

# 全国の行政検査結果(1996年度)を基にした食品中の保存料 の濃度実態及び摂取量の推定

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**Report**

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**Estimation of Preservative Concentrations in Food and Their Daily Intake Based on Official Inspection Results in Japan in Fiscal Year 1996\***

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Mean concentration and daily intake of preservatives were estimated based on the results of analysis of 112,131 samples of food obtained at official inspections by Japanese local governments in fiscal year 1996. The mean concentration of benzoic acid was 7.8% of the allowable limits, and those of dehydroacetic acid, *p*-hydroxybenzoic acid, propionic acid and sorbic acid were 0.4%, 2.9%, 1.7% and 14.1%, respectively. Daily intakes of these preservatives per person estimated from the concentrations and daily consumption of the foods were 11.0 mg, 0.0474 mg, 1.06 mg, 5.43 mg and 26.0 mg, respectively, and assuming a body weight of 50 kg, these amounts of benzoic acid, *p*-hydroxybenzoic acid, and sorbic acid were 4.4%, 0.2% and 2.1% of the acceptable daily intakes, respectively. These values were similar to those based on the results of the official inspection in fiscal year 1994.

**Key words:** preservative; concentration in food; daily intake; benzoic acid; dehydroacetic acid; *p*-hydroxybenzoic acid ester; propionic acid; sorbic acid; official inspection

**Introduction**

Acceptable daily intakes (ADIs) of food additives have been established by the Joint FAO/WHO Food Standard Programme<sup>1)</sup> to ensure that consumers can always confidently choose healthy and enjoyable diets from a safe and varied food supply. Estimation of the daily intake of food additives, especially in comparison with ADI, is very important to ensure public health. Repeated studies are necessary to obtain

better estimates.

Estimates of the daily intake of 16 food additives based on the results of official inspection in Japan in fiscal year 1994 have been reported<sup>2-6)</sup>. We repeated the same surveillance study on the same 16 food additives based on the results of official inspection in fiscal year 1996. In the present study, we estimated the mean concentrations of five preservatives, benzoic acid, dehydroacetic acid, *p*-hydroxybenzoic acid, propionic acid, and sorbic acid in processed foods, and deduced the daily intakes of these preservatives per person from the mean concentration and amounts of foods consumed.

**Methods**

The methods used were the same as those previously described<sup>2, 3)</sup>, but this time the new official inspection results obtained in fiscal year

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\* Concentration of Food Additives in Foods and the Daily Intake in Japan (Report No. 5) [Report No. 4 was entitled "Evaluation of the Contents of BHA, BHT, Propylene Glycol, and Sodium Saccharin in Foods and Estimation of Daily Intake Based on the Results of Official Inspection in Japan in Fiscal Year 1994", published in this Journal, 39, 89-100 (1998).]

**Table 1.** Number of Local Governments that Performed Inspection of Preservatives and Number of Food Samples Inspected

Preservative	Number of local governments	Sample number		
		Domestic	Imported	Total
Benzoic acid	90	24,517	3,755	28,272
Dehydroacetic acid	64	19,303	3,310	22,613
<i>p</i> -Hydroxybenzoic acid	81	16,320	2,579	18,899
Propionic acid	47	569	258	827
Sorbic acid	98	37,497	4,023	41,520
Total	99	98,206	13,925	112,131

1996 were used.

### 1. Investigation methods and items studied

#### a) Questionnaire

A questionnaire concerning the results of official inspections for food additives from April 1, 1996 to March 31, 1997 (Japanese fiscal year 1996) was sent by the Division of Food Chemistry, Ministry of Health and Welfare of Japan<sup>7)</sup> to all 108 local governments which are obliged to establish public health centers by the Regional Public Health Law.

#### b) Items queried

The following preservatives were investigated in this study: benzoic acid (benzoic acid and sodium benzoate), dehydroacetic acid (sodium dehydroacetate), *p*-hydroxybenzoic acid (ethyl, propyl, *i*-propyl, butyl, and *i*-butyl esters of *p*-hydroxybenzoic acid), propionic acid (propionic acid, calcium propionate, and sodium propionate), and sorbic acid (sorbic acid and potassium sorbate). Substances in the above parentheses are permitted to be used as preservatives in Japan. The concentrations of *p*-hydroxybenzoic acid esters are represented as *p*-hydroxybenzoic acid, and the concentrations of other preservatives are represented as free acid, in accordance with the Japanese Standards for Use of Food Additives<sup>8)</sup>. The names of both imported and domestic foods, the numbers of food samples inspected, the numbers of samples in which these preservatives were detected, the maximum, minimum, and mean concentrations in the samples in which they were detected, and the detection limit of the analysis for each preservative were recorded.

