



2012

Total dietary studies and food safety assessment in Taiwan-food preservatives as an illustration

Follow this and additional works at: <https://www.jfda-online.com/journal>

Recommended Citation

Hsieh, D.P.H.; Huang, H.-Y.; Ling, M.-P.; Chen, Y.-S.; Huang, L.-L.I.; Wu, C.-H.; Ni, S.-P.; Hung, H.-C.; and Chiang, C.-F. (2012) "Total dietary studies and food safety assessment in Taiwan-food preservatives as an illustration," *Journal of Food and Drug Analysis*: Vol. 20 : Iss. 4 , Article 5.
Available at: <https://doi.org/10.38212/2224-6614.2023>

This Review Article is brought to you for free and open access by Journal of Food and Drug Analysis. It has been accepted for inclusion in Journal of Food and Drug Analysis by an authorized editor of Journal of Food and Drug Analysis.

Total Dietary Studies and Food Safety Assessment in Taiwan-Food Preservatives as an Illustration

DENNIS PAUL HSIENTANG HSIEH^{1*}, HUI-YING HUANG², MIN-PEI LING¹, YUH-SHUEN CHEN³, LIANG-LI HUANG¹, CHIU-HUA WU¹, SHIH-PEI NI¹, HUI-CHUAN HUNG² AND CHOW-FENG CHIANG¹

¹. Department of Health Risk Management, China Medical University, Taichung, Taiwan, 40402, R.O.C.

². Department of Nutrition, China Medical University, Taichung, Taiwan, 40402, R.O.C.

³. Department of Food Science and Technology, Hungkuang University, Taichung, Taiwan, 43302, R.O.C.

(Received: June 1, 2012; Accepted: December 10, 2012)

ABSTRACT

This second total diet study (TDS) in Taiwan was initiated to assess the health risk posed on general consumers from the dietary intake of benzoic acid and sorbic acid as an illustration of a risk assessment of food preservatives. Health risk was assessed by estimating the ratio of the exposure level to the acceptable daily intake (ADI) level of an analyte. This ratio, known as the hazard index (HI), must be less than 100% to ensure no health risk of concern. The ADI values were obtained from the Joint FAO/WHO Expert Committee on Food Additives (JECFA). The present TDS was conducted based on the two analytes, benzoic acid and sorbic acid. Exposure levels of the analytes were determined by using three sets of local data: 1) the analyte concentrations (C) in pertinent food samples, 2) the individual consumption rates (CR) of these food samples, and 3) the body weight (BW) of consumers. C values were obtained by chemical analysis of the analytes in food samples, while CR and BW values were derived from the database of the Nutrition and Health Survey in Taiwan (NAHSIT). The HI values were calculated using the equation below and expressed as % ADI.

$$HI_j = \sum_{i=1}^n \%ADI_j = \sum_{i=1}^n \frac{ADD_{ij}}{ADI_p} \times 100\% = \sum_{i=1}^n \frac{C_i \times CR_{ij}}{BW_j \times ADI_p} \times 100\%$$

A scheme was developed to select food items to represent the total diet consumed in Taiwan. Based on the NAHSIT database, the total diet was classified into 12 categories and 47 sub-categories. By ranking food consumption rates, 128 food items were selected to form a basic list for the TDS, which represented 83% of the total diet consumed daily in Taiwan. Taking into consideration the occurrence pattern of the analytes in foods, the list was adjusted to a total of 97 food items for sample collection and preparation for chemical analysis. Food products were purchased from 50 strategic sampling sites throughout Taiwan over two seasons (spring/summer and autumn/winter) for two consecutive years. Food samples were prepared according to the conditions of serving and were homogenized and mixed prior to chemical analysis to obtain data on C, of which the maximum concentration of each food item was used to make a conservative estimate. The BW of nine age groups and CR of individual food items by each age group were used as exposure factors in risk calculation. The results indicated that the levels of exposure to benzoates and sorbates of the general consumers at 95th percentile in Taiwan were below 50% ADI for benzoates and around 10% ADI for sorbates, which suggest relatively low risk of concern. The present TDS work has helped to renew and strengthen the framework of TDS in Taiwan and facilitate further similar risk assessment work on other target chemicals in food.

Key words: total diet study, health risk, food preservatives, benzoic acid, sorbic acid

INTRODUCTION

The Total Diet Study (TDS), also known as the “market basket study”, is a research exercise that determines the levels of various contaminants and nutrients in foods as actually consumed. From this information, dietary intakes of those analytes by population groups of a country or a defined region, and hence the associated health risk, can be assessed. Since

its inception in 1961 as a program of the U.S. Food and Drug Administration (USFDA)⁽¹⁾ to monitor radioactive contamination of foods, the TDS has been performed by various regional, national and international food safety agencies on a continuing basis to survey a broad range of analytes in diets, including pesticide residues, industrial chemicals, and toxic and nutrient elements⁽²⁾. A unique aspect of the TDS is that food samples are prepared as they would be consumed (table-ready) prior to analysis, so the analytical results provide the basis for a realistic estimation of the dietary intake of these

* Author for correspondence. Tel: +886-4-2208-0633;
Fax: +886-4-2208-0633; E-mail: dphsieh@mail.cmu.edu.tw

analytes, and hence a reasonable assessment of the health risk posed by the exposure to any of these analytes.

In 2002, a TDS on persistent organic pollutants (POPs) was listed as a focal task among the priority projects compiled by the Health Risk Assessment Group of the National Sustainable Development Committee of the Taiwan Environment Protection Administration⁽³⁾. In 2003, the Department of Health (DOH) commissioned National Tsinghua University, Hsinchu, to monitor 17 dibenzo-p-dioxins/dibenzofurans (PCDD/Fs) and 12 dioxin-like polychlorinated biphenyls (dl-PCBs) in 14 uncooked food groups of animal origin from 11 locations in Taiwan⁽⁴⁾. In the same year, the Taiwan Agricultural Chemicals and Toxic Substances Research Institute, Council of Agriculture (TACTRI/COA), launched the first full-blown TDS in Taiwan, with the financial assistance of DOH, to assess the health risks posed by 190 pesticides and metabolites, 8 metals, aflatoxins, and PCDD/Fs and dl-PCBs through dietary intake of these analytes⁽⁵⁻⁷⁾. The food groups in the total diet and the exposure factors used in this TDS were derived from the data accumulated from a Nutrition and Health Survey in Taiwan (NAHSIT) program^(8,17,33), which constitutes a unique resource that greatly facilitated and effectively shaped this study. Simultaneously, DOH also commissioned a “dry lab” study to review international TDS literature and develop a TDS framework to help establish a national TDS program for continuing operation⁽⁹⁾.

Subsequently, the TDS program in Taiwan received a statutory endorsement by the national approval of a White Paper on Food Safety and Nutrition compiled by the DOH in 2007⁽¹⁰⁾. In this Paper, it was emphasized that food safety management in Taiwan must be based on the principles and practices of health risk analysis in keeping with the TDS exercises performed in the international food safety management communities⁽¹¹⁾. The momentum of TDS in Taiwan was greatly enhanced by the establishment of the Taiwan Food and Drug Administration (TFDA) in 2010. This new arch-agency immediately invigorated the TDS program by commissioning the second TDS in Taiwan to the China Medical University in Taichung to conduct a food safety risk assessment (FSRA) of two selected food preservatives in the total diet, namely benzoic acid and sorbic acid. It was intended that by this renewed TDS project, the infrastructure and basic resources for TDS in Taiwan would be strengthened so that Taiwan would join the international community in the mainstream of FSRA. The models and methodologies renewed and developed in this second TDS in Taiwan are summarized in this article, based on the Final Report of this TDS, using the two targeted food preservatives as an illustration⁽¹²⁾.

