THE SOLUBILITY OF AN ENAMEL ON A SET OF DINNERWARE IN CERTAIN LIQUIDS AND IN FOOD

Cups and other articles from a set of enameled dinnerware were investigated to determine the solubility of the enamel in certain liquids, and in food during normal use in the household.

MATERIALS AND TEST CONDITIONS

Cups of the enameled ware were tested with hot aqueous solutions of vinegar (5% and 0.5%), lactic acid (1%), Tide 1%, and soluble coffee, together with brewed tea and tap water, in the manner described in an initial report of June 1, 1955.

Sets of the dinnerware were also used by a subject in the customary manner in the household. Duplicate samples of the food eaten were handled exactly as that which was eaten, by introducing comparable portions into the proper serving dish, plate, bowl or cup, so that the food submitted for analysis during the test period had essentially the same type and duration of contact as that eaten by the subject. The lead content of 24-hour samples of urine and feces of the subject, as well as that of the food, was determined over the period of three weeks during which the tableware was used, and over periods prior to and following the test period, in order to compare the amounts of lead found in these materials before, during, and after the use of the tableware by the subject. (The intake of lead in food and beverages of the subject and his output of lead in the feces and urine had been followed day by day for a prolonged period prior to the initiation of this experiment, so that the pattern of his metabolism of lead was well known. The facts are

illustrated satisfactorily by the data obtained during one week just prior to that of the first use of the dinnerware.)

RESULTS

The results of the chemical tests of the cups are tabulated in Table 1.

The results obtained in the use test are recorded in chronological order in Table 2. The data obtained over a period of one week prior to the use of the tableware, and over the three week period of use starting August 29, 1955, are given (Table 2). The results obtained during the week of September 19-25, following the termination of the use of the dinnerware by the subject, have also been included for purposes of comparison.

DISCUSSION

The accelerated test (hot 5% vinegar) showed that appreciable quantities of lead were removed from the enamel. The first period of contact of a series of three cups with hot 5% vinegar released lead into the vinegar in the average concentration of 290 ppm. The average concentration of 141 ppm resulted when the same cups, after treatment with a solution of 1% Tide, were again tested with hot 5% vinegar. The tests with hot 0.5% vinegar proved that this material also extracted significant quantities of lead from the enamel. The average concentration of 117 ppm was found in the 0.5% vinegar used in the three cups that were tested. Soluble coffee leached lead from the glaze to produce the average concentration of 32 ppm in coffee that was allowed to remain in the cups for a period of 30 minutes. Tea extracted somewhat less lead from the enamel, the average

concentration reaching approximately 11.5 ppm. A solution containing 1% Tide also extracted significant quantities of lead. The average concentration of 5.3 ppm was found in the 1% Tide solution following the first wash. The release of lead from the enamel into 1% Tide increased to the average value of 11.7 ppm following the second treatment. Treatment of the cups with hot water also resulted in extraction of lead from the glaze, three cups yielding the average quantity of 0.22 ppm, ~~compared to the average of 0.06 ppm obtained by treating the ware with hot water.~~

It was also noted that coffee and tea stained the cups heavily.

As may be seen in Table 2, the food introduced into the dinnerware became grossly contaminated with lead. The lead in the food averaged 2.27 mg. per day during the first week of use, 4.14 mg. per day during the second week, and 1.94 mg. per day during the third week, in contrast to the average of only 0.13 mg. per day during the week of August 22-29.

The increase in the lead intake by the subject was reflected by a prompt increase in the lead output in the urine. The average concentration in the urine during the week of August 22-29, immediately prior to the use of the dinnerware (a period which yielded characteristic data), was 0.05 mg. per liter (0.043 mg. per day). The average quantity of lead excreted in the urine increased progressively during the test period, being 0.09 mg. per day during the first week, 0.21 mg. per day during the second, and 0.19 mg. per day during the third. The average level of lead concentration in the urine increased progressively from the normal level of 0.039 mg. per liter, to 0.09, 0.20 and 0.21 mg. per liter, respectively during the first, second and third weeks of the test period. The lead content of the feces also

increased promptly in accordance with the ingestion of increased quantities of lead with the food and beverages, and that in the blood increased from the average pre-experimental value of 0.03 to 0.055 mg. per 100 grams of whole blood.

It was obvious, therefore, that the intake and absorption of lead resulting from the use of this dinnerware over the short test period was sufficient to be hazardous if it were to be continued over a period of months. Since no information pertinent to the primary purposes of this experiment could be obtained by its prolongation (extensive observations have been carried out previously on human subjects at this approximate level of ingestion), and since this subject would be rendered useless for further investigations of this type, if the experiment were prolonged, the use of the tableware was terminated. Even after this brief period of abnormal lead ingestion, the output of lead in the urine decreased only gradually on the termination of the experimental exposure. It did not return to an approximately normal level (that of the week of August 22-29) until November 1, 1955. Likewise the concentration of lead in the blood remained elevated for about 3 weeks.

The ready solubility of the enamel in the coffee suggests that this material was an important source of the lead ingested by the subject during the test period.

CONCLUSION

The release tests, as well as the use test, revealed convincingly that the type of enamel used in producing the dinnerware was unsatisfactory.