#### c) Sampling of foods and methods of determining preservatives

In accordance with the annual program of each local government, samples were chosen by food inspectors in markets or factories manufacturing food products. The GC method was used to analyze propionic acid<sup>9)</sup> and HPLC methods for other preservatives<sup>10)</sup>, as required by the Environmental Health Bureau of the Ministry of Health and Welfare.

### 2. Analyses of reports from the local governments

Data sent from the local governments were classified according to the categories of foods in the standards for use of food additives<sup>8)</sup>. Foods in which these compounds are not allowed to be used were categorized according to the Guide for Categorization of Food<sup>11)</sup>. Concentrations of these preservatives were regarded as 0 mg/kg, as in previous papers<sup>2), 3)</sup>, when they were not detected.

### 3. Calculations and estimation of daily intake

The daily intakes of the preservatives per person were estimated based on the mean concentrations of these preservatives in all foods including nonpermissible foods obtained in the present study and the daily food consumption levels reported by the Investigation Group of the Daily Intake of Food Additives in Japan (Japanese group)<sup>12)</sup>. The consumption of foods in the fiscal year 1996 was assumed to be the same as that in the previous paper<sup>3)</sup>. When the consumption level of a food was unknown, 0.1 g was assumed to be the daily consumption per person, as described in previous papers.<sup>2), 3)</sup>

## Results

### 1. Questionnaire return and number of samples

One hundred local governments out of the 108 local governments (92.6%), *i.e.*, 43 prefectures, 34 cities, and 23 wards, representing most of Japan, replied to the questionnaire. Preservatives were inspected by 99 governments (99.0% of the 100 local governments replied). Inspection for benzoic acid was performed by 90 local governments, for dehydroacetic acid by 64 local governments, for *p*-hydroxybenzoic acid by 81 local governments, for propionic acid by 47 local governments, and for sorbic acid by 98 local governments. The total number of food samples inspected for these preservatives was 112,131, of which 98,206 were samples of domestic food. The total sample number in 1996 was 1.5 times that in 1994 (Table 1). The results obtained in the present study were therefore considered to be highly reliable, since inspection results were received from most of the local governments in Japan and large numbers of samples were tested.

### 2. Concentrations of preservatives in foods

Preservatives were detected in 16,660 (14.9%) of the total of 112,131 food samples.

#### a) Benzoic acid

Benzoic acid was detected in 1,345 (4.8%) out of the 28,272 samples tested (Table 2). The mean concentration of benzoic acid was 7.8% of the allowable limit according to the Food Sanitation Law<sup>8)</sup>. No benzoic acid was detected in margarine (30 samples), which is one of the foods in which benzoic acid is allowed. Benzoic acid was detected in 586 (2.3%) out of 25,430 samples in which the compound is not allowed to be used (nonpermissible foods), such as milk products (14.5% of samples inspected), seasonings (14.0%), health foods (12.1%), dried fruits (8.2%), and other foods. Some local governments did not break down nonpermissible foods in which preservatives was detected. In this case, foods are not shown in the list of the breakdown in tables. Milk products<sup>13), 14)</sup> and dried fruits<sup>14), 15)</sup> are known to contain naturally occurring benzoic acid. Benzoic acid in some seasonings may have been carried over from soy sauce which is one of the allowable foods.

#### b) Dehydroacetic acid

Dehydroacetic acid was detected in 16 out of the 22,613 samples tested (0.1%) (Table 3). The compound was detected only in cheese (14 out of 510 samples, 2.7%) among allowable foods. The mean concentration in cheese was 0.0060 g/kg, and was 1.2% of the allowable limit (0.50 g/kg). Dehydroacetic acid was detected at a concentration of 0.87 g/kg in 2 samples (0.1%) out of 2,829 samples of confectionery ("kashi"), a food in which sodium dehydroacetate is not allowed to be used, and the mean concentration was 0.000615 g/kg in all samples of confectionery.

#### c) *p*-Hydroxybenzoic acid esters

Ethyl, propyl, *i*-propyl, butyl, and *i*-butyl esters of *p*-hydroxybenzoic acid are allowed as food additives in Japan<sup>8)</sup>, and the limits of these esters are regulated as the total amount of *p*-hydroxybenzoic acid. All results in the present paper are reported as the total amount of *p*-hydroxybenzoic acid, in accordance with the regulation.