FRAMEWORK OF TDS IN TAIWAN

I. Tasks of TDS

The framework of the second TDS in Taiwan on food preservatives is consistent with the principles and practices

of FSRA generally accepted by international food safety authorities such as the WHO/FAO^(13,14) and EFSA⁽¹⁵⁾. The framework laid out in Figure 1 consists of the following 10 focal tasks:

- (I) Selection of target analytes as hazards for health risk assessment.
- (II) Determination of acceptable daily intake (ADI) values of the target analytes.
- (III) Grouping of individual foods in the total diet based on the NAHSIT database.
- (IV) Listing of major food items of the Taiwan total diet that contain food preservatives.
- (V) Collection of listed food items from designated sampling sites in two seasons for two years.
- (VI) Preparation of food samples according to specified recipes to mimic table-ready food items for chemical analysis.
- (VII) Laboratory analysis of food samples for target analytes to generate data on their appropriate concentrations (C) in the food samples.
- (VIII) Determination of the body weights (BW) of different age groups of male and female consumers in Taiwan as an exposure factor.
- (IX) Determination of the consumption rates (CR) of the listed individual food items by different consumer groups as another exposure factor.
- (X) Calculation of the exposure level of each targeted chemical and the associated health risk in each consumer group.

Upon completion of these tasks, the four standard steps in a generally accepted FSRA process⁽¹³⁾ would have been accomplished. The four steps are:

- (I) Hazard identification
- (II) Hazard characterization
- (III) Exposure assessment
- (IV) Risk characterization

It should be noted that though the underlining toxicological principles are the same, the emphases and data requirements of the FSRA are considerably varied from those of environmental health risk assessments and occupational health risk assessments. Furthermore, the FSRA framework in Taiwan is uniquely characterized by its dependence on the large amount of food consumption data available from the Taiwan NAHSIT program that has been in progress for more than twenty years^(16,17).

II. Mathematical Representation of TDS

Mathematically, the TDS framework in Taiwan can be represented by the following equations:

- (I) Acceptable daily intake (ADI) and no-observed adverse effect level (NOAEL):

$$\text{ADI (mg/kg-BW/day)} = \frac{\text{NOAEL}}{\text{UF}} \quad (1)$$

Both toxicological parameters are in mg/kg-BW/day, implying a chronic exposure scenario. The NOAEL of a

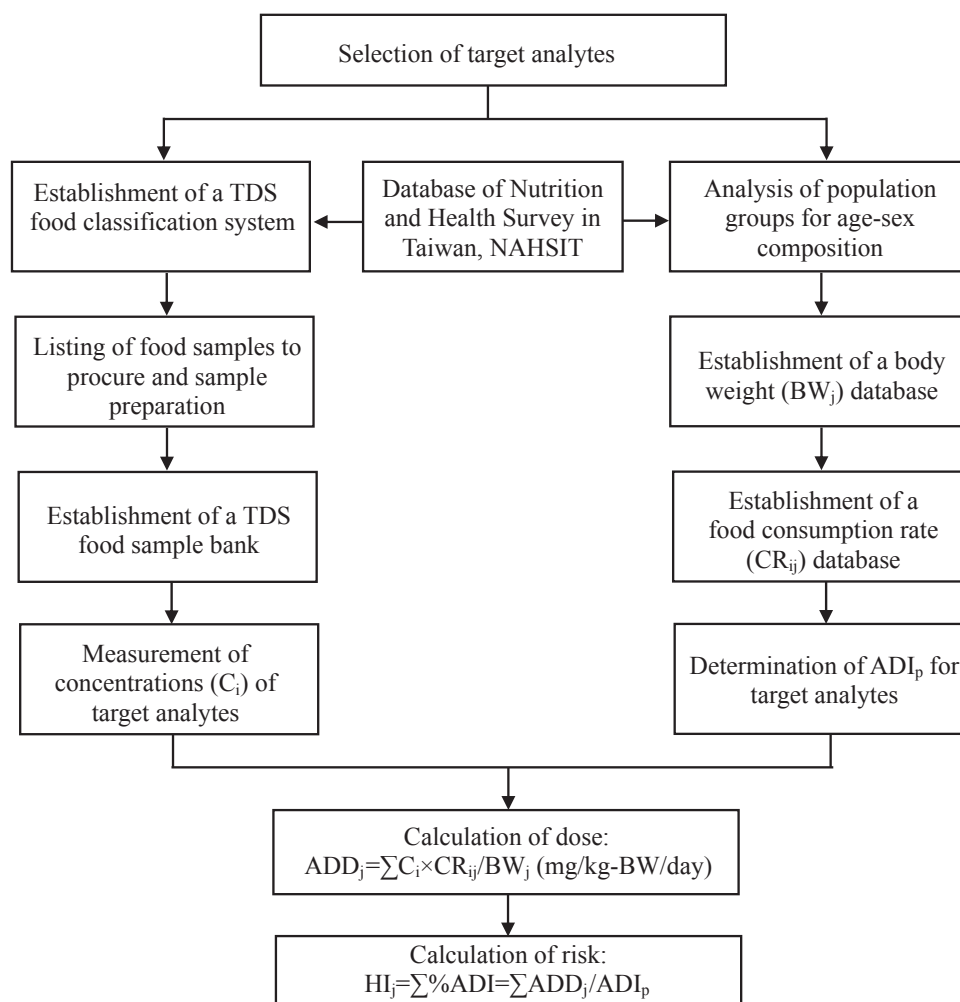


Figure 1. The framework of TDS on food preservatives in Taiwan.

chemical can usually be obtained from animal experiments reported in toxicology literature, such as the JECFA^(18,19). UF are unit-less numbers between 100 and 1,000 used to extrapolate from dose for animal to dose for human in the discretion of the risk assessor.

- (II) The average daily dose (ADD) of the target chemical in the total diet from food item i of the specified age group j :

$$ADD_j = \sum_{i=1}^n \frac{C_i \times CR_{ij}}{BW_j} \quad (2)$$

where C_i is concentration (mg/kg) of the analyte in food item i , CR_{ij} is the consumption rate (g/person/day) of food item i of age group j , and BW_j is the average body weight of the age group j .

- (III) Hazard index (HI), a measure of ADD as a percentage of ADI:

$$HI_j = \frac{ADD_j}{ADI_p} \times 100\% \quad (3)$$

where HI_j is hazard index of the age group j and ADI_p is the acceptable daily intake for chemical p . By definition, HI

must be less than 100% to indicate that no harm would result from dietary exposure to the analyte in the lifetime of any consumer. Equations 1, 2 and 3 can be combined to form a single equation to facilitate electronic computation as shown below:

$$HI_j = \sum_{i=1}^n \%ADI_{ij} = \sum_{i=1}^n \frac{ADD_j}{ADI_p} \times 100\% \\ = \sum_{i=1}^n \frac{C_i \times CR_{ij}}{BW_j \times ADI_p} \times 100\% \quad (4)$$

DATA REQUIREMENT IN TDS

Based on the overall equation (4), to calculate HI_j posed by a target chemical p in the total diet, the experimental data on the following variables would be required:

- I. NOAEL and UF for calculating ADI_p . In the present study, values of ADI_p were taken from those promulgated by JECFA.
- II. C_i of the target chemical in the representative food

items selected for TDS, such as mg of benzoates per kg of bean curd.

III. BW_j of a specified population of interest, such as male consumers of ages 19 to 50.

IV. CR_{ij} of food item i ingested by an individual in a specified population j , in g per person per day.

The toxicity data for NOAEL and UF, and hence ADI_p , are generally accepted worldwide as an intrinsic property of the target chemical p . C_1 values reflecting the quality of diet of a country have to be actually measured by chemical analysis. The data on BW_j and CR_{ij} are exposure factors characteristic of local dietary practice of a specified population of interest, which have to be derived from local food consumption surveys such as the NAHSIT in Taiwan.

