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Exposure Assessments of Benzoate Preservatives in Foods Consumed in Indonesia

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An exposure assessment was performed to estimate the potentially intake of benzoate preservatives in the Indonesian population. Food consumption data of six different population groups, such as children aged 0-59 months, school-age children, adolescent, adult, elderly and all ages were used for calculation based on the 2014 Indonesia Individual Food Consumption Survey. Levels of benzoate in food were derived from food registration in NADFC from 2012 to 2016. Dietary intakes of the preservatives were estimated and compared to respective acceptable daily intakes using an average intake scenario and assuming that concentration of benzoate in food is at the highest level based on regulation, level used and result of product test, estimated dietary intakes of all studied are well below ADI for all different population age groups (7.40-57.40 % of ADI) show no safety concern for benzoate exposure. Major contributors to the total intake of exposure were beverages and condiments.

Keywords: Benzoate, Exposure assessment, Deterministic, Individual Food Consumption Survey.

INTRODUCTION

Exposure assessment is a qualitative and/or quantitative evaluation of likely intake of biological, chemical and physical agents *via* food as well as exposures from other sources if relevant [1]. Exposure assessment is determined within the framework with a stepwise approach to achieve the objective in which screening methods can be applied. The exposure levels can be calculated by deterministic (point estimates) or probabilistic (distribution) approach [2]. The selected approach will determine the working method of exposure assessment based on data and resource availabilities. A deterministic approach for exposure assessment results in a single value that describes some exposure parameters such as average exposure of population.

Benzoate is a food preservative used to extend the shelf life of food products by inhibiting microbial growth. Benzoate is most effective at pH 2.5-4.0 and significantly loses its effectiveness at pH above 4.5 [3]. The Joint FAO/WHO Expert Committee on Food Additives (JECFA) [4,5] assigned the value of the acceptable daily intake (ADIs) for benzoic acid to be 5 mg kg^{-1} bw day^{-1}. The ADI is the maximum amount of dietary intake (mg kg^{-1} bw day^{-1}) that can be consumed during a life time without causing adverse effects on health.

The use of benzoate preservatives in Indonesia is regulated through the Decree of the Head of National Agency for Drug and Food Control (NADFC) Republic of Indonesia no. 36 year 2013 concerning the Maximum Permitted Use Level of Food Additives Preservatives such as benzoic acid in various food categories [6]. The maximum levels of benzoic acid in Indonesia ranges from 40 to 2000 mg kg^{-1}.

On the 48th Codex Committee on Food Additive (CCFA) council meeting, it has been determined that the maximum levels of benzoate preservative in beverage is to be reduced from 400 to 250-300 mg L^{-1} with the purpose of consumer protection. Therefore, in order to find out whether the maximum levels of benzoate preservative in Indonesia is still above the amount of benzoate consumed in Indonesia, it is necessary to study the consumers exposure levels to benzoate preservatives at the national level as a scientific information for the government and the public.

The objective of this study was to obtain the consumers exposure level to benzoate preservatives from foods in Indonesia through deterministic approach using food consumption

data from the 2014 Indonesia Individual Food Consumption Survey (IFCS) and benzoate preservative concentration in foods registered at National Agency for Drug and Food Control Republic of Indonesia from year 2012-2016. Another objective was to identify food categories that contribute to benzoate exposure in Indonesia.

EXPERIMENTAL

Food consumption data: According to the guidelines for the study of dietary exposure assessment of chemicals in food [2], food consumption data can be estimated through food consumption surveys at an individual or household level or approximated through food production statistics. Food consumption surveys include record/diaries, food frequency questionnaires (FFQs), dietary recall and total diet studies.

The 24 h dietary recall consists of listing of foods and beverages (including drinking-water and sometimes dietary supplements) consumed during the previous day or 24 h prior to the recall interview [2]. The 24 h dietary recall was used in the 2014 Indonesia Individual Food Consumption Survey (IFCS) where it provides detailed information on the characteristics of respondents and average food consumption per person per day in various food groups and age groups [7].

Total respondents in the 2014 IFCS Report were 145,360 participants consisting of 73,011 men and 72,348 women. Respondents were grouped into five age groups, namely: children aged 0-59 months (n = 6.093), school-age children (5-12 years old) (n = 14.871), adolescent (13-18 years old) (n = 17.228), adult (19-55 years old) (n = 88.634) and elderly (above 55 years old) (n = 18.533).

Deriving food consumption suspected containing benzoate preservatives from the 2014 IFCS Report for exposure calculation was performed with the determination of equivalency between 17 food groups and 16 food categories [8]. The equivalence is based on:

(1) Identification of food groups according to the 2014 IFCS report suspected to contain benzoate preservatives accordance with the Decree of the Head of NADFC no. 36 year 2013.

(2) Equivalency between food types in food groups in the 2014 IFCS report with food categories suspected to contain benzoate preservatives accordance with the Decree of the Head of NADFC no. 36 year 2013.

(3) Calculation of the total individual food consumption suspected to contain benzoate preservatives (g person^{-1} day^{-1}) in various age group.

Benzoate preservatives concentration on foods: Deriving concentration data for use in estimating dietary exposure especially for chemicals that are intentionally added to foods may be derived from manufacturers' use data (food additives, including flavours) and monitoring or surveillance data [2]. The concentration of benzoate preservative from food in Indonesia can be derived from food registration in National Agency for Drug and Food Control Republic of Indonesia based on manufacturers' use level and result of product tests.