*p*-Hydroxybenzoic acid was detected in 652 (3.4%) out of the 18,899 samples tested (Table 4). The mean concentration in all foods in which the esters of the compounds are allowed to be used was 3.2% of the limits. The highest detection rate (47.9%) was observed in soy sauce, and the mean concentration in all tested soy sauce samples was also the highest: 0.0301 g/kg. This concentration corresponded to 12.1% of the permissible limit. *p*-Hydroxybenzoic acid was detected in 16 out of the 16,189 samples (0.1%) of foods in which the esters are not allowed to be used, and the mean concentration was 0.000063 g/kg. Most foods in which *p*-hydroxybenzoic acid was detected were seasoned with soy sauce.

#### d) Propionic acid

Propionic acid was determined in 827 foods in fiscal year 1996. The number of inspected samples was about 1/20 or less than those for other preservatives in the present study. Propionic acid was detected in 59 samples (7.1%) (Table 5). The highest detection rate (11.5%) among permissible foods was found in bread. Bread was also the highest in mean concentration (0.0641 g/kg) and ratio to the permissible limit (2.6%). The mean concentration of propionic acid in all foods in which propionic acid is allowed to be

Table 2. Concentration of Benzoic Acid in Foods and Estimated Daily Intake

Foods categorized by the standards for use	Regulation (g/kg)	Number of samples		Detection rate (%)	Detected samples		Samples tested		Daily intake per person		Contribution to total intake (%)
		Tested	Detected		Mean conc. (g/kg)	Ratio to limit (%)	Mean conc. (g/kg)	Ratio to limit (%)	Food (g)	Benzoic acid (mg)	
Caviar	2.5	6	5	83.3	0.406	16.2	0.338	13.5	0.1	0.034	0.3
Fruit paste for making confectionery	1.0	8	2	25.0	0.040	4.0	0.010	1.0	0.1	0.001	0.0
Margarine	1.0	30	0	0.0	0.000	0.0	0.000	0.0	1.9	0.000	0.0
Nonalcoholic beverages	0.60	1,791	549	30.7	0.198	33.0	0.061	10.1	150.2	9.125	82.7
Syrup	0.60	31	9	29.0	0.267	44.4	0.077	12.9	0.1	0.008	0.1
Soy sauce	0.60	976	194	19.9	0.282	47.0	0.056	9.4	20.7	1.161	10.5
Nonpermissible foods*	—	25,430	586	2.3	0.136	—	0.003	—	594.8	—	—
Total (or average)	—	28,272	1,345	( 4.8)	—	—	—	—	767.9	—	—
Breakdown of nonpermissible foods											
(detected only)**											
Preserved foods boiled down in soy sauce, "tsukudani"	—	936	49	5.2	0.081	—	0.004	—	3.0	0.013	0.1
Processed marine products	—	1,496	7	0.5	0.375	—	0.002	—	9.9	0.017	0.2
Fish paste products	—	2,981	3	0.1	0.473	—	0.000	—	13.0	0.006	0.1
Seasonings	—	401	56	14.0	0.203	—	0.028	—	3.6	0.102	0.9
Processed vegetables and fruits	—	1,156	17	1.5	0.150	—	0.002	—	0.1	0.000	0.0
Boiled beans	—	488	15	3.1	0.061	—	0.002	—	2.4	0.005	0.0
Fruit sauce	—	279	3	1.1	0.037	—	0.000	—	3.0	0.001	0.0
Condensed or diluted seasoned soy sauce, "tare" or "tsuyu"	—	253	13	5.1	0.101	—	0.005	—	0.4	0.002	0.0
Soybean paste, "miso"	—	418	1	0.2	0.020	—	0.002	—	15.7	0.030	0.3
Soy sauce-pickled foods, "shoyu-zuke"	—	1,363	71	5.2	0.082	—	0.004	—	6.1	0.026	0.2
Rice bran-pickled radish, "takuan-zuke"	—	415	2	0.5	0.020	—	0.000	—	4.6	0.000	0.0
Soy bean paste-pickled foods, "miso-zuke"	—	96	2	2.1	0.023	—	0.000	—	0.3	0.000	0.0
Salt-pickled foods, "shio-zuke"	—	287	11	3.8	2.079	—	0.080	—	2.9	0.231	2.1
Vinegar-pickled foods, "su-zuke"	—	627	6	1.0	0.042	—	0.000	—	2.1	0.001	0.0
Jam	—	100	1	1.0	0.040	—	0.000	—	1.1	0.000	0.0
Cheese	—	399	36	9.0	0.016	—	0.001	—	3.4	0.005	0.0
Noodles	—	271	7	2.6	0.064	—	0.002	—	42.2	0.070	0.6
Canned or bottled foods	—	264	1	0.4	0.410	—	0.002	—	8.4	0.013	0.1
Meat products	—	2,136	11	0.5	0.145	—	0.001	—	10.3	0.008	0.1