SELECTION OF TARGET ANALYTES

The classes of food chemicals that have been subjects of TDS in the literature include radionuclides⁽²⁰⁾, persistent organic pollutants^(4,5), metals⁽²¹⁻²³⁾, mycotoxins^(6,24), pesticides⁽²⁵⁻²⁷⁾ and food additives⁽²⁸⁾. Prioritization of TDS on a particular class of chemicals as target analytes would take into consideration the following factors:

- I. Toxic potency of the analytes and hence the health concern
- II. Widespread occurrence in the diet consumed
- III. Frequency and severity of regulatory violations
- IV. Political and economic demands

For the present second TDS in Taiwan, the target analytes selected by the TFDA were two food preservatives, benzoic acid and sorbic acid, for their widespread usage and high rates of regulatory violations. Currently, there are 22

chemicals listed as legal preservatives permitted for use in certain specified foods in Taiwan⁽²⁹⁾, of which five chemicals have ADI values available from the JECFA⁽³⁰⁾. It was decided that, with limited funding available, the present TDS be focused on benzoates and sorbates as target analytes to illustrate and strengthen the TDS endeavors in Taiwan.

FOOD LISTING FOR TDS

The massive food consumption data available from NAHSIT conducted in 2005-2008 were grouped into 12 major categories and 47 sub-categories based on nutrient contents. The 268,431 raw data entries obtained from 6,104 questionnaires were consolidated into 11,182 different food items under the 47 sub-categories. The number of food items to remain in each sub-category for TDS was determined by the percentage of this sub-category in the weight (e.g. grams) of total diet consumed, with the last fraction of 1% also considered as 1%. For example, the sub-category "rice and rice products" represented 10.4% of the weight of total diet consumed, and hence the top 11 food items in descending order of consumption rate (g/day) were selected to represent this sub-category. One exception was sub-categories 36 (ice and beverages) and 45 (soup), where due to the large water content and relative uniformity of these food groups, the percentages of people consuming these groups (4.58 and 0.14%) instead of the percentages of amount consumed (29.80 and 10.72%) were used to keep the numbers of food items small. Following this rule, a total of 128 food items were selected from the 47 sub-categories to form a basic list of food items for TDS in Taiwan as shown in Table 1. The summation of the amounts of these 128 food items consumed

Table 1. The list of food items selected for TDS on food preservatives in Taiwan^a

Major Categories of food in Taiwan (12)	Sub-Categories of food in Taiwan (47)	Ratio to total diet consumed (%)	Numbers of food items listed for TDS	Food items listed for TDS (128)	Food items listed for preservative analysis (97)
				1 Rice	
				2 Other rice	1 Other rice
				3 Rice milk	2 Rice milk
				4 Rice dumpling	3 Rice dumpling
				5 Salty rice pudding	4 Salty rice pudding
				6 Sushi	5 Sushi
01 Grains	01 Rice and rice products	10.42	11	7 Steamed rice cake with pig blood	6 Steamed rice cake with pig blood
				8 Rice noodles	7 Rice noodles
				9 Sticky rice ball	8 Sticky rice ball
					9 Mochi
				10 Rice bran	10 Rice bran
				11 Rice flat noodle	11 Rice flat noodle

Table 1. Continued

Major Categories of food in Taiwan (12)	Sub-Categories of food in Taiwan (47)	Ratio to total diet consumed (%)	Numbers of food items listed for TDS	Food items listed for TDS (128)	Food items listed for preservative analysis (97)
01 Grains	02 Wheat and wheat products	3.57	4	12 Noodles	12 Noodles
					13 Thin noodles
				13 Bread bun	14 Bread bun
				14 Green onion pancakes	15 Green onion pancakes
				15 Wheat flake and bran	16 Wheat flake and bran
				16 Sweet potato	
03 Starchy vegetable foods and products	1.47	2	17 Starchy foods	17 Tapioca	
				18 Taro balls	
04 Dry bean and starchy vegetable foods	0.54	1	18 Corn	19 Corn	
				20 Dried beans	
02 Oils	05 Vegetable oil	1.00	1	19 Vegetable oil	21 Salad dressings
	06 Animal oil	0.21	1	20 Animal oil	
	07 Nuts and nut products	0.23	1	21 Peanuts	22 Peanuts
03 Poultry and poultry products	08 Chicken and chicken products	1.41	2	22 Chicken	23 Chicken
				23 Chicken giblets	24 Chicken giblets
	09 Duck and duck products	0.26	1	24 Duck	25 Duck
	10 Other poultry and the products	0.09	1	25 Goose	
04 Meat and meat products	11 Pork and pork products	5.55	6	26 Pork	26 Pork
				27 Sparerib	27 Sparerib
				28 Pettitoe	28 Pettitoe
				29 Haslet	29 Haslet
				30 Sausage	30 Sausage
				31 Other pork products	31 Other pork products
				32 Beef	32 Beef
12 Beef and beef products	0.88	1			
13 Other meat and meat products	0.28	1	33 Mutton		
05 Fish and aquatic products	14 Freshwater fish	0.83	1	34 Milkfish	
	15 Seawater fish	2.01	3	35 Hair tail	
				36 Grouper	
				37 Dried fish	33 Dried fish
	16 Fish's viscera and the products	0.50	1	38 Kamaboko	34 Kamaboko
17 Other aquatic and the products	1.16	2	39 Shrimp		
			40 Processed fish products	35 Processed fish products	
06 Other proteins	18 Egg and egg products	2.28	3	41 Egg	
				42 Stewed egg	36 Stewed egg
				43 Cooked egg	37 Cooked egg
	19 Dairy foods	4.60	5	44 Milk	38 Milk
				45 Fermented milk	39 Fermented milk

Table 1. Continued

Major Categories of food in Taiwan (12)	Sub-Categories of food in Taiwan (47)	Ratio to total diet consumed (%)	Numbers of food items listed for TDS	Food items listed for TDS (128)	Food items listed for preservative analysis (97)
06 Other proteins	19 Dairy foods	4.60	5	46 Milk powder	
				47 Flavored Milk	40 Flavored Milk
				48 Cheese and Condensed milk	41 Cheese and Condensed milk
					42 Butter
				49 Soybean milk and Soft tofu	43 Soybean milk
	44 Soft tofu				
	20 Soy bean and the products	6.80	7	50 Tofu	45 Tofu
				51 Dried Tofu	46 Bai-ye tofu
					47 Fried bean curd
				52 Bean curd sheet	48 Dried tofu
					49 Packaged dried tofu
				53 Veg bean products	50 Bean curd sheet
					51 Dried bean threads
	07 Fruits	21 Fresh fruits	12.93	13	52 Veg bean products
54 Gluten					53 Gluten
55 Fermented bean curd					54 Fermented bean curd
					55 Fermented black beans
	56 Miso				
	57 Bean Pastes				
	56 Guava				
	57 Apple				
	58 Banana				
	59 Red watermelon				
	60 Pineapple				
	61 Tangerine				
	62 Orange				
	63 Tomato				
	64 Pear				
	65 Bell fruit				
	66 Grape				
	67 Papaya				
	68 Jujube				
	22 Fruit products	0.14	1	69 Preserved fruits	58 Preserved fruits
	23 Fresh fruits juices	0.83	1	70 Orange juice	
08 Vegetables	24 Dark-colored vegetable	9.64	10	71 Sweet potato leaves	
				72 Baby bukchoy	
				73 Water spinach	
				74 Spinach	
				75 Carrot	

