
10	Melamine	Dish	ND	ND	0.95	0.001	ND	28.0	61.0
11	Melamine	Dish	ND	ND	2.53	0.004	ND	43.0	106.0
12	Melamine	Dish	ND	ND	3.00	0.001	ND	5.0	10.0
13	Polyethylene	Cup			0.47	0.01	ND	30.0	21.0
14	Polyethylene	Cup			1.11	0.005	ND	25.0	30.0
15	Polyethylene	Cup			0.79	0.004	ND	63.0	88.0
16	Polyethylene	Dish			ND	0.003	ND	52.0	48.0
17	Polyethylene	Dish			0.32	0.001	ND	52.0	56.0
18	Polyethylene	Bucket			1.58	0.004	ND	34.0	54.0
19	Polyethylene	Straw			0.47	0.01	ND	58.0	50.0
20	Polyethylene	Straw			0.63	0.003	ND	54.0	51.0
21	Polyethylene	Straw			0.31	0.013	ND	48.0	47.0
22	Polyethylene	Plate			0.31	0.011	ND	49.0	46.0
23	Polyethylene	Plate			0.31	0.007	0.001	14.0	16.0
24	Polyethylene	Dish			ND	0.003	0.003	9.0	9.0
25	Polyethylene	Bowl			ND	0.01	0.001	9.0	10.0
26	Polyethylene	Dish			0.95	0.009	ND	30.0	29.0
27	Polyethylene	Dish			0.63	0.005	ND	29.0	30.0
28	Polyethylene	Dish			0.32	0.016	ND	44.0	51.0
29	Polyethylene	Dish			1.26	0.005	ND	39.0	51.0
30	Polyethylene	Dish			0.31	0.002	ND	29.0	50.0
31	Polypropylene	Dish			0.95	0.005	ND	20.0	30.0
32	Polypropylene	Dish			1.89	0.032	ND	13.0	18.0
33	Polypropylene	Dish			0.31	0.001	ND	12.0	27.0
34	Polypropylene	Dish			0.95	0.001	ND	1.0	12.0
35	Polypropylene	Plate			0.63	0.008	ND	9.0	12.0
36	Polypropylene	Plate			2.70	0.027	ND	9.0	8.0
37	Polypropylene	Plate			4.10	0.01	ND	4.0	9.0
38	Polypropylene	Plate			3.10	0.006	ND	5.0	3.0
39	Polypropylene	Plate			1.26	0.03	ND	10.0	9.0
40	Polypropylene	Plate			0.10	0.016	ND	8.0	6.0
41	Polypropylene	Plate			3.00	0.012	ND	4.0	5.0
42	Polypropylene	Plate			0.79	0.03	ND	3.0	6.0
Japanese regulation			Not detectable	Not detectable	10	Not more than 1 ppm as Pb		30	30

ND : less than 0.001 ppm.