Table 2. Continued

Foods categorized by the standards for use	Regulation (g/kg)	Number of samples		Detection rate (%)		Detected samples		Samples tested		Daily intake per person		Contribution to total intake (%)
		Tested	Detected	Mean conc. (g/kg)	Ratio to limit (%)	Mean conc. (g/kg)	Ratio to limit (%)	Food (g)	Benzoic acid (mg)			
										Mean conc. (g/kg)	Ratio to limit (%)	
Confectionery, "kashi"	—	2,886	25	0.9	—	0.001	—	43.7	0.027	0.2	0.0	
Dried fruits	—	331	27	8.2	—	0.005	—	0.8	0.004	0.0	0.0	
Pre-cooked foods, "sozai"	—	2,738	116	4.2	—	0.004	—	19.7	0.070	0.6	0.6	
Milk products	—	311	45	14.5	—	0.002	—	31.4	0.061	0.6	0.6	
Soaked foods in syrup	—	90	2	2.2	—	0.000	—	0.1	0.000	0.0	0.0	
Juice	—	61	1	1.6	—	0.000	—	11.2	0.004	0.0	0.0	
Boil-in-the-bag foods	—	126	3	2.4	—	0.003	—	1.4	0.004	0.0	0.0	
Health foods	—	33	4	12.1	—	0.002	—	0.1	0.000	0.0	0.0	
Daily intake of benzoic acid										11.031	100.0	

\* Breakdown of nonpermissible foods in which benzoic acid was not detected: dried marine products 418, wine 297, sweetened red bean paste "an" 278, marine products 205, lees-pickled foods "kasu-zuke" 95, roe 88, bread 84, koji-pickled foods 78, flour paste 67 samples, etc.

\*\* Foods categorized as "nonpermissible foods" or "other foods" were omitted from the breakdown.

Table 3. Concentration of Dehydroacetic Acid in Foods and Estimated Daily Intake

Foods categorized by the standards for use	Regulation (g/kg)	Number of samples		Detection rate (%)	Detected samples		Samples tested		Daily intake per person		Contribution to total intake (%)
		Tested	Detected		Mean conc. (g/kg)	Ratio to limit (%)	Mean conc. (g/kg)	Ratio to limit (%)	Food (g)	Dehydroacetic acid (mg)	
Cheese	0.50	510	14	2.7	0.22	44.0	0.00604	1.2	3.4	0.0205	43.3
Butter	0.50	16	0	0.0	0	0.0	0.00000	0.0	0.9	0.0000	0.0
Margarine	0.50	44	0	0.0	0	0.0	0.00000	0.0	1.9	0.0000	0.0
Nonpermissible foods*	—	22,043	2	0.0	0.87	—	0.00008	—	761.7	—	—
Total (or average)	—	22,613	16	(0.1)	—	—	—	—	767.9	—	—
Breakdown of nonpermissible foods (detected only)											
Confectionery, "kashi"	—	2,829	2	0.1	0.87	—	0.00062	—	43.7	0.0269	56.7
Daily intake of dehydroacetic acid										0.0474	100.0

\* Breakdown of nonpermissible foods in which dehydroacetic acid was not detected: fish paste 2,581, meat products 1,886, pre-cooked foods "sozai" 1,787, marine products 1,341, fruit or vegetable products 1,005, soy sauce-pickled foods 939, nonalcoholic beverages 938, preserved foods boiled down in soy sauce "tsukudani" 630, vinegar pickled foods "su-zuke" 498, boiled bean 376, seasonings 347, dried marine products 343, soy sauce 340, soy bean paste 340, sweetened red bean paste "an" 320 samples, etc.