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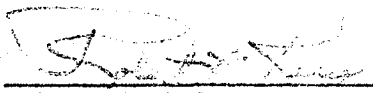
Approved: 
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TABLE 1

DESCRIPTION OF TESTS AND THE RESULTS OF THE CONTACT OF ENAMELED CUPS WITH CERTAIN MATERIALS

Test	Material	MGS. LEAD IN 150 ML. Cup 1	Cup 2	Cup 3	Average	Average Lead in ppm
A	Hot tap water	0.04	0.03	0.03	0.043	0.22
B-1	Hot 1% Tide	0.71	0.77	0.93	0.80	5.35
C-1	Hot 5% Vinegar	30.31	44.31	47.75	43.8	291.9
B-2	Hot 1% Tide	1.86	1.49	2.24	1.9	11.75
C-2	Hot 5% Vinegar	19.45	23.05	21.50	21.3	142.2
Control	Hot 5% Vinegar	0.0012				
D	Hot 1% Lactic Acid	18.84	26.19	23.38	22.8	152.0
E	Soluble coffee	5.43	5.24	4.24	5.0	33.10
Control	Soluble coffee	0.000				
F	Soluble tea	1.93	1.43	1.80	1.7	11.44
Control	Soluble tea	0.0015				
G	Hot 0.5% Vinegar	18.05	17.75	16.0	17.3	117.0

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TABLE 2

LEAD IN THE URINE, BLOOD AND FECES, AND IN THE FOOD
BEFORE, DURING, AND AFTER THE USE OF THE DINNERWARE

CONTROL PERIOD

	LEAD IN URINE IN MILLIGRAMS		LEAD IN MILLIGRAMS		LEAD IN BLOOD
Date	Per 24-hours	Per Liter	In Feces	In Food	Mg. per 100 g.
8-22-55	0.040	0.04	0.16	0.12	
8-23-55	0.052	0.06		0.09	
8-24-55	0.053	0.06	0.33	0.12	
8-25-55	0.038	0.06		0.12	
8-26-55	0.034	0.03		0.12	0.03
8-27-55	0.040	0.06	0.29	0.09	
8-28-55	0.044	0.05		0.27	
Average	0.043	0.05	0.11	0.13	0.03

Table 2 (continued)

BEGINNING OF TEST PERIOD

Date	LEAD IN URINE IN MILLIGRAMS		LEAD IN MILLIGRAMS		LEAD IN BLOOD
	Per 24-hours	Per Liter	In Feces	In Food	Mg. per 100 g.
8-29-55	0.066	0.09	0.39	3.24	
8-30-55	0.061	0.05		1.26	
8-31-55	0.060	0.09	2.88*	0.90	
9- 1-55	0.088	0.10		1.83	0.03
9- 2-55	0.100	0.07	3.20	5.43	
9- 3-55	0.115	0.12	3.35	2.91	
9- 4-55	0.140	0.14		0.32	
Average	0.09	0.092	1.43	2.27	
9- 5-55	0.116	0.15	4.24	0.51	
9- 6-55	0.152	0.16		5.88	
9- 7-55	0.160	0.13	4.48	3.42	
9- 8-55	0.234	0.16		13.62	
9- 9-55	0.213	0.28	11.35	0.81	0.06
9-10-55	0.232	0.25	4.61	2.91	
9-11-55	0.348	0.29		1.83	
Average	0.208	0.20	3.53	4.14	

*First evacuation after ingestion of food contaminated by the dinnerware, the initial value (0.39mg.) being the result of the ingestion of lead in ordinary food during the day or two before the test began. From here on during the test period, the quantities recorded, less an amount ranging between 0.10 and 0.30 mg. which may be presumed to have been in the food and beverages, are to be regarded as the lead contributed by the dinnerware to the food and beverages consumed by the subject.

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Table 2 (continued

Date	LEAD IN URINE IN MILLIGRAMS Per 24-hours	Per Liter	LEAD IN MILLIGRAMS In Feces	In Food	LEAD IN BLOOD Mg. per 100 g.
9-12-55	0.190	0.21	2.91	1.14	
9-13-55	0.220	0.21		0.57	
9-14-55	0.184	0.20	3.51	1.89	0.05
9-15-55	0.147	0.23	2.60	1.23	
9-16-55	0.250	0.18	2.72	2.40	
9-17-55	0.147	0.23	3.43	5.85	
9-18-55	0.216	0.22	3.31	0.48	
Average	0.193	0.21	2.64	1.94	
		END OF TEST PERIOD			
9-19-55	0.204	0.28		0.12	
9-20-55	0.173	0.18	1.64	0.30	
9-21-55	0.168	0.20	0.24**	0.21	0.055
9-22-55	0.113	0.21	0.33	0.15	
9-23-55	0.133	0.23	0.30	0.12	
9-24-55	0.140	0.13	0.28	0.15	
9-25-55	0.119	0.23		0.21	
Average	0.150	0.20	0.40	0.18	

** The first evacuation after the alimentary tract had been emptied of any residuum of food ingested during the test period. The abrupt decrease to the normal level of ingestion is characteristic of the response to the cessation of abnormal ingestion.