Foods registered at NADFC from year 2012-2016 used for obtained concentration of benzoate preservatives levels data in food by the following stages:

(1) Data retrieval of concentration of benzoate preservative levels on registered foods and data cleaning. Data cleaning stage was done through cleaning the overall variables for food type, food category, registration period, level used and result of product tests by manufacturer.

(2) Identification of the food categories profile which benzoate preservatives used.

(3) Identification of benzoate preservatives concentration level in food products based on average, lowest and highest level used report by manufacturer.

Estimation of dietary exposure to benzoate preservative: Estimation of consumer exposure to benzoate preservatives is performed using a deterministic approach, assuming that the highest level of benzoate concentration is reported in each food category. The calculation of consumer exposure to benzoate preservative combines the average food consumption levels which are suspected to contain benzoate preservatives as revealed by the 2014 IFCS report with data on the concentration of benzoate preservative obtained from food registered at NADFC year 2012-2016. Estimated daily intake (EDI) to benzoate preservative is calculated as follows [2]:

$$\text{Dietary exposure (mg kg}^{-1}\text{ bw day}^{-1}\text{)} = \Sigma\ \text{Dietary intake level (g kg}^{-1}\text{ bw day}^{-1}\text{)} \times \text{Benzoate concentration (mg g}^{-1}\text{)}$$

This study used concentration of benzoate preservatives data from the maximum level of regulation, the highest manufacturer level used and result of product test by the manufacturer. The assumption that all consumers consume all foods suspected to contain benzoate preservatives and the dietary exposure is considered as the average value of food consumption per individuals in different age groups.

The exposure estimates derived from the maximum levels from regulation should be considered as the most conservative considering the use of benzoates preservatives in food categories [1]. The refined exposure assessment of benzoate preservative is based on the highest manufacturer level used and result of product tests by the manufacturer.

Estimation of risk characterization of benzoate preservative: Risk characterization of consumer exposure to benzoate preservatives is processed by calculating the percentage of exposure against ADI to determine whether exposure to benzoate preservatives derived from food products is exceeded. Benzoate preservatives exposure has no safety concern to public if % ADI is less than 100 % ADI [2].

RESULTS AND DISCUSSION

Food consumption: Food consumption data from the 2014 IFCS Report including weight of food, food material consumed by population according to the food groups and body weight information of each age group. The average body weight per person (kg person^{-1}) from the 2014 IFCS report was compared with the average weight on various guidelines for exposure assessment as presented in Table-1.

In general, the average body weight of each age group in Indonesia was lower than that of age group in the guidelines for exposure assessment from FAO/WHO [9], EFSA [10] and EPA [11]. The average body weight for the adult aged 19-55 years old was 57.87 kg person^{-1} higher than the general body

TABLE-1
AVERAGE BODY WEIGHT (kg person^{-1}) ACCORDING TO THE 2014 IFCS REPORT

IFCS report		Guideline of exposure assessment	
Age group	Average body weight (kg person^{-1})	Age group	Average body weight (kg person^{-1})
Children below five years (0-59 months)	11.67	0-12 month[a]	5.00
School-age children (5-12 years)	27.50	1-3 years[a]	12.00
Adolescents (13-18 years)	46.33	Common children[b]	15.00
Adults (19 - 55 years)	57.87	6-11 years[c]	31.80
Elderly (> 55 years)	52.30	11-16 years[c]	56.80
All ages	50.78	>18 years[a]	70.00
		16-21 years[c]	71.60
		Adult[b]	60.00
		Adult (Asia)[b]	55.00
		>21 years[c]	80.00

Description: [a]EFSA 2012; [b]FAO/WHO 2014; [c]EPA 2011

weight reported by FAO/WHO for Asian adults who weigh 55 kg person^{-1}.

Of the 17 food groups in the 2014 IFCS report, a total of eight groups were suspected of containing benzoate preservatives, namely (1) cereal and its processed products, (2) tuber and its processed products, (3) fruit and its processed products, (4) milk and its processed products (5) oils, fats and its processed products, (6) sugar, syrup and confectionary, (7) condiments and its preparations and (8) beverages. The results of the equivalence between food types and food groups in the IFCS Report and NADFC food categories showed that food consumption in each food groups can be consisted of several food categories. In order to obtain food consumption level suspected to contain benzoate preservatives in accordance with the Decree of the Head of NADFC no. 36 year 2013, the categorization of food categories refers to the type of food in the 2014 IFCS report at various age groups as presented in Table-2.

The total food consumption suspected to contain benzoate preservatives ranged from 28-83.22 g or mL person^{-1} day^{-1} (1.45-4.94 % of total average food consumption per person per day) with the largest food contribution presumed to contain benzoate preservatives were beverages, condiments and processed fruits. School-age children and adolescent demonstrated the largest group of consumers that is suspected to be exposed to foods containing benzoate preservatives. It was 83.22 (4.94 %) and 69.60 g or mL person^{-1} day^{-1} (3.74 %) which is dominated by beverages.