Table 4. Concentration of *p*-Hydroxybenzoic Acid in Foods and Estimated Daily Intake

Foods categorized by the standards for use	Regulation (g/kg)	Number of samples		Detected samples		Samples tested		Daily intake per person (mg)	Contribution to total intake (%)		
		Detection rate (%)		Mean conc. (g/kg)	Ratio to limit (%)	Mean conc. (g/kg)	Ratio to limit (%)				
		Tested	Detected								
Soy sauce	0.25	867	415	47.9	0.0630	25.2	0.0301	12.1	20.7	0.624	58.9
Fruit sauce	0.20	309	14	4.5	0.1175	58.8	0.0053	2.7	3.0	0.016	1.5
Vinegar	0.10	53	1	1.9	0.0900	90.0	0.0017	1.7	2.5	0.004	0.4
Nonalcoholic beverages	0.10	1,453	206	14.2	0.0178	17.8	0.0025	2.5	161.4	0.408	38.5
Syrup	0.10	13	0	0.0	0.0000	0.0	0.0000	0.0	0.1	0.000	0.0
Fresh vegetables and peel of fruits	0.012	15	0	0.0	0.0000	0.0	0.0000	0.0	64.1	0.000	0.0
Nonpermissible foods*	—	16,189	16	0.1	0.0641	—	0.0001	—	619.0	—	—
Total (or average)	—	18,899	652	( 3.4)	—	—	—	—	767.9	—	—
Breakdown of nonpermissible foods (detected only)											
Preserved foods boiled down in soy sauce, "tsukudani"	—	545	4	0.7	0.0085	—	0.0001	—	3.0	0.000	0.0
Boiled beans	—	315	1	0.3	0.0400	—	0.0001	—	2.4	0.000	0.0
Meat products	—	1,271	2	0.2	0.0300	—	0.0000	—	10.3	0.000	0.0
Soy sauce-pickled foods "shoyu-zuke"	—	800	3	0.4	0.0400	—	0.0002	—	6.1	0.001	0.1
Prunes	—	17	1	5.9	0.1900	—	0.0112	—	0.1	0.001	0.1
Seasonings	—	355	2	0.6	0.2100	—	0.0012	—	3.6	0.004	0.4
Condensed or diluted seasoned soy sauce, "tare" or "tsuyu"	—	141	3	2.1	0.0607	—	0.0013	—	0.4	0.001	0.0
Daily intake of <i>p</i> -hydroxybenzoic acid									1.060		100.0

\* Breakdown of nonpermissible foods in which *p*-hydroxybenzoic acid was not detected: confectionery 2,071, fish paste 1,454, pre-cooked foods 1,414, marine products 1,058, vinegar-pickled foods 480, frozen foods 452, soy bean paste 364, fruit or vegetable products 324, cheese 244, sweetened red bean paste 220, rice bran-pickled radish "takuan-zuke" 216, dried marine products 206 samples, etc.



**Table 5.** Concentration of Propionic Acid in Foods and Estimated Daily Intake

Foods categorized by the standards for use	Regulation (g/kg)	Number of samples		Detected samples		Samples tested		Daily intake per person		Contribution to total intake (%)
		Tested	Detected	Mean conc. (g/kg)	Ratio to limit (%)	Mean conc. (g/kg)	Ratio to limit (%)	Food (g)	Propionic acid (mg)	
Cheese	3.0	294	18	0.575	19.2	0.0352	1.2	3.4	0.12	2.2
Bread	2.5	182	21	0.556	22.2	0.0641	2.6	32.0	2.05	37.8
Cakes "yo-gashi"	2.5	269	17	0.526	21.1	0.0333	1.3	4.8	0.16	2.9
Nonpermissible foods*	—	82	3	0.227	—	0.0083	—	727.7	—	—
Total (or average)	—	827	59	—	—	—	—	767.9	—	—
Breakdown of nonpermissible foods										
(detected only)										
Frozen pizza	—	3	1	0.150	—	0.0500	—	0.4	0.02	0.4
Fish products	—	6	1	0.380	—	0.0633	—	35.3	2.24	41.2
Seasonings	—	5	1	0.150	—	0.0300	—	28.2	0.85	15.6
Daily intake of propionic acid									5.43	100.0

\* Breakdown of nonpermissible foods in which propionic acid was not detected: nonpermissible cakes 37, milk products 5, salt-pickled foods 3, jam 2 samples, etc.