Table 1. Continued

Major Categories of food in Taiwan (12)	Sub-Categories of food in Taiwan (47)	Ratio to total diet consumed (%)	Numbers of food items listed for TDS	Food items listed for TDS (128)	Food items listed for preservative analysis (97)
08 Vegetables	24 Dark-colored vegetable	9.64	10	76 Lettuce	
				77 Bukchoy	
				78 Romane lettuce	
				79 Chinese Kale	
				80 Broccoli	
	25 Light-colored vegetable	6.00	6	81 Cabbage	
				82 Chinese cabbage	
				83 Chinese radish	
				84 Onion	
				85 Bean sprout	
	26 Bamboo shoot	0.81	1	87 Bamboo shoot	
	27 Cucurbits	2.36	3	88 Sponge gourd	
				89 Bottle gourd	
				90 Bitter gourd	
28 Legumes	0.27	1	91 Green beans		
29 Fungus	0.62	1	92 Needle mushroom		
30 Other vegetable products	0.78	1	93 Seaweed	59 Seaweed	
31 Preserved vegetables	0.50	1	94 Pickled vegetables	60 Pickled vegetables	
				61 Dried pickled radish	
				62 Pickled cucumbers	
				63 Fermented vegetables	
				64 Dried bamboo shoot	
09 Desert	32 Bread	1.69	2	95 Toast	65 Toast
				96 Bread	66 Bread
	33 Cooked and snacks	1.19	2	97 Cakes	67 Cakes
				98 Biscuit	68 Biscuit
34 Desert and candies	0.40	1	99 Confectionery	69 Confectionery	
35 Chinese deserts	0.93	1	100 Chinese pastry	70 Pastry	
				71 Red bean cake	
09 Desert	36 Ice and beverages	29.80 (4.58) ^a	5	101 Tea	72 Tea
				102 Coffee	73 Coffee
				103 Carbonated beverages	74 Carbonated beverages
				104 Ice	75 Ice
				105 Other beverages	76 Other beverages
	37 Processed fruit juices	2.16	3	106 Fresh juices	77 Fresh juices
				107 Fruit vinegar	78 Fruit vinegar
				108 Fruit teas	79 Fruit tea
				80 Fruit flavor enhancers	

Table 1. Continued

Major Categories of food in Taiwan (12)	Sub-Categories of food in Taiwan (47)	Ratio to total diet consumed (%)	Numbers of food items listed for TDS	Food items listed for TDS (128)	Food items listed for preservative analysis (97)
10 Alcoholic beverages	38 Alcoholic beverages	4.39	5	109 Beer	81 Beer
				110 Rice wine	82 Rice wine
				111 Sorghum liquor	
				112 Grape wine	
				113 Other wine	
11 Seasonings	39 Sugar	0.90	1	114 Sugar	83 Sugar
	40 Salts	0.17	1	115 Salt	
	41 Sauces	1.37	2	116 Soya sauce	84 Soya sauce
				117 vinegar	85 vinegar
	42 Other seasonings	1.51	2	118 Mono Sodium Glutamate (MSG)	
				119 Other seasonings	86 Other seasonings 87 Tomato sauce
	12 Others	43 Processed foods (meat)	3.14	4	120 Dumplings and pot stickers
121 Meat balls					89 Meat balls
122 Steam buns					90 Steam buns
123 Steamed meatballs					91 Steamed meatballs
44 Processed foods (others)		0.36	1	124 Oyster omelet	92 Oyster omelet 93 Tempura
45 Processed foods (soup)		10.72 (0.14) ^b	1	125 Prepared soups	94 Prepared soups
46 Instant noodles		0.65	1	126 Instant noodles	95 Instant noodles
47 Ready-to-go food	1.74	2	127 Fast foods	96 Fast foods	
			128 Thick soups	97 Thick soups	
Total		99.71	128	128	97

^a See Table 6 for the English translation of the names of local Taiwanese foods.

^b Percentage of weight (g) consumed (percentage of people consuming).

daily represented 83% of the total dietary intake of a population of ages between 19 and 50 in Taiwan. This level of representation is comparable to the levels found in international TDS reports^(28,31).

It should be noted that it is possible to find the top item in one-subcategory to have a percentage of total diet smaller than the last item listed in another sub-category, because each nutrient-based sub-category was treated independently in the selection of the specified number of food items in it, to achieve the maximum representation possible.

The food list specific for preservatives was constructed by making the following adjustments to the basic list of 128 items:

I. Omitting from the basic list the food items that do not likely contain preservatives, such as fresh vegetables and fruits,

II. Adding to the list the food items that were known to contain especially high levels of preservatives including those known to frequently violate the preservative use regulations, and

III. Adding to the list the food items that are legally permitted to use preservatives, regardless of their weights of daily consumption.

A list of 97 food items was obtained upon these adjustments as shown in Table 1, which represented the total diet in Taiwan consumed by the population of ages 3 and above that may contain food preservatives. This list was used as the basis for purchasing food products for preparation of food samples for the chemical analysis of food preservatives and for the construction of a bank of food samples kept for future TDS work.

PURCHASE AND PREPARATION OF FOOD SAMPLES

Food sampling was based on consumption rates. For each of the 97 items associated with food preservatives (Table 2), one to three food products of the largest consumption rate were selected for purchase to result in a list of 156 products to be obtained. Food products were purchased in

two seasons, spring/summer (May - July) and autumn/winter (September - November), each year for two consecutive years (2010 and 2011), from 50 strategic sampling sites located in four parts of Taiwan, north, central, south, and east. In each part, two major cities of the largest population size were selected, and food products were purchased from four types of markets in these cities: 1) super-markets, 2) traditional wet markets, 3) large distributor discount stores,

Table 2. Concentrations of food preservatives (C) in listed food items and their food consumption rates (CR) in Taiwan

Food items listed for preservative analysis (97)*	Maximum benzoate concentration (g/kg)	Maximum sorbate concentration (g/kg)	Consumption rate (male) (g/d)	
			Age 19-50	Age ≥ 3
1 Other rice	ND	ND	LN(18.92,3.74) ^a	LN(18.70,3.02)
2 Rice milk	ND	ND	LN(27.16,2.67)	LN(9.76,4.25)
3 Rice dumpling	0.151	0.026	LN(8.30,4.42)	LN(6.08,3.67)
4 Salty rice pudding	0.0532	0.1140	LN(1.81,4.61)	LN(3.27,5.24)
5 Sushi	0.083	0.224	LN(2.50,6.29)	LN(3.56,4.12)
6 Steamed rice cake with pig blood	0.1468	0.213	LN(5.18,2.25)	LN(3.01,3.99)
7 Rice noodles	0.125	ND	LN(1.27,5.34)	LN(1.52,4.43)
8 Sticky rice ball	0.0477	0.076	LN(0.50,8.53)	LN(1.05,6.53)
9 Mochi	0.2832	0.0960	LN(0.96,4.70)	LN(0.46,6.61)
10 Rice bran	ND	ND	LN(1.52,4.65)	LN(3.24,7.42)
11 Rice flat noodle	0.2504	ND	LN(1.40,3.91)	LN(1.42,5.34)
12 Noodles	0.0305	ND	LN(37.12,1.82)	LN(26.84,2.46)
13 Thin noodles	ND	ND	LN(12.10,4.39)	LN(6.74,4.01)
14 Bread bun	ND	ND	LN(4.51,3.00)	LN(6.23,3.22)
15 Green onion pancakes	0.043	0.4170	LN(10.79,4.00)	LN(8.58,3.49)
16 Wheat flake and bran	ND	ND	LN(6.72,13.08)	LN(9.95,8.19)
17 Tapioca	0.2423	0.121	LN(1.26,9.49)	LN(0.96,6.53)
18 Taro balls	ND	0.1330	LN(1.07,2.94)	LN(0.61,5.23)
19 Corn	ND	0.081	LN(1.92,2.43)	LN(2.34,3.10)
20 Dried beans	0.032	0.1620	LN(1.98,6.20)	LN(2.64,4.27)
21 Salad dressings	0.089	0.284	LN(0.26,8.14)	LN(0.12,15.37)
22 Peanuts	ND	ND	LN(1.62,2.45)	LN(1.52,3.85)
23 Chicken	ND	0.1620	LN(13.67,2.03)	LN(11.97,2.47)
24 Chicken giblets	0.070	ND	LN(1.59,2.17)	LN(0.50,4.29)
25 Duck	ND	ND	LN(1.63,5.22)	LN(1.22,4.65)
26 Pork	0.1069	ND	LN(38.77,1.61)	LN(33.33,1.72)
27 Sparerib	ND	0.199	LN(7.92,3.82)	LN(5.07,3.73)
28 Pettitoe	0.047	ND	LN(3.32,4.74)	LN(1.99,5.10)
29 Haslet	0.1199	0.172	LN(2.92,4.78)	LN(2.75,4.04)
30 Sausage	0.5233	0.5810	LN(5.71,2.01)	LN(3.37,5.17)
31 Other pork products	ND	1.2250	LN(2.28,3.22)	LN(2.49,3.41)
32 Beef	0.0866	0.7820	LN(10.78,3.12)	LN(5.80,3.46)
33 Dried fish	ND	ND	LN(0.79,3.91)	LN(0.72,3.99)
34 Kamaboko	0.265	0.435	LN(4.25,5.38)	LN(3.82,4.14)
35 Processed fish products	0.108	0.060	LN(0.79,8.22)	LN(1.07,5.81)