TABLE II. Elution Test for Milk Bottles and Caps

No.	Plastic		Phenol (ppm)	Formal- dehyde (ppm)	Consump- tion of KMnO ₄ (ppm)	Heavy metal		Non-volatile residue (ppm)		
	Kind	Shape				Pb (ppm)	Cd (ppm)	Water	4% acetic acid	<i>n</i> -Heptane
1	PC	Milk bottle	ND	ND	3.95	0.004	ND	30.0	29.0	6.0
2	PP	Cap of bottle	ND	ND	0.16	0.007	ND	18.0	52.0	17.2
3	PC	Milk bottle	ND	ND	0.47	0.005	ND	30.0	14.0	6.0
4	PP	Cap of bottle	ND	ND	0.16	0.001	ND	49.0	55.0	19.0
5	PC	Milk bottle	ND	ND	0.79	0.002	ND	2.0	3.0	0.2
6	PP	Cap of bottle	ND	ND	1.10	0.005	ND	2.0	3.0	10.2
7	PC	Milk bottle	ND	ND	0.63	0.001	ND	5.0	2.0	0.4
8	PC	Milk bottle	ND	ND	1.26	0.003	ND	4.0	3.0	0.8
9	PP	Cap of bottle	ND	ND	1.90	0.004	ND	10.0	4.0	13.4
10	PC	Milk bottle	ND	ND	ND	ND	ND	2.0	5.0	1.8
11	PP	Cap of bottle	ND	ND	0.32	0.005	ND	4.0	10.0	12.0
12	PC	Milk bottle	ND	ND	0.16	ND	ND	3.0	1.0	1.2
13	PP	Cap of bottle	ND	ND	ND	ND	ND	2.0	6.0	9.4
14	PC	Milk bottle	ND	ND	0.95	0.003	ND	1.0	2.0	0.8
15	PP	Cap of bottle	ND	ND	1.42	0.004	ND	1.0	1.0	6.0
16	PC	Milk bottle	ND	ND	ND	ND	ND	2.0	2.0	2.4
17	PP	Cap of bottle	ND	ND	0.32	ND	ND	19.0	18.0	18.0
18	PC	Milk bottle	ND	ND	1.26	ND	ND	26.0	24.0	4.0
19	PP	Cap of bottle	ND	ND	0.79	ND	ND	12.0	24.0	6.0
20	PC	Milk bottle	ND	ND	0.16	ND	ND	9.0	6.0	1.2
21	PP	Cap of bottle	ND	ND	0.95	ND	ND	23.0	12.0	5.8
22	PC	Milk bottle	ND	ND	0.95	ND	ND	2.0	3.0	0.6
23	PP	Cap of bottle	ND	ND	0.63	ND	ND	6.0	13.0	5.4
24	PC	Milk bottle	ND	ND	ND	ND	ND	23.0	10.0	2.0
25	PP	Cap of bottle	ND	ND	1.26	ND	ND	6.0	13.0	9.0
26	PC	Milk bottle	ND	ND	0.63	ND	ND	20.0	30.0	6.0
27	PP	Cap of bottle	ND	ND	0.63	ND	ND	30.0	33.0	12.8
Japanese regulation			ND	ND	10.0	less than 1 ppm as Pb		30.0	30.0	30.0

PC : Polycarbonate. PP : Polypropylene. ND : less than 0.001 ppm.

4. Identification of Plastics—The burning test and the mechanical test³⁾ using an infrared spectrophotometer were carried out to identify plastics.

5. Procedure—a) Elution Test : A sample was washed with distilled water, then placed in extraction solution (water, 4% acetic acid or *n*-heptane), and heated to 60°C ; the container was covered with a watch glass and kept at 60°C for 30 min with occasional shaking. The solution was then tested for formaldehyde, phenol, consumption of KMnO₄, heavy metals and non-volatile residue.

b) Material Test : The following items were tested according to the Japanese Food Sanitation

Law.²⁾ Cadmium, lead and volatile substances for polystyrene. cadmium, lead, dibutyl tin, cresol phosphoric acid ester, vinyl chloride and phthalic esters for polyvinyl chloride.

Results and Discussion

1. Cup, Dish, Plate, etc.

The analytical results are shown in Table I.

Almost all samples made of melamine and polyethylene were over the limit (30 ppm) for non-volatile residues. No. 2 had an extremely large value. This sample was a yellow-colored plate (diameter ; 22.7 cm). In this

TABLE III. Elution Test for Vegetable Oil Bottles and Caps

(unit : ppm)

No.	Plastic		Consumption of KMnO ₄	Heavy metal		Non-volatile residue		
	Kind	Shape		Pb	Cd	Water	4 % Acetic acid	<i>n</i> -Heptane
1	PVC	Bottle	0.32	ND	ND	14.0	25.0	5.6
2	PP	Cap of bottle	0.95	ND	ND	43.0	58.0	103.0
3	PVC	Bottle	0.32	ND	0.001	30.0	36.0	6.4
4	PP	Cap of bottle	0.63	ND	0.002	84.0	68.0	281.5
5	PVC	Bottle	0.95	0.002	0.002	36.0	41.0	8.8
6	PP	Cap of bottle	2.53	ND	ND	76.0	82.0	984.0
7	PVC	Bottle	2.84	ND	0.001	20.0	23.0	12.0
8	PP	Cap of bottle	9.48	0.020	0.010	46.0	68.0	394.0
9	PVC	Bottle	5.68	0.002	0.002	11.0	21.0	10.2
10	PVC	Bottle	0.95	ND	0.002	62.0	63.0	13.8
11	PVC	Bottle	2.21	ND	ND	12.0	24.0	6.0
12	PVC	Bottle	0.32	0.003	0.002	31.0	45.0	12.4
13	PP	Cap of bottle	0.95	0.003	0.003	52.0	34.0	379.0
14	PVC	Bottle	0.63	0.002	0.002	55.0	55.0	11.0
15	PP	Cap of bottle	0.95	0.004	0.002	52.0	105.0	447.0
Japanese regulation			10.00	1 ppm as Pb		30.0	30.0	30.0