Based on the 2014 IFCS report, the total beverage consumption of Indonesian population for all age groups was 1.317 mL person^{-1} day^{-1}, derived from drinking water of 1.146 mL person^{-1} day^{-1}, branded drinking water of 146 mL person^{-1} day^{-1} and beverage of 25 mL person^{-1} day^{-1} [7]. The average beverages consumption level for the school-age children (5-12 years old) and adolescent (13-18 years old) groups was 55.02 and 45.90 mL person^{-1} day^{-1}, respectively, indicating a higher value compared to all age groups (25.40 mL person^{-1} day^{-1}).

Concentration of benzoate preservatives in food: For five years, a total of 73,224 registration approval for food were issued with the amount of food containing benzoate preservatives was 9,203 (13 %). Benzoate preservatives was used for 3,443 food products including methyl *para*-hydroxybenzoate preservatives (10 food products). The types of benzoate used were single benzoates salt (n = 2,779 (66 %)), single benzoic acid (n = 50 (2 %)) and the mixture of benzoate and other preservatives (n = 1,104 (32 %)). The combination of preservative were benzoic-sorbic acids (n = 699), benzoic acids–sulphite (n = 366) and benzoic-sorbic acids-sulphite (n = 39). The food categories using benzoate preservatives on the registered food presented on Fig. 1. Beverages and condiments are the food categories that most used in food.

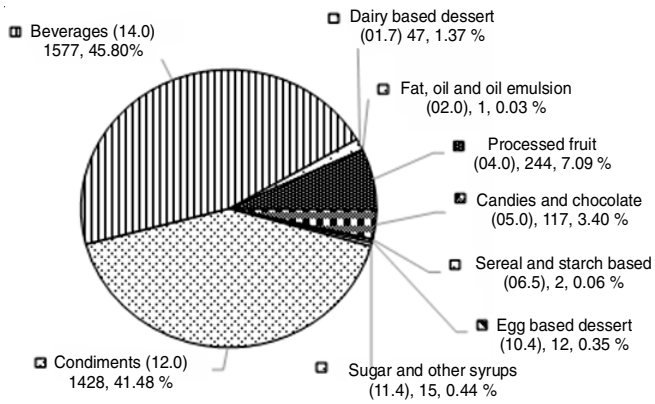

Fig. 1. Food categories using benzoate preservatives profile

The average, lowest and highest level used and result of product tests by manufacturer are presented in Table-3. To determine the worst scenario of dietary intake of benzoate preservatives in Indonesia population using concentration of benzoate levels from the maximum levels of regulation, the highest manufacturer level used and result of product tests by the manufacturer as presented in Table-4. Reported benzoate levels for the used and the result of product tests are close to the maximum limit of regulation indicate that the benzoate is relatively stable at processing.

Non-emulsified sauce category (12.6.2) was the most widely used for benzoate preservatives in food product (811 registered products) with benzoate concentration level ranged from 0-969.49 mg kg^{-1} (the maximum permitted level for this category is 1000 mg kg^{-1}). A study in Belgium reported that the average concentration of benzoate preservatives in non-emulsified sauce was 594.3 mg kg^{-1} [12] and 287.6-788.7 mg kg^{-1} for tomato sauce and tomato puree in Austria [13], in which it was much lower than benzoate preservatives use in Indonesia.

TABLE-2
AVERAGE FOOD CONSUMPTION ACCORDING TO THE 2014 IFCS REPORT WHICH IS SUSPECTED TO CONTAIN BENZOATE PRESERVATIVES AND ITS EQUIVALENCY BASED ON THE FOOD CATEGORY

No.	Food Consumption Data According to the 2014IFCS Report		Equivalency results of food consumption data based on food category						
	Food Group According to the 2014 IFCS Report		Food category	Average consumption level (g person^{-1}day^{-1} or mL person^{-1}day^{-1})					
	Food groups	Food types		0-59 months	5-12 years	13-18 years	19-55 years	>55 years	All ages
1	Processed milk	Ice cream, cheese, fermented milk, yogurt	Dairy based desserts (01.7)	3.90	3.30	1.10	0.40	0.20	0.90
2	Oil, fat and its processed products	Vegetable and animal oils, margarine, butter, mayonnaise, lard and buffalo fat	Oil, fat and its processed products margarine and other products (02.2.1), emulsified Sauce (*e.g.*, mayonnaise, salad dressing) (12.6.1)	0.30	0.50	0.40	0.40	0.30	0.40
3	Sugar and confectionery	Honey, jam, jelly	Processed fruits fruit based fruits (04.1.2.8), fruit based desserts (04.1.2.9), vegetable puree, nuts and seeds (*e.g.*, peanut butter) (04.2.2.5)	4.20	4.90	2.00	0.60	0.50	1.30
	Fruit and its processed products	Smoke fruits, candied fruits, dodol, gethuk, lempong, canned mix fruits, canned pineapple							
4	Sago and its processed products	Sago, sago palm, kemplang/sago cracker, tapioca pearl, glosor noodles	Cereals and starch based desserts (06.5)	1.10	1.90	1.30	1.30	0.70	1.30
5	Sugar and confectionery	Candies	Candies Confectionery/candies (05.2), cake decoration, topping and fruit sauces (05.4)	1.20	1.10	0.40	0.10	0.00	0.30
6	Corn and its processed products	Corn, dried noodles, cornstarch, corn snack, corn flour (red, yellow, custard)	Egg-based dessert (custard) (10.4)	1.70	3.40	4.10	4.30	4.60	4.10
7	Spices	Instant seasonings	Condiments Seasonings (12.2.2)	1.00	1.70	1.80	1.40	0.80	1.40
8	Spice blends	Onion, chilli, soy sauce (sweet, salty, english), seasonings, vinegar, tempoya, kluwek, petis	Non-emulsified sauces (*e.g.*, tomato sauce, cheese sauce, cream sauce, brown gravi) (12.6.2), non-fermented soy sauces (12.9.2.2), soy sauce, dressing (soy sauce, sweet soy sauce, tauco) (12.9.2.3)	6.30	11.40	12.60	15.50	14.90	14.30
9	Sugar and confectionery	Syrup	Beverages Concentrate for flavoured beverages (14.1.4.3), sugar and other syrups (11.4)	0.20	0.60	0.30	0.30	0.10	0.30
10	Soft drink	Cincau beverages, isotonic drinks, chocolate drink, soya, liquid instan tea and others	Cocoablends (05.1.5), fruit juices (14.1.2), flavouredbeverages (14.1.4), coffee, coffee substitute, tea, herbal drink, cereal grain beverages and hot cereal drinks (14.1.5)	31.60	52.10	40.50	16.00	4.20	21.70
	Other beverages	Coconut water, sugar cane water, energy drinks and others							
11	Carbonated beverages	Various flavours and brands	Carbonated flavoured beverages (14.1.4.1)	0.70	2.30	4.70	2.40	0.80	2.40
12	Alcoholic beverages	Beer, Chinese wine, rum alcohol and others	Alcoholic beverages with various aromas (14.2.7)	0.00	0.02	0.40	1.30	0.90	1.00
	Total food consumption suspected to contain benzoate (g person^{-1}day^{-1})			52.20	83.22	69.60	44.00	28.00	49.40
	Total food consumption per day (g person^{-1}day^{-1})			1164.50	1686.00	1859.10	2167.90	1925.80	2009.10
	Percentage (%) of food consumption suspected to contain benzoate preservatives			4.48	4.94	3.74	2.03	1.45	2.46