Table 6. Concentration of Sorbic Acid in Foods and Estimated Daily Intake

Foods categorized by the standards for use	Regulation (g/kg)	Number of samples		Detection rate (%)		Detected samples		Samples tested		Daily intake per person		Contribution to total intake (%)
		Tested	Detected	Mean conc. (g/kg)	Ratio to limit (%)	Mean conc. (g/kg)	Ratio to limit (%)	Mean conc. (g/kg)	Ratio to limit (%)	Food (g)	Sorbic acid (mg)	
Cheese	3.0	549	24	4.4	0.618	20.6	0.027	0.9	3.4	0.09	0.4	
Fish paste products	2.0	7,644	4,589	60.0	1.004	50.2	0.603	30.1	13.0	7.83	30.1	
Whale meat products	2.0	3	2	66.7	0.105	5.3	0.070	3.5	0.1	0.01	0.0	
Meat products	2.0	4,087	1,912	46.8	0.912	45.6	0.426	21.3	10.3	4.39	16.9	
Sea urchin products, "uni"	2.0	500	16	3.2	0.219	10.9	0.007	0.4	0.1	0.00	0.0	
Smoked cuttlefish and octopus	1.5	272	235	86.4	0.715	47.7	0.618	41.2	0.5	0.31	1.2	
Sweetened red bean paste, "an"	1.0	857	161	18.8	0.473	47.3	0.089	8.9	0.1	0.01	0.0	
Fruit paste for making confectionery	1.0	70	0	0.0	0.000	0.0	0.000	0.0	0	0.00	0.0	
Lees-pickled foods, "kasu-zuke"	1.0	228	129	56.6	0.416	41.6	0.235	23.5	1.1	0.26	1.0	
Koji-pickled foods, "koji-zuke"	1.0	163	99	60.7	0.499	49.9	0.303	30.3	0.1	0.03	0.1	
Salt-pickled foods, "shio-zuke"	1.0	572	68	11.9	0.506	50.6	0.060	6.0	2.9	0.17	0.7	
Soy sauce-pickled foods, "shoyu-zuke"	1.0	2,594	2,058	79.3	0.507	50.7	0.402	40.2	6.1	2.45	9.4	
Soy bean-pickled foods, "miso-zuke"	1.0	233	140	60.1	0.489	48.9	0.294	29.4	0.3	0.09	0.3	
Rice bran-pickled radish, "takuan-zuke"	1.0	905	704	77.8	0.457	45.7	0.356	35.6	4.6	1.64	6.3	
(Sorbic acid allowable pickled foods)	1.0	822	453	55.1	0.496	49.6	0.273	27.3	—	—	—	
Candied cherries	1.0	5	0	0.0	0.000	0.0	0.000	0.0	0.1	0.00	0.0	
Dried fish and shellfish	1.0	1,128	427	37.9	0.427	42.7	0.162	16.2	7.7	1.24	4.8	
Jam	1.0	208	25	12.0	0.276	27.6	0.033	3.3	1.1	0.04	0.1	
Syrup	1.0	31	0	0.0	0.000	0.0	0.000	0.0	0.1	0.00	0.0	
Foods boiled down in soy sauce, "tsukudani"	1.0	1,794	1,091	60.8	0.485	48.5	0.295	29.5	3.0	0.88	3.4	
Boiled beans	1.0	953	364	38.2	0.395	39.5	0.151	15.1	2.4	0.36	1.4	
Gnocchi	1.0	0	0	0.0	0.000	0.0	0.000	0.0	0.1	0.00	0.0	
Flour paste	1.0	230	83	36.1	0.571	57.1	0.206	20.6	0.1	0.02	0.1	
Margarine	1.0	36	2	5.6	0.540	54.0	0.030	3.0	1.9	0.06	0.2	
Soy bean paste	1.0	943	246	26.1	0.487	48.7	0.127	12.7	15.7	2.00	7.7	
Ketchup	0.50	24	0	0.0	0.000	0.0	0.000	0.0	1.2	0.00	0.0	
Vinegar-pickled foods, "su-zuke"	0.50	1,227	851	69.4	0.279	55.7	0.193	38.6	2.1	0.41	1.6	
Soup	0.50	17	0	0.0	0.000	0.0	0.000	0.0	0.1	0.00	0.0	
Condensed or diluted seasoned soy sauce, "tare" or "tsuyu"	0.50	218	6	2.8	0.098	19.7	0.003	0.5	0.4	0.00	0.0	
Prune	0.50	108	52	48.1	0.300	59.9	0.144	28.9	0.1	0.01	0.1	