Table 2. Continued

Food items listed for preservative analysis (97)*	Maximum benzoate concentration (g/kg)	Maximum sorbate concentration (g/kg)	Consumption rate (male) (g/d)	
			Age 19-50	Age ≥ 3
36 Stewed egg	0.265	ND	LN(1.14,4.56)	LN(1.17,4.67)
37 Cooked egg	ND	ND	LN(2.08,4.73)	LN(2.02,3.62)
38 Milk	ND	ND	LN(22.99,3.08)	LN(24.84,3.76)
39 Fermented milk	0.035	ND	LN(8.71,4.44)	LN(9.81,4.25)
40 Flavored Milk	ND	ND	LN(10.65,4.03)	LN(11.16,4.93)
41 Cheese and Condensed milk	ND	0.6130	LN(0.55,7.09)	LN(0.58,5.44)
42 Butter	0.035	ND	LN(0.12,9.97)	LN(0.05,13.10)
43 Soybean milk	ND	ND	LN(41.74,2.44)	LN(34.06,2.49)
44 Soft tofu	0.1531	ND	LN(26.38,1.41)	LN(8.18,3.62)
45 Tofu	0.513	0.148	LN(15.09,1.61)	LN(13.24,1.96)
46 Bai-ye tofu	0.039	ND	LN(1.92,1.43)	LN(0.75,10.61)
47 Fried bean curd	0.263	ND	LN(4.25,3.87)	LN(2.47,4.24)
48 Dried tofu	1.0297	1.694	LN(3.81,3.91)	LN(2.81,3.49)
49 Packaged dried tofu	1.121	ND	LN(1.46,4.92)	LN(0.78,6.14)
50 Bean curd sheet	0.1287	ND	LN(3.13,5.50)	LN(2.52,4.48)
51 Dried bean threads	0.7712	ND	LN(0.26,34.34)	LN(0.63,6.03)
52 Veg bean products	0.2367	0.5650	LN(1.33,7.29)	LN(1.25,5.73)
53 Gluten	0.1919	0.199	LN(1.01,2.44)	LN(0.98,4.89)
54 Fermented bean curd	ND	ND	LN(0.15,4.20)	LN(0.27,4.81)
55 Fermented black beans	0.2267	ND	LN(0.06,24.22)	LN(0.16,14.71)
56 Miso	ND	0.2890	LN(0.07,10.57)	LN(0.08,8.62)
57 Bean Pastes	1.5088	0.2420	LN(0.08,7.20)	LN(0.04,10.96)
58 Preserved fruits	0.386	0.1890	LN(0.25,7.99)	LN(0.46,6.22)
59 Seaweed	0.1087	0.234	LN(1.82,4.30)	LN(1.79,3.87)
60 Pickled vegetables	0.2391	0.200	LN(0.83,5.27)	LN(0.47,6.87)
61 Dried pickled radish	3.263	ND	LN(0.76,3.86)	LN(0.65,3.70)
62 Pickled cucumbers	0.680	ND	LN(0.57,3.47)	LN(0.66,4.21)
63 Fermented vegetables	0.675	ND	LN(2.24,3.79)	LN(2.23,3.04)
64 Dried bamboo shoot	0.1746	0.205	LN(0.61,4.40)	LN(0.52,4.41)
65 Toast	ND	0.022	LN(9.18,1.81)	LN(7.52,2.55)
66 Bread	0.021	ND	LN(11.14,3.45)	LN(7.82,3.51)
67 Cakes	0.097	1.1970	LN(3.41,6.72)	LN(4.52,3.90)
68 Biscuit	0.0263	0.565	LN(7.32,3.24)	LN(4.85,4.17)
69 Confectionery	ND	ND	LN(1.89,4.89)	LN(1.23,5.80)
70 Pastry	ND	0.112	LN(6.94,5.24)	LN(7.18,4.23)
71 Red bean cake	ND	ND	LN(1.41,3.17)	LN(1.14,3.38)
72 Tea	ND	ND	LN(532.61, 1.51)	LN(358.68, 1.98)
73 Coffee	ND	ND	LN(35.36,2.75)	LN(8.00,8.19)
74 Carbonated beverages	0.080	ND	LN(28.35,2.78)	LN(27.58,2.88)
75 Ice	ND	ND	LN(12.69,3.57)	LN(9.80,3.46)
76 Other beverages	ND	ND	LN(38.45,5.54)	LN(25.19,4.82)
77 Fresh juices	ND	ND	LN(28.16,3.70)	LN(18.84,3.77)
78 Fruit vinegar	ND	ND	LN(5.62,3.17)	LN(2.57,7.11)

Table 2. Continued

Food items listed for preservative analysis (97)*	Maximum benzoate concentration (g/kg)	Maximum sorbate concentration (g/kg)	Consumption rate (male) (g/d)	
			Age 19-50	Age ≥ 3
79 Fruit tea	0.056	0.053	LN(26.95,1.94)	LN(7.94,5.74)
80 Fruit flavor enhancers	ND	ND	LN(0.00,2.81)	LN(0.00,5.46)
81 Beer	ND	ND	LN(42.81,4.88)	LN(22.74,6.33)
82 Rice wine	ND	ND	LN(5.04,2.53)	LN(2.82,3.47)
83 Sugar	ND	ND	LN(5.70,3.87)	LN(3.79,6.09)
84 Soya sauce	0.3703	0.0280	LN(14.47,1.45)	LN(9.39,1.89)
85 vinegar	ND	ND	LN(0.51,3.70)	LN(0.28,4.46)
86 Other seasonings	1.026	0.0860	LN(19.00,1.31)	LN(15.52,1.96)
87 Tomato sauce	ND	ND	LN(0.87,3.76)	LN(0.33,9.69)
88 Dumplings and pot stickers	0.2765	ND	LN(18.02,3.17)	LN(14.02,3.80)
89 Meat balls	0.146	0.1550	LN(1.93,4.89)	LN(1.92,4.50)
90 Steam buns	ND	0.0580	LN(10.89,2.73)	LN(9.62,3.04)
91 Steamed meatballs	ND	ND	LN(2.20, 8.39)	LN(1.57, 6.21)
92 Oyster omelet	ND	ND	LN(2.58, 9.85)	LN(1.34, 9.70)
93 Tempura	ND	0.7470	LN(0.36, 9.16)	LN(0.57, 8.10)
94 Prepared soups	ND	ND	LN(1.74, 8.38)	LN(1.78, 11.26)
95 Instant noodles	ND	ND	LN(7.18, 3.72)	LN(4.61, 4.55)
96 Fast foods	ND	ND	LN(10.27, 4.98)	LN(7.44, 4.34)
97 Thick soups	ND	ND	LN(9.72, 2.68)	LN(5.26, 6.56)

*The sequence numbers given in this column are the same as those in column 6 of Table 1. For each of the 97 items, one to three food products of the largest consumption rates were selected to obtain a list of 156 products to be purchased.

^aLN (gm, gSD) represents log normal distribution with geometric mean (gm) and geometric standard deviation (gSD).

and 4) night markets. A map showing the distribution of sampling sites is shown in Figure 2. The detailed numbers of samples collected from different sites in different months were documented⁽¹²⁾.