In addition, as many as 774 registered products for beverages (14.1.4.2) had benzoate concentrations of 0-394.09 mg kg^{-1}. This value is similar to other studies in Hong Kong in which benzoate concentration for soft drinks ranged from n/d-410 mg kg^{-1} [14]. Moreover in Austria, the average concentration for non-alcoholic beverages was much lower (14.5-69.8 mg kg^{-1}) than in Indonesia [13].

Dietary intake of benzoate preservatives: The calculation of the exposure level and the exposure risk level to benzoate preservatives in different age groups is performed to determine whether the maximum regulation limit may still provide protection for the public to benzoate exposure (Table-5). The highest exposure to benzoate preservatives was found in children aged 0-59 months (2.19-2.87 mg kg^{-1} bw day^{-1}) representing 43.87-57.40 % of ADI, followed by school-age children (1.55-1.96 mg kg^{-1} bw day^{-1}) representing 30.92-39.20 % of ADI. All age groups exposed to benzoate preservatives of 0.57-0.69 mg kg bw^{-1} day^{-1} (11.40-13.80 % of ADI) which were lower than in both age groups previously. Benzoate preservatives exposure in Indonesia is not exceeded ADI indicate the risk characterization of benzoate exposure in Indonesia has no safety concern which demonstrates that the remaining margin of the safety of benzoate use as a preservative in Indonesia is still large.

Dietary patterns also became one of the factors that make the benzoate preservatives exposure in Indonesia is low. Based on the 2014 IFCS report, the food consumption level suspected to contain benzoates preservatives is 1.45-4.94 % of total food

TABLE-3
DISTRIBUTION OF REGISTERED FOOD PRODUCTS DATA USING BENZOATE PRESERVATIVES ACCORDING TO THE FOOD CATEGORY AND ITS MAXIMUM REGULATION LEVELS