Table 6. Continued

Foods categorized by the standards for use	Regulation (g/kg)	Number of samples		Detected samples		Samples tested		Daily intake per person		Contribution to total intake (%)
		Tested	Detected	Mean conc. (g/kg)	Ratio to limit (%)	Mean conc. (g/kg)	Ratio to limit (%)	Food (g)	Sorbic acid (mg)	
Fermented beverage made from rice, "amasake"	0.30	9	0	0.000	0.0	0.000	0.0	0.1	0.00	0.0
Fermented milk	0.30	156	0	0.000	0.0	0.000	0.0	9.7	0.00	0.0
Fruit wine	0.20	509	95	0.128	64.2	0.024	12.0	1.7	0.04	0.2
Miscellaneous alcoholic beverages, "zasshu"	0.20	26	4	0.128	63.8	0.020	9.8	0.1	0.00	0.0
Lactic acid bacteria beverages	0.050	123	5	0.062	123.2	0.003	5.0	0.1	0.00	0.0
Nonpermissible foods*	—	14,276	747	0.349	—	0.018	—	677.5	—	—
Total (average)	—	41,520	14,588	—	(35.1)	—	—	767.9	—	—
Breakdown of nonpermissible foods (detected only)										
Pre-cooked foods	—	3,760	209	0.347	—	0.019	—	19.7	0.38	1.5
Nonpermissible fish products	—	1,067	105	0.462	—	0.045	—	12.6	0.57	2.2
Confectionery, "kashi"	—	3,724	278	0.301	—	0.022	—	43.7	0.98	3.8
Seasonings	—	394	2	0.365	—	0.002	—	10.2	0.02	0.1
Soy sauce	—	471	3	0.505	—	0.003	—	20.7	0.07	0.3
Nonalcoholic beverages	—	1,202	2	0.135	—	0.000	—	161.4	0.04	0.1
Nonpermissible pickled foods	—	152	48	0.439	—	0.139	—	0.8	0.11	0.4
Dried fruits other than prunes	—	261	39	0.279	—	0.042	—	0.7	0.03	0.1
Noodles	—	210	1	0.650	—	0.003	—	42.2	0.13	0.5
Salted fish roe	—	126	9	0.472	—	0.034	—	1.2	0.04	0.2
Bread	—	81	12	0.278	—	0.041	—	32.0	1.32	5.1
Daily intake of sorbic acid	—							26.04		100.0

\* Breakdown of nonpermissible foods in which sorbic acid was not detected: fruit sauce 304, canned or bottled foods 295, processed agricultural products 192, nonpermissible alcoholic beverages 133, boiled vegetables 94, fruits in syrup 86, processed eggs 72, vinegar 47, ice cream 43, rice paste 32, fresh marine products 31, dressings 31 samples, etc.

Table 7. Estimated Daily Intake of Preservatives

Preservative	Daily intake (mg/person)								ADI (mg) (as 50 kg b.w.)
	Present study	Ratio to ADI (%)	Reference values						
			Japan* <sup>1</sup>	Finland* <sup>2</sup>	Japan* <sup>3</sup>	U. K.* <sup>4</sup>	Japan* <sup>5</sup>	France* <sup>6</sup>	
Benzoic acid	11.0	4.4	11.0	40	4.20	48.9	2.4	17.4	250
Dehydroacetic acid	0.0474		0.0769		0.63		0.1		
<i>p</i> -Hydroxybenzoic acid	1.06	0.2	1.37	0.18* <sup>7</sup>	0.35	0.1* <sup>7</sup>	0.124* <sup>7</sup>		500* <sup>7</sup>
Propionic acid	5.43		3.88	16.0	1.05	4.9	2.2		Not limited
Sorbic acid	26.0	2.1	32.9	37.0	33.18	29.4	27.5	158	1,250

\*<sup>1</sup> Based on the official inspection in fiscal year 1994<sup>3)</sup>

\*<sup>2</sup> Based on the official analysis and data in journals<sup>16)</sup>

\*<sup>3</sup> Based on the production and distribution amounts<sup>19)</sup>

\*<sup>4</sup> Based on the production and usage amounts<sup>18)</sup>

\*<sup>5</sup> Based on a market-basket method<sup>12), 17)</sup>

\*<sup>6</sup> Based on a budget method (corrected values using information from industry)<sup>20)</sup>

\*<sup>7</sup> Total of permissible esters

used was 1.7% of the limit. Propionic acid was also detected in one sample each of frozen pizza (among 3 samples), fish products (6 samples) and seasonings (5 samples).