In each season, the listed 156 food products were singly and randomly purchased from different markets, and shipped cold (-18°C) to the dietary laboratory, where they were labeled and coded, washed, chopped, mixed and cooked if necessary according to specified recipes. They were then homogenized. Ninety-seven national composite food samples were prepared by mixing equal weights of food products collected from all sampling sites in four seasons to represent the 97 food items specifically listed for TDS on benzoates and sorbates. Four types of food samples were prepared and stored in a sample bank at -80°C: 1) original purchased food products, 2) homogenized individual food products requiring no cooking, 3) homogenized cooked food items prepared according to specified recipes from individual food products, and 4) homogenized national composite food samples to represent the 97 listed food items. The last type of homogenized samples was used for the chemical analysis for food preservatives.

CHEMICAL ANALYSIS AND CONCENTRATION DATA

For food preservatives as target analytes, their concentrations in the 97 food samples were analyzed by a certified high performance liquid chromatography (HPLC) method (Chinese National Standards 10949-N6190). This method was set up to simultaneously measure the concentrations of five food preservatives, benzoic acid, sorbic acid, dehydroacetic acid, salicylic acid and alkyl p-hydroxy-benzoates, with a limit of quantification (LOQ) of 0.02 g/kg. This means when the concentration is labeled as not detected (ND), the actual concentration is 0.02 g/kg or less. This limit of detection is considerably lower than those required for the routine monitoring of preservatives in food for regulatory purposes. Thus the international requirement for higher analytical sensitivities in TDS was met in the present study⁽³²⁾.

A total of 440 homogenized national composite samples prepared in two years (2010-2011) and four seasons were analyzed, and their concentrations of benzoates and sorbates were compiled and compared. For risk assessment purpose, only the highest concentration found in the samples representing each of the 97 food items was listed to pair with the

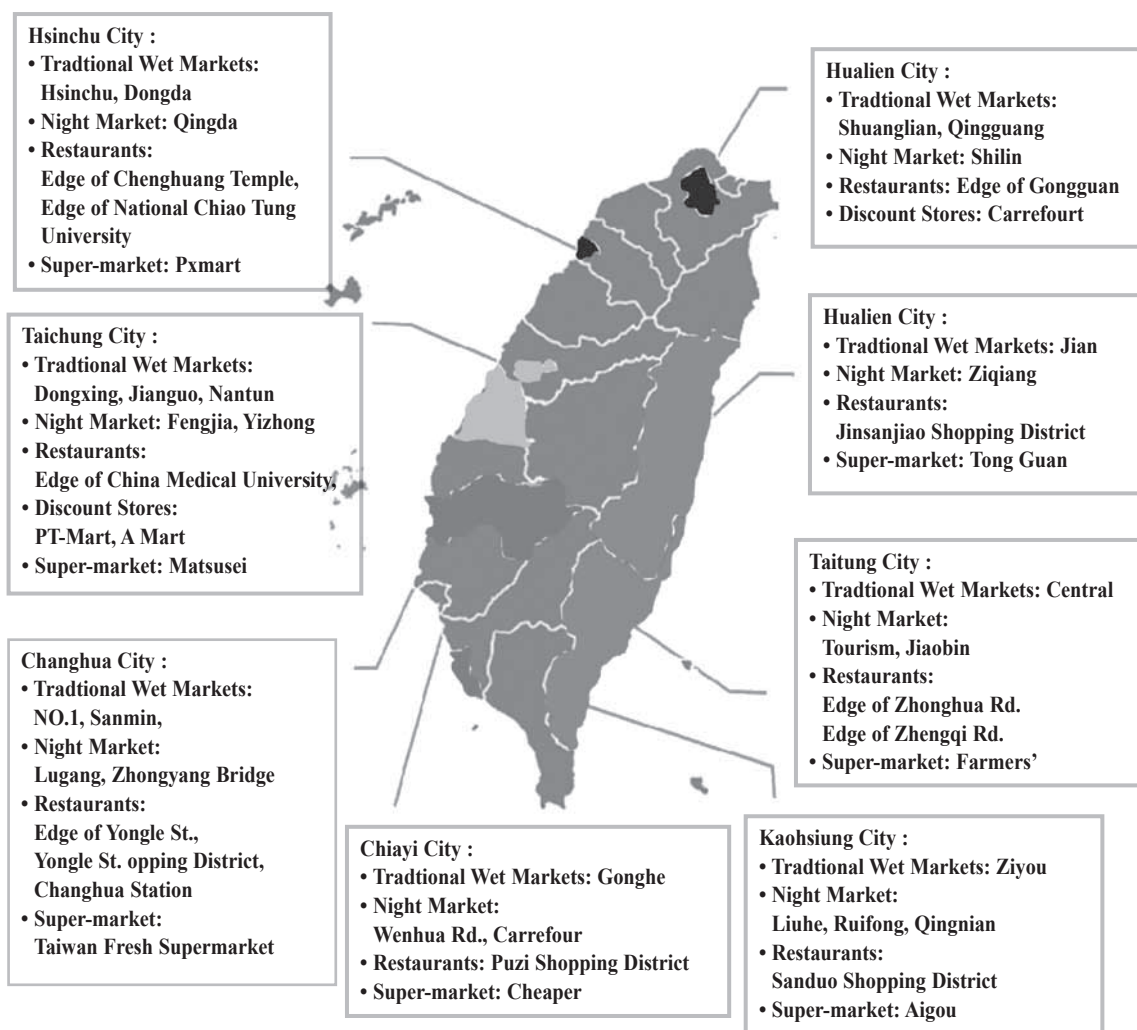


Figure 2. Distribution of purchasing sites of food samples for the analysis of food preservatives in the inland Taiwan.

food consumption rate data for dose and risk calculations. The highest concentrations of benzoates and sorbates found in the 97 food items that represented the maximum possible presence of these two analytes in the total diet consumed by the population of ages 3 and above in Taiwan are listed in Table 2. Detection rates of benzoates and sorbates were 53 and 42% of the total diet samples analyzed, respectively.

EXPOSURE ASSESSMENT

To estimate the ADD of an analyte received by a sex- and age-specified population using equation (2), the data on the BW and CR of each of the 97 representative food items were required, in addition to the concentrations of the analyte as presented in Table 2. Our data on the exposure factors were derived from the data accumulated from the NAHSIT survey conducted in 2005-2008⁽³³⁾.

Using this database, the population in Taiwan was stratified into 9 age-groups of each sex: below-1, 1-2, 3-6, 7-12,

13-18, 19-50, 51-65, 66 and above, and 3 and above. For each sex- and age-specified group, the best BW value was derived from the extrapolation of the NAHSIT questionnaire data using the weight ratio (WR) of the number of population in this specified group in Taiwan to the number of sampled subjects. Thus the sum of each sampled individual BW value multiplied by WR was divided by the sum of WR used to give the best average BW value of the group. The BW values for the 9 age groups were shown in Table 3.

Similarly, for the CR of each food item of interest, the data on individual 24-h collections from the NAHSIT questionnaires were extrapolated by using the WR of the number of population in this specified group in Taiwan to the number of sampled subjects. Thus the sum of each sampled individual CR value of a food item multiplied by WR was divided by the sum of WR used to give the best average CR value of the food item of this group. The CR values for the 97 preservative-associated food items as consumed by the age-group 3 and above were shown in Table 2.

When necessary, distributions of data values were

Table 3. Distribution of body weights in different age groups in Taiwan

Age group	Body weight (kg)	
	Male	Female
<1 ^a	N(8.42,0.84) ^d	N(7.42,0.74)
1-2 ^a	N(12.46,2.09)	N(11.68,2.44)
3-6 ^a	N(19.61,3.84)	N(18.81,3.10)
7-12 ^b	N(40.74,11.33)	N(35.79,6.44)
13-18 ^c	N(56.87,6.46)	N(51.45,1.83)
19-50 ^a	N(69.95,4.24)	N(56.43,3.71)
51-65 ^a	N(67.74,4.28)	N(58.51,2.97)
≥ 66 ^a	N(62.73,5.60)	N(55.17,4.96)
≥ 3 ^{a,b,c}	N(62.36,13.03)	N(52.99, 10.02)

^aNutrition and Health Survey in Taiwan 2005-2008.