Food category	Number of registered foods	Benzoic acid concentration (mg kg^{-1})						
		Maximum permitted levels (NADFC 2013)	Reported level used by the manufacturer			Result of product tests by the manufacturer		
			Average	Lowest	Highest	Average	Lowest	Highest
Dairy based desserts (01.7)	47	200.00	119.76±43.84	5.00	169.49	110.77±46.04	0.61	167.54
Margarine and similar products (02.2.1)	1	1,000.00	339±0.00	339.00	339.00	347.46±0.00	347.46	347.46
Jams, jelly and marmalade (04.1.2.5)	68	200.00	101.46±54.61	0.17	169.49	105.40±46.63	0.00	184.89
Fruit based raw materials (04.1.2.8)	4	1,000.00	219.28±8.74	211.86	228.81	218.01±8.26	209.32	226.27
Fruit based desserts (04.1.2.9)	170	200.00	100.72±58.90	0.85	200.00	91.17±54.88	0.00	173.06
Vegetable purees, nuts and seeds (*e.g.*, peanut butter) (04.2.2.5)	2	500.00	108.9±1.80	107.63	110.17	109.14±2.01	107.72	110.57
Chocolate drinks (05.1.5)	1	500.00	152.54±0.00	152.54	152.54	159.58±0.00	159.58	159.58
Confectionery/candies (05.2)	84	500.00	281.64±143.33	65.00	423.73	187.01±106.56	50.24	412.98
Decorations, toppings and sweet sauces (05.4)	32	500.00	282.08±174.37	0.17	423.73	272.71±171.65	0.00	423.01
Cereals based desserts and starch (06.5)	2	500.00	8.47±0.00	8.47	8.47	62.71±3.60	60.17	65.25
Egg based dessert (*e.g.*, custard) (10.4)	12	500.00	85.95±65.18	33.90	186.44	84.36±65.96	31.04	187.29
Sugar and other syrups (11.4)	15	600.00	167.91±56.08	4.24	245.24	192.85±84.27	3.56	374.58
Spices and Condiments (12.2.2)	142	600.00	323.29±205.04	6.27	599.50	305.11±171.39	0.00	594.60
Emulsified sauces (*e.g.*, mayonnaise, salad dressing) (12.6.1)	108	1,000.00	442.63±224.51	0.85	847.46	385.76±175.35	0.00	827.97
Non-emulsified sauces (12.6.2)	811	1,000.00	501.38±216.51	0.85	1000.00	438.61±204.81	0.00	969.49
Non-fermented soy sauces (12.92.2)	5	600.00	364.24±178.74	50.00	500.00	215.03±149.48	0.00	400.00
Other soy sauces (soy sauce, sweet soy sauce, tauco) (12.9.2.3)	352	1,000.00	418.09±179.97	4.75	847.46	351.77±177.47	0.00	843.22
Other soy sauces (soy sauce, sweet soy sauce, tauco) (12.9.2.3) [a]	10	600.00	132.00±69.69	20.00	250.00	147.99±65.43	8.72	205.99
Juices (14.1.2)	31	600.00	298.22±110.99	50.85	497.46	204.04±110.18	0.00	495.88
Carbonated favoured beverages (14.1.4.1)	295	400.00	167.19±76.49	0.85	338.98	167.29±79.23	0.00	337.85
Non-carbonated flavoured beverages (14.1.4.2)	774	400.00	192.92±87.20	0.02	389.83	173.46±85.38	0.00	394.09
Concentrate for flavoured beverages (14.1.4.3)	414	600.00	288.50±147.01	0.85	508.47	265.38±143.49	0.00	499.25
Coffee, coffee substitute, tea, herbal drink, cereal grain beverages and hot ceral drinks (14.1.5)	8	600.00	235.17±94.12	84.75	389.83	236.76±68.34	165.06	372.47
Alcoholic beverages with various aromas ((14.2.7)	55	1,000.00	181.05±56.76	84.75	423.73	170.58±55.97	73.26	409.20

Description: [a] benzoate as methyl *para*-hydroxybenzoate

TABLE-4
BENZOATE LEVELS IN VARIOUS REGISTERED FOODS USED IN THE EXPOSURE ASSESSMENT

No.	Food category	Nuumber of registered foods	Benzoic acid level (mg g^{-1})		
			Maximum regulation level	Highest manufacturers level used	Highest result of product tests by the manufacturer
1	Dairy based desserts (01.7)	47	0.20	0.17	0.17
2	Margarine and similar products (02.2.1), emulsified sauces (*e.g.*, mayonnaise, salad dressings) (12.6.1)	109	1.00	0.85	0.83
3	Jams, jelly and marmalade (04.1.2.5), fruit based raw materials (04.1.2.8), fruit based desserts (04.1.2.9), vegetable puree, nuts and seeds (*e.g.*, peanut butter) (04.2. 2.5)	244	1.00	0.23	0.23
4	Cereals and starch based desserts (06.5)	2	0.50	0.01	0.07
5	Confectionery/candies (05.2), decoration, topping and sweet sauces (05.4)	116	0.50	0.42	0.42
6	Egg-based desserta (*e.g.*, custard) (10.4)	12	0.50	0.19	0.19
7	Spices and Condiments (12.2.2)	142	0.60	0.60	0.59
8	Non-emulsified sauce (12.6.2), non-fermented soy sauce (12.9.2.2), other soy sauces (soy sauce, sweet soy sauce, tauco) (12.9.2.3)	1168	1.00	1.00	0.97
9	Fermented soy sauces * (12.9.2.1)	10	0.60	0.25	0.21
10	Concentrate for flavoured beverages (14.1.4.3), sugar and other syrups (11.4)	429	0.60	0.51	0.50
11	(14.1.4), Flavoured beverages (14.1.4), coffee, coffee substitute, tea, herbal drink, grain cereal beverages and hot cereal drinks (14.1.5)	814	0.60	0.50	0.50
12	Carbonated flavoured beverages (14.1.4.1)	295	0.40	0.34	0.34
13	Alcoholic beverages with various aromas (14.2.7)	55	1.00	0.42	0.41

Description: * benzoate as methyl para-hydroxybenzoate

consumption per day. Food that dominant to consume in Indonesia is cereals and its processed such as rice, processed wheat and noodles with food consumption level were 1164.5-2167.9 g person^{-1} day^{-1} followed by drinking water with consumption level were 742-1439 mL person^{-1} day^{-1}.

According to the exposure data of the benzoate preservatives from FAO/WHO [15], it is found that benzoate exposure levels in the soft drink for toddlers and young children groups were 0.3-4.1 mg kg^{-1} bw day^{-1} and 0.1-1.7 mg kg^{-1} bw day^{-1} for adult group. In this study, benzoate exposure levels from beverages in Indonesian for the children aged 0-59 months, school-age children and adolescent ranged from 0.57-1.65 mg kg^{-1} bw day^{-1} which categorized within the range of the international benzoate preservatives data.