#### e) Sorbic acid

The results for sorbic acid are shown in Table 6. Sorbic acid was detected in 14,588 (35.1%) out of 41,520 samples tested. The mean concentration of sorbic acid in foods in which use of the compound is allowed was 14.1% of the allowable limits. The highest detection rate (86.4%) and concentration ratio (41.2%) to the allowable limit were observed in smoked cuttlefish and octopus. No sorbic acid was detected in the following allowable foods: fermented milk (156 samples), fruit paste for making confectionery (70 samples), syrup (31 samples). Sorbic acid was detected in some nonpermissible foods (5.2% of 14,276 samples), such as nonpermissible pickled foods (detection rate 31.6%), dried fruits other than prunes (14.9%), and bread (14.8%).

### 3. Estimation of the daily intake of preservatives per person

The daily intake of preservatives was estimated based on both the concentrations of preservatives obtained in the present studies and daily consumption of foods estimated by a Japanese group<sup>12)</sup>. The group estimated that 767.9 g of processed foods was consumed per person per day in Japan. Estimated daily intake of preservatives is as follows: benzoic acid, 11.0

mg; dehydroacetic acid, 0.0474 mg; *p*-hydroxybenzoic acid, 1.06 mg; propionic acid, 5.43 mg; and sorbic acid, 26.0 mg. Foods contributed most to the daily intake, followed by nonalcoholic beverages (82.7% of daily intake) and soy sauce (10.5%) for benzoic acid, confectionery (56.7%) and cheese (43.3%) for dehydroacetic acid, soy sauce (58.9%) and nonalcoholic beverages (38.5%) for *p*-hydroxybenzoic acid, fish products (41.2%) and bread (37.8%) for propionic acid, and fish paste products (30.1%) and meat products (16.9%) for sorbic acid. The estimated daily intakes and foods that contributed to the daily intake of preservatives in the present investigation were similar to the results obtained in previous reports except for the detection of propionic acid in some fish products. The estimated daily intake of preservatives is summarized in Table 7 together with the results reported in the previous paper<sup>3)</sup> based on the official inspection in fiscal year 1994, reported in the references<sup>12), 16-20)</sup>, and the ADIs<sup>1)</sup>.

The ratio of the daily intake of benzoic acid to the ADI was the highest (4.4% of the ADI), and those of sorbic acid and *p*-hydroxybenzoic acid were 2.1% and 0.2%, respectively. The ADI of propionic acid has not been limited, and that of dehydroacetic acid has not been evaluated.

### Discussion

The concentration of preservatives in foods and estimated daily intake based on official in-

spections by local governments in Japan in fiscal year 1994 were reported<sup>2)-6)</sup> earlier. The same investigation was repeated employing the same method but using the results of official inspections in fiscal year 1996 instead, and similar results were obtained. The concentrations and estimated daily intake of preservatives reported in the present paper include both over- and underestimation factors, but are more likely to be overestimated, as discussed in the previous papers<sup>2), 3)</sup>. Daily intake of food additives has been estimated by using the official analysis in Finland<sup>16)</sup> (*i.e.* almost the same method as in the present paper), by a market basket method in Japan<sup>12), 17)</sup>, and by a questionnaire on production, circulation, and amounts used administered to food and food additive producers in the UK<sup>18)</sup> and in Japan<sup>19)</sup>, or by a budget method in France<sup>20)</sup>. Accumulation of results by different methods and repetition of studies by the same method are required to estimate more accurately the daily intake of food additives. There were no marked differences in daily intake between the results obtained by the present method in fiscal year 1994 and fiscal year 1996, and between the results obtained by other methods, except that an about 10 times higher amount of *p*-hydroxybenzoic acid was estimated by the present method, and an about 5 times higher amount of sorbic acid was estimated in France by a budget method. Estimated daily intakes based on official inspection are probably generally higher than the results obtained by other methods. The most influential cause of overestimation is probably that most of the sample foods inspected were foods in which preservatives are allowed and nonpermissible foods, such as perishable foods, in which food producers may want to use preservatives.

### Conclusion

Mean concentration and daily intake of preservatives were estimated based on the results of analysis of 112,131 samples of food obtained by official inspection by Japanese local governments in fiscal year 1996. The mean concentration of benzoic acid was 7.8% of the allowable limits, and those of dehydroacetic acid, *p*-hydroxybenzoic acid, propionic acid and sorbic acid were 0.4%, 3.2%, 1.7% and 14.1%, respec-

tively. The daily intake of these preservatives per person estimated from their concentrations and daily food consumption were 11.0 mg, 0.0474 mg, 1.06 mg, 5.43 mg and 26.0 mg, respectively. The highest ratio of the daily intake to the ADI was observed for benzoic acid (4.4% of the ADI). These results were similar to the results based on the official inspection results in fiscal year 1994.

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