^bNutrition and Health Survey on Elementary School Children in Taiwan 2001-2002.

^c Nutrition and Health Survey in Taiwan 1993-1996.

^d N (m, SD) represents the normal distribution with mean (m) and standard deviation (SD).

analyzed by Monte Carlo simulation techniques to obtain probabilistic parameters such as percentile values, using the Crystal Ball[®] software available from Decisioneering, Inc., Denver, Co., USA. The detailed operations were described elsewhere⁽¹²⁾.

RISK CALCULATION

The health risks of dietary exposure to benzoates and sorbates were assessed by calculating the HI as a percentage of ADI, using equation (4). The definition of ADI specifies that when HI is less than 100% ADI, exposure to the analyte through diet is unlikely to cause any health effect of concern in one's lifetime. In the present study, the C_i (maximum benzoates and sorbates concentrations in food items) and the CR_{ij} values in Table 2 and the BW values in Table 3 were used in equation⁽⁴⁾, along with the ADI values of benzoates and sorbates to obtain values of HI for the specified population. In the present study, for food items that contained ND (not detectable) levels of either analyte, 0 g/kg was used in the calculation, because ND was found for over 60% of the samples analyzed. This practice was consistent with those described in other reported TDS⁽³⁴⁻³⁶⁾. The ADI values of benzoates and sorbates used in this study were 5 mg/kg-BW/day and 25 mg/kg-BW/day, respectively, as promulgated by the Joint FAO/WHO Expert Committee on Food Additives⁽³⁰⁾.

The distributional HI values in equation (4) were obtained through the same Monte Carlo simulation method. The means of HI values of benzoates and sorbates for the male and female groups of ages 3 and above are shown in Table 4. The HI values for this age group were greater than

Table 4. HI values (% ADI) of benzoates and sorbates for males and females of two age groups in Taiwan

Sex	Age	50*	90	95	97.5
Benzoate					
Male	≥ 3	21.0 ^a	34.6	41.1	48.5
	19-50	20.5	29.1	33.3	38.7
Female	≥ 3	24.6	40.2	48.1	56.6
	19-50	24.3	35.0	40.5	46.3
Sorbates					
Male	≥ 3	5.17	8.90	10.8	13.1
	19-50	4.00	6.67	8.00	9.56
Female	≥ 3	4.11	7.16	8.72	10.7
	19-50	4.82	7.82	9.32	11.5

*Percentile.

^aEntries are in % ADI.

those of other age groups. For benzoates, the 95th percentile of HI was 41% ADI for males and 48% ADI for females, and for sorbates, the 95th percentile of HI was 11% ADI for males and 9% ADI for females. Thus, our results indicated that the total dietary exposure to benzoates and sorbates of general consumers in Taiwan are below their ADI levels with a considerable margin of safety.

DISCUSSION

The 97 food items selected to represent the total diet in Taiwan that contain benzoates and sorbates ingested by the population of ages 3 and above (referred to as general consumers) are appropriate and acceptable, in view of the three criteria used in the selection of these food items: 1) high relative consumption rates, 2) historical high levels of occurrence of the analytes, and 3) permission of use of the preservatives on these items. The 128 food items in the TDS basic list, from which part of the 97 items were derived (Table 1), represented 83% of the weight (g) of the total diet consumed by the general consumers in Taiwan. This level of representation is greater than the levels of representation seen in the TDS reports of other countries^(28,31). For example, in Australia, the level of representation is 70%.

In the calculation of HI using equation (4), C and ADI were deterministic terms with C being the maximum value found among all the samples of each individual food item analyzed for four seasons in two years. BW and CR were distributional terms to result in the outcome of HI values being distributional or probabilistic. From the results shown in Table 4, the 95th percentile exposure levels (or ADD received) of benzoates in the populations of ages 3 and above were 41% ADI for males and 48% ADI for females; and those of sorbates were 11% ADI for males and 9% ADI for females. The exposure levels of other age groups were

lower than this group (data not shown). Based on this highly conservative assessment of the dairy exposure, our results indicated with strong evidence that there is a large margin of safety in the use of benzoates and sorbates as food preservatives in Taiwan.

In Taiwan, benzoates and sorbates were permitted for use as food preservatives in 34 food items (Table 5). They are either food products or ingredients of other manufactured foods. Presumably, therefore, these two preservatives should be found only in food items that contain any of these 34 regulated food items as ingredients. Yet, among the 97 food items listed for analysis, 39 items (about 40%) that contained none of these 34 regulated food items as ingredients were found to have detectable levels of these preservatives (Table 2). This result suggests that the current use of benzoates and sorbates as food preservatives in Taiwan is more widespread than the legally permitted range. The food products that are currently contributing significantly to the exposure to these two chemicals include various rice and flour containing products (Tables 2 and 5).

In the preparation of this article, we were faced with the challenge of proper English translation of the names of many local Taiwanese foods. We used both generic and proper translations to compile a table of food names as shown in Table 6. We hope that this attempt will be useful towards the standardization of introducing Taiwanese foods to the international food safety communities.

CONCLUSIONS

A full blown TDS with highly conservative assessment revealed that the total dietary exposure to benzoates and sorbates as food preservatives to the general consumers in Taiwan is below their ADI levels with ample margin of safety. Through this project, a renewed and strengthened framework of TDS was established to facilitate further similar work on additional target food chemicals in Taiwan.

Table 5. Food items that are permitted to use preservatives and the use limits in Taiwan

Food items that are permitted to use preservatives (34)		Use limit (g/kg)		Matching food items on the list of 97 analyzed*
		Benzoates	Sorbates	
1 花生醬	1 Peanut butter	1.0	2.0	22 Peanuts 23 Chicken 25 Duck 26 Pork
2 肉製品	2 Meat products	1.0	2.0	30 Sausage 31 Other pork products 32 Beef
3 魚肉煉製品	3 Kamaboko	1.0	2.0	34 Kamaboko
4 烏魚子	4 Mullet roe	0.6	1.0	35 Processed fish products
5 魚子醬	5 Caviar	1.0	2.0	35 Processed fish products
6 魚貝類乾製品	6 Processed fish products	0.6	1.0	35 Processed fish products
7 海膽	7 Sea urchin	1.0	2.0	35 Processed fish products
8 乾酪	8 Cheese	1.0	2.0	41 Cheese and Condensed milk
9 乳酪	9 Cheese	1.0	1.0	41 Cheese and Condensed milk
10 奶油	10 Butter	1.0	1.0	42 Butter
11 人造奶油	11 Margerin	1.0	1.0	42 Butter
12 豆皮豆干類	12 Bean curd sheet and Dried tofu	0.6	2.0	48 Dried tofu 49 Packaged dried tofu 50 Bean curd sheet
13 豆腐乳	13 Fermented bean curd	1.0	1.0	54 Fermented bean curd
14 味噌	14 Miso	1.0	1.0	56 Miso
15 糖漬果實類	15 Preserved fruit	1.0	1.0	58 Preserved fruits
16 脫水水果	16 Dried fruit	1.0	1.0	58 Preserved fruits
17 果醬	17 Jam	1.0	1.0	58 Preserved fruits
18 濃糖果漿	18 Syrup	1.0	1.0	83 Sugar
19 煮熟豆	19 Cooked beans	1.0	1.0	20 Dried beans