Many countries have conducted exposure assessment on various food additives with the total diet study database. Expo-

TABLE-5
ESTIMATED DAILY INTAKE (mg kg^{-1} body weight day^{-1}) OF BENZOATE PRESERVATIVES FOR DIFFERENT INDONESIAN POPULATION GROUPS

No.	Food category	0-59 Month	5-12 Year	13-18 Year	19-55 Year	>55 Year	All Ages
		Exposure level based on the regulation maximum level per age group (mg kg^{-1} bw day^{-1})					
1	Dairy based desserts (01.7)	0.07	0.02	0.00	0.00	0.00	0.00
2	Oil, fat and its preparations: Margarine and similar products (02.2.1), emulsified sauces (eg mayonnaise, salad dressings) (12.6.1)	0.03	0.02	0.01	0.01	0.01	0.01
3	Processed Fruits: Jams, jelly and marmalade (04.1.2.5), fruit-based raw materials (04.1.2.8), fruit-based desserts (04.1.2.9), vegetable purees, nuts and seeds (eg peanut butter) (04.2. 2.5)	0.36	0.18	0.04	0.01	0.01	0.03
6	Confectionery/candies (05.2), decoration, topping and sweet sauces (05.4)	0.05	0.02	0.00	0.00	0.00	0.00
4	Cereals based dessert and starch (06.5)	0.05	0.03	0.01	0.01	0.01	0.01
5	Egg based dessert (eg custard) (10.4)	0.07	0.06	0.04	0.04	0.04	0.04
6	Condiments	0.59	0.45	0.29	0.28	0.29	0.30
	A. seasonings and condiments (12.2.2)	0.05	0.04	0.02	0.01	0.01	0.02
	B. Non-emulsified sauces (12.6.2), non-fermentedsoy sauces (12.9.2.2), othersoy sauces (soy sauce,weetsoy sauce, tauco) (12.9.2.3)	0.54	0.41	0.27	0.27	0.28	0.28
7	Beverages	1.65	1.18	0.57	0.21	0.08	0.30
	A. Concentrate for flavoured beverages (14.1.4.3), sugar and other syrup (11.4)	0.01	0.01	0.00	0.00	0.00	0.00
	B. Chocolate drink (05.1.5), Juices (14.1.2), flavoured bevereges(14.1.4), coffee, coffee substitute, tea, herbaldrink, grain cereal beverages and hot cereal drinks(14.1.5)	1.62	1.14	0.52	0.17	0.05	0.26
	C. Carbonated flavoured beverages (14.1.4.1)	0.02	0.03	0.04	0.02	0.01	0.02
	D. Alcoholic beverages with various aroma (14.2.7)	0.00	0.00	0.01	0.02	0.02	0.02
	Total (mg kg^{-1} bw day^{-1})	2.87	1.96	0.96	0.56	0.44	0.69
	Percentage (%) against ADI value (5 mg kg^{-1} bw day^{-1})	57.40	39.20	19.20	11.20	8.80	13.80
		Highest manufacturer level used of benzoate preservative per age group (mg kg^{-1} bw day^{-1})					
1	Dairy based desserts (01.7)	0.06	0.02	0.00	0.00	0.00	0.00
2	Oil, fat and its preparations: Margarine and similar products (02.2.1), emulsified sauces (eg mayonnaise, salad dressings) (12.6.1)	0.02	0.02	0.01	0.01	0.00	0.01
3	Processed Fruits: Jams, jelly and marmalade (04.1.2.5), fruit-based raw materials (04.1.2.8), fruit-based desserts (04.1.2.9), vegetable purees, nuts and seeds (eg peanut butter) (04.2. 2.5)	0.08	0.04	0.01	0.00	0.00	0.01
6	Confectionery/candies (05.2), decoration, topping and sweet sauces (05.4)	0.04	0.02	0.00	0.00	0.00	0.00
4	Cereals based dessert and starch (06.5)	0.00	0.00	0.00	0.00	0.00	0.00
5	Egg based dessert (eg custard) (10.4)	0.03	0.02	0.02	0.01	0.02	0.02
6	Condiments	0.59	0.45	0.29	0.28	0.29	0.30
	A. seasonings and condiments (12.2.2)	0.05	0.04	0.02	0.01	0.01	0.02
	B. Non-emulsified sauces (12.6.2), non-fermentedsoy sauces (12.9.2.2), othersoy sauces (soy sauce,weetsoy sauce, tauco) (12.9.2.3)	0.54	0.41	0.27	0.27	0.28	0.28
7	Beverages	1.38	0.99	0.47	0.16	0.06	0.24
	A. Concentrate for flavoured beverages (14.1.4.3), sugar and other syrup (11.4)	0.01	0.01	0.00	0.00	0.00	0.00
	B. Chocolate drink (05.1.5), Juices (14.1.2), flavoured bevereges(14.1.4), coffee, coffee substitute, tea, herbaldrink, grain cereal beverages and hot cereal drinks(14.1.5)	1.35	0.95	0.44	0.14	0.04	0.21
	C. Carbonated flavoured beverages (14.1.4.1)	0.02	0.03	0.03	0.01	0.01	0.02
	D. Alcoholic beverages with various aroma (14.2.7)	0.00	0.00	0.00	0.01	0.01	0.01
	Total (mg kg^{-1} bw day^{-1})	2.20	1.56	0.80	0.46	0.37	0.58
	Percentage (%) against ADI value (5 mg kg^{-1} bw day^{-1})	44.00	31.12	16.00	9.20	7.40	11.60
		Highest result of benzoate preservative product tests by manufacturer per age group (mg kg^{-1} bw day^{-1})					
1	Dairy based desserts (01.7)	0.06	0.02	0.00	0.00	0.00	0.00
2	Oil, fat and its preparations: Margarine and similar products (02.2.1), emulsified sauces (eg mayonnaise, salad dressings) (12.6.1)	0.02	0.02	0.01	0.01	0.00	0.01
3	Processed Fruits: Jams, jelly and marmalade (04.1.2.5), fruit-based raw materials (04.1.2.8), fruit-based desserts (04.1.2.9), vegetable purees, nuts and seeds (eg peanut butter) (04.2. 2.5)	0.08	0.04	0.01	0.00	0.00	0.01
6	Confectionery/candies (05.2), decoration, topping and sweet sauces (05.4)	0.04	0.02	0.00	0.00	0.00	0.00
4	Cereals based dessert and starch (06.5)	0.01	0.00	0.00	0.00	0.00	0.00
5	Egg based dessert (eg custard) (10.4)	0.03	0.02	0.02	0.01	0.02	0.02
6	Condiments	0.57	0.44	0.28	0.27	0.29	0.29
	A. seasonings and condiments (12.2.2)	0.05	0.04	0.02	0.01	0.01	0.02
	B. Non-emulsified sauces (12.6.2), non-fermentedsoy sauces (12.9.2.2), othersoy sauces (soy sauce,weetsoy sauce, tauco) (12.9.2.3)	0.52	0.40	0.26	0.26	0.28	0.27
7	Beverages	1.38	0.99	0.47	0.16	0.06	0.24
	A. Concentrate for flavoured beverages (14.1.4.3), sugar and other syrup (11.4)	0.01	0.01	0.00	0.00	0.00	0.00
	B. Chocolate drink (05.1.5), Juices (14.1.2), flavoured beverages (14.1.4), coffee, coffee substitute, tea, herbaldrink, grain cereal beverages and hot cereal drinks (14.1.5)	1.35	0.95	0.44	0.14	0.04	0.21
	C. Carbonated flavoured beverages (14.1.4.1)	0.02	0.03	0.03	0.01	0.01	0.02
	D. Alcoholic beverages with various aroma (14.2.7)	0.00	0.00	0.00	0.01	0.01	0.01
	Total (mg kg^{-1} bw day^{-1})	2.19	1.55	0.79	0.45	0.37	0.57
	Percentage (%) against ADI value (5 mg kg^{-1} bw day^{-1})	43.87	30.92	15.80	9.00	7.40	11.40