PVC : polyvinyl chloride. PP : polypropylene. ND : less than 0.001 ppm.

TABLE IV. Material Test for Vegetable Oil Bottles

No.	Plastic		Heavy metals		Vinyl chloride	Dibutyl tin compound	Cresol phosphoric acid ester	Dimethyl phthalate	Diethyl phthalate	Dibutyl phthalate	Diocetyl phthalate
	Kind	Shape	Pb	Cd							
1	PVC	Bottle	0.70	2.20	11.20	ND	ND	23.4	ND	16.8	ND
3	PVC	Bottle	1.00	0.90	0.75	ND	ND	ND	ND	9.6	ND
5	PVC	Bottle	0.50	0.50	13.43	ND	ND	ND	ND	19.2	ND
7	PVC	Bottle	1.10	0.60	1.19	ND	ND	ND	ND	16.8	305.9
9	PVC	Bottle	0.70	0.03	3.43	ND	ND	ND	ND	ND	ND
10	PVC	Bottle	0.10	0.03	6.56	ND	ND	ND	ND	4.0	ND
11	PVC	Bottle	0.40	0.40	1.64	ND	ND	ND	27.1	ND	ND
12	PVC	Bottle	0.30	0.02	1.04	ND	ND	ND	ND	ND	ND
14	PVC	Bottle	1.20	0.12	3.43	ND	ND	ND	ND	ND	29.5
Japanese regulation			1 ppm as Pb		1.00	100	1,000	—	—	—	—

PVC : polyvinyl chloride.

case, the coating agent on the plate might have been eluted with water and 4 % acetic acid solution.

2. Milk Bottles and Caps

Milk bottles were made of polycarbonate, and the caps were made of polypropylene. All of them were imported from Japan, England or the U.S.A. The analytical results are shown in Table II.

3. Vegetable Oil Bottles and Caps

Vegetable oil bottles were made of polyvinyl chloride, and the caps were made of polypropylene. All of the samples had been manufactured in Thailand. The analytical results are shown in Tables III and IV.

Table III shows that polypropylene had high levels of non-volatile residues. When *n*-heptane was used as a solvent, the samples gave extremely high values. Some of them did not retain their original shape after the

TABLE V. Elution Test and Material Test for Polystyrene

Sample	Elution test (ppm)					Material test (ppm)		
	Consumption of KMnO_4	Heavy metals		Non-volatile residue		Heavy metals		Volatile substances
		Pb	Cd	H_2O	4% CH_3COOH	Pb	Cd	
A	0.63	0.021	0.007	8.7	13.7	1.50	0.20	1685.0
B	2.37	0.001	0.003	11.3	20.0	0.30	0.03	1682.8
C	1.11	0.004	0.002	20.0	12.5	0.10	0.06	1141.2
D	2.68	ND	ND	8.8	17.5	ND	ND	ND
E	1.71	0.012	0.001	21.0	14.0	ND	0.06	6137.6
F	0.32	0.004	0.002	24.0	12.0	0.70	0.06	231.6
Japanese regulation	10.00	1 ppm as Pb		30.0	30.0	100	100	5000

Note : Samples are unprocessed polystyrene granules.

elution test. Table IV shows that these samples had high contents of vinyl chloride monomer. Dimethyl, dibutyl and dioctyl tin dichloride were not detected, while an unknown spot was detected from each sample on a paper chromatogram.

4. Polystyrene

All of the samples of polystyrene were granular raw materials and not food con-

tainers. The analytical results are shown in Table V.

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