sure assessment of benzoate preservatives has been conducted in several countries such as Taiwan, Thailand, New Zealand and Austria. The exposure level of benzoic acid on food in Taiwan was less than 60 % of ADI and does not endanger public health [16]. The exposure level of benzoic acid on food in Thailand was 55.4 mg person^{-1} day^{-1} or by 20.5 % of ADI indicating that Thai consumers are safe from exposure to benzoic acid [17].

The exposure level of benzoate preservatives in New Zealand was 1-8 % or below ADI which indicates a low risk level for public health [18]. Meanwhile, the exposure to benzoate preservatives in Austria comes primarily from consumption of fish and its derivatives, amounting to 43-68 % of average intake and approximately 25-33 % in the worst scenario [13].

Overall, the exposure level to benzoate preservatives for all age groups both from the highest manufacturer level used and the highest result of product tests by manufacturer did not exceed from the regulation maximum limit. This indicates that determination of the regulation maximum limit provides the level of protection to the public with the worst scenario assumption.

In general, according to various finding results in several countries, the average exposure level of benzoate preservatives is still below ADI. Based on some study results in certain age groups, high consumption level of benzoate preservatives may exceed ADI as in Belgium for preschool children group (aged 2-6 years) that have benzoate exposure of 118.2 % of ADI in the 95th percentile [12], while exposure level of benzoate preservatives in Hong Kong for high consumers (boys aged 11-14) exceeded ADI by 28.0 % [14] and ADI was exceeded in the brand-loyal scenario in particular for toddlers and children groups consuming on a regular basis of beverages in Europe [19].

One limitation in this study is no calculation on the exposure values to some consumers that may also be loyal to those foods or brands of food consuming higher amount (high-consumer) than average food consumption from the 2014 IFCS report. Concerns may be raised especially in case of high-consumer who consume preferential food containing benzoate preservatives.

Contribution of food category to dietary intake: The food category that contributes to the benzoate exposure is seen based on ADI profile of dietary intake suspected to contain benzoate preservatives in the all age group based on the maximum regulation limit, the highest level used and result of product tests by manufacturer as presented in Fig. 2. The food category that contributed to benzoate preservative exposure were condiments, beverages, egg based desserts, processed fruits, as well as oils, fats and other food products such as dairy based desserts, cereals and starch based dessert and confectionery.

Condiments and beverages became the dominated food categories contributed to benzoate preservatives exposure in all age groups, respectively 43.38-51.72 % and 41.38-43.48 %. In the adult and elderly age group, condiments became the food category which highly contributed to benzoate preservatives exposure of 0.27-0.28 and 0.29 mg kg^{-1} bw day^{-1}, followed by beverages of 0.16-0.21 and 0.06-0.08 mg kg^{-1} bw day^{-1}. Condiments include seasonings such as soy sauce and ketchup.

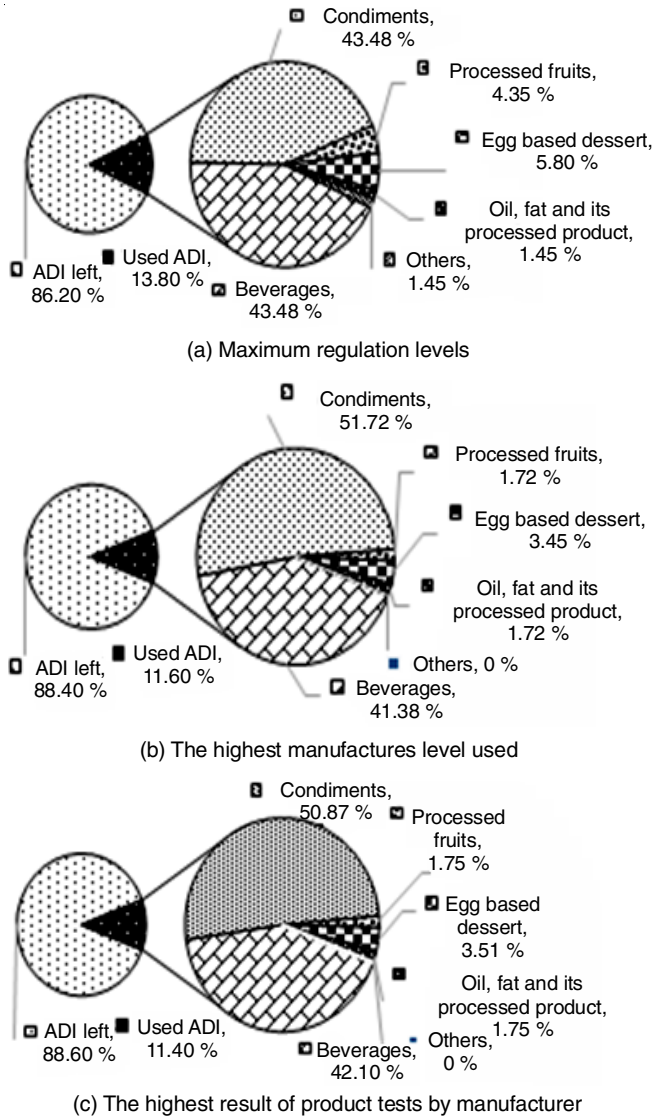

Fig. 2. Food categories that contribute to exposure to benzoate preservatives in all age groups profiles

Beverages is the main food category that contributed to benzoate preservatives exposure. Exposure to benzoate preservatives in each group age were as follows: children aged 0-59 months was 1.38-1.65 mg kg^{-1} bw day^{-1}, school-age children group was 0.99-1.18 mg kg^{-1} bw day^{-1} and adolescent group was 0.47-0.57 mg kg^{-1} bw day^{-1}. Other food category that contribute to benzoate exposure were condiments and processed fruit (jam, jelly and marmalade).

Beverages have been reported by some countries as food that highly contributes to the benzoate exposure such as in South Korea that was 2.25 % ADI [20], soft drinks in Belgium [12], beverages other than fat based salad such as salad dressing in Denmark [21] and Hong Kong specifically examined the exposure level of benzoic acid in soft drinks with the exposure level was 6.1 % of ADI [14]. Further study considering the high consumption level of beverages needs to be conducted in order to obtain refinement of benzoate preservatives exposure data that may exceed ADI. This is due to the high average consumption level in children aged 0-59 months, school-age children and adolescent group.

The low use of ADI from benzoate exposure in the all age groups indicates a low risk of the use of benzoate preservatives in Indonesian consumers. These data suggest that children groups have a high risk of exposure to benzoate preservatives every day, particularly for the beverage category.

Conclusion

In this study, the level of dietary intake suspected to contain benzoate preservatives in all age groups was 49.40 g kg^{-1} bw day^{-1} (2.46 %) from total dietary intake that was 2009.10 g kg^{-1} bw day^{-1}. The highest level used of benzoate preservatives by manufacturer is similar as determined by the regulation in each food category as evidenced by the product testing results. The dietary exposure to benzoate preservatives in Indonesia for all age groups was still below ADI with a range of 0.57-0.69 mg kg^{-1} bw day^{-1}. Among all age groups, foods that highly contributed to the benzoate exposure were beverages, condiments, egg based desserts and processed fruits.

Risk characterization of benzoate preservatives in all age groups ranged from 7.40-57.40 % of ADI which indicates that ADI is not exceeded even in the worst case scenario using the maximum regulation limit, the highest level used and the highest product test results by the manufacturer so that the exposure risk to benzoate preservatives from food consumed by Indonesian consumers is safe.

Considering many limitations of this study, particularly in terms of the use of dietary intake data based on the 2014 IFCS Report as the average value per person per day, further research is needed to calculate more refined exposure levels. Probabilistic approach and high level food consumption suspected containing benzoate preservatives can be used to obtain more refined exposure value.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

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