Table 5. Continued

Food items that are permitted to use preservatives (34)		Use limit (g/kg)		Matching food items on the list of 97 analyzed*
		Benzoates	Sorbates	
20 海藻醬類	20 Seaweed paste	1.0	1.0	59 Seaweed
21 醬菜類	21 Fermented vegetables	0.6	2.0	63 Fermented vegetables
22 水分含量 25% 以上 (含 25%) 之蘿蔔乾	22 Dried pickled radishes with ≥ 25% water content	1.0	2.0	61 Dried pickled radish
23 醃漬蔬菜	23 Pickled vegetables	0.6	2.0	60 Pickled vegetables
				62 Pickled cucumbers
				64 Dried bamboo shoot
24 糕餅	24 Pastry	1.0	1.0	70 Pastry
				71 Red bean cake
25 碳酸飲料	25 Carbonated beverages / Soft drink	0.6	0.5	74 Carbonated beverages
26 不含碳酸飲料	26 Non-carbonated beverages	0.6	0.5	72 Tea
				73 Coffee
				76 Other beverages
27 果汁	27 Fresh juices	1.0	1.0	77 Fresh juices
28 調味糖漿	28 Seasoning syrup	1.0	1.0	83 Sugar
29 醬油	29 Soya sauce	1.0	1.0	84 Soya sauce
30 番茄醬	30 Tomato sauce	1.0	1.0	87 Tomato sauce
31 辣椒醬	31 Chili sauce	1.0	1.0	86 Other seasonings
32 其他調味醬	32 Other seasonings	1.0	1.0	86 Other seasonings
33 膠囊狀食品	33 Encapsulated nutraceuticals	2.0	2.0	
34 錠狀食品	34 Nutraceutical tablets	2.0	2.0	

*The sequence numbers given in this column (Matching food items on the list of 97 analyzed) are the same as the sequence numbers in column 6 of Table 1 (Food items listed for preservative analysis).

Table 6. English and Chinese names of local Taiwanese foods in this TDS work

*Food items listed for TDS (128)		*Food items listed for preservative analysis (97)	
1 Rice	1 白米飯		
2 Other rice	2 其他米飯	1 Other rice	1 其他米飯
3 Rice milk	3 米漿	2 Rice milk	2 米漿
4 Rice dumpling	4 肉粽	3 Rice dumpling	3 肉粽
5 Salty rice pudding	5 碗粿	4 Salty rice pudding	4 碗粿
6 Sushi	6 壽司	5 Sushi	5 壽司
7 Steamed rice cake with pig blood	7 米血	6 Steamed rice cake with pig blood	6 米血
8 Rice noodles	8 米粉(細)	7 Rice noodles	7 米粉(細)
9 Sticky rice ball	9 圓仔	8 Sticky rice ball	8 圓仔
		9 Mochi	9 麻糬
10 Rice bran	10 米麩	10 Rice bran	10 米麩
11 Rice flat noodle	11 板條	11 Rice flat noodle	11 板條
		12 Noodles	12 麵條
12 Noodles	12 麵條	13 Thin noodles	13 麵線
		14 Bread bun	14 饅頭
13 Bread bun	13 饅頭	14 Bread bun	14 饅頭
14 Green onion pancakes	14 蔥餅類	15 Green onion pancakes	15 蔥餅類
15 Wheat flake and bran	15 麥片麥粉	16 Wheat flake and bran	16 麥片麥粉

Table 6. Continued

*Food items listed for TDS (128)		*Food items listed for preservative analysis (97)	
16 Sweet potato	16 蕃薯		
17 Starchy foods	17 粉類	17 Tapioca	17 粉圓
		18 Taro balls	18 芋圓
18 Corn	18 玉米	19 Corn	19 玉米
		20 Dried beans	20 乾豆類
19 Vegetable oil	19 調理用油	21 Salad dressings	21 沙拉醬
20 Animal oil	20 動物性油脂		
21 Peanuts	21 花生	22 Peanuts	22 花生
22 Chicken	22 雞肉	23 Chicken	23 雞肉
23 Chicken giblets	23 雞內臟	24 Chicken giblets	24 雞內臟
24 Duck	24 鴨肉	25 Duck	25 鴨肉
25 Goose	25 鵝肉		
26 Pork	26 豬肉	26 Pork	26 豬肉
27 Sparerib	27 排骨	27 Sparerib	27 排骨
28 Pettitoe	28 豬腳	28 Pettitoe	28 豬腳
29 Haslet	29 豬內臟	29 Haslet	29 豬內臟
30 Sausage	30 香腸	30 Sausage	30 香腸
31 Other pork products	31 其他豬肉製品	31 Other pork products	31 其他豬肉製品
32 Beef	32 牛肉	32 Beef	32 牛肉
33 Mutton	33 羊肉		
34 Milkfish	34 虱目魚		
35 Hair tail	35 白帶魚		
36 Grouper	36 石斑魚		
37 Dried fish	37 魚乾	33 Dried fish	33 魚乾
38 Kamaboko	38 魚漿製品	34 Kamaboko	34 魚漿製品
39 Shrimp	39 蝦		
40 Processed fish products	40 海產加工產品	35 Processed fish products	35 海產加工產品
41 Egg	41 生蛋		
42 Stewed egg	42 滷蛋	36 Stewed egg	36 滷蛋
43 Cooked egg	43 熟蛋	37 Cooked egg	37 熟蛋
44 Milk	44 鮮奶	38 Milk	38 鮮奶
45 Fermented milk	45 發酵乳	39 Fermented milk	39 發酵奶
46 Milk powder	46 奶粉		
47 Flavored Milk	47 調味奶	40 Flavored Milk	40 調味奶
48 Cheese and Condensed milk	48 起司煉乳	41 Cheese and Condensed milk	41 起司煉乳
		42 Butter	42 奶油
49 Soybean milk and Soft tofu	49 豆漿豆花	43 Soybean milk	43 豆漿
		44 Soft tofu	44 豆花
50 Tofu	50 豆腐	45 Tofu	45 豆腐
		46 Bai-ye tofu	46 百頁豆腐
		47 Fried bean curd	47 油豆腐
51 Dried Tofu	51 豆干	48 Dried tofu	48 豆干
		49 Packaged dried tofu	49 包裝豆干
52 Bean curd sheet	52 豆皮	50 Bean curd sheet	50 豆皮

Table 6. Continued

*Food items listed for TDS (128)		*Food items listed for preservative analysis (97)	
53 Veg bean products	53 素料	51 Dried bean threads	51 干絲
		52 Veg bean products	52 素料
54 Gluten	54 麵筋	53 Gluten	53 麵筋
55 Fermented bean curd	55 豆腐乳	54 Fermented bean curd	54 豆腐乳
		55 Fermented black beans	55 豆豉
		56 Miso	56 味噌
		57 Bean Pastes	57 豆瓣醬
56 Guava	56 蕃石榴(芭樂)		
57 Apple	57 蘋果		
58 Banana	58 香蕉		
59 Red watermelon	59 紅西瓜		
60 Pineapple	60 鳳梨		
61 Tangerine	61 柑橘:橘子		
62 Orange	62 柳橙(丁)		
63 Tomato	63 蕃茄		
64 Pear	64 水梨		
65 Bell fruit	65 蓮霧		
66 Grape	66 葡萄		
67 Papaya	67 木瓜		
68 Jujube	68 棗子		
69 Preserved fruits	69 果醬蜜餞	58 Preserved fruits	58 果醬蜜餞
70 Orange juice	70 柳丁汁		
71 Sweet potato leaves	71 地瓜葉		
72 Baby bukchoy	72 小白菜		
73 Water spinach	73 空心菜		
74 Spinach	74 菠菜		
75 Carrot	75 胡蘿蔔		
76 Lettuce	76 A仔菜		
77 Bukchoy	77 青江菜		
78 Romane lettuce	78 大陸妹		
79 Chinese Kale	79 芥蘭菜		
80 Broccoli	80 綠色花椰菜		
81 Cabbage	81 高麗菜		
82 Chinese cabbage	82 大白菜		
83 Chinese radish	83 蘿蔔		
84 Onion	84 洋葱		
85 Bean sprout	85 綠豆芽		
86 Cauliflower	86 花椰菜		
87 Bamboo shoot	87 麻竹筍		
88 Sponge gourd	88 絲瓜		
89 Bottle gourd	89 瓠瓜		
90 Bitter gourd	90 苦瓜		
91 Green beans	91 四季豆		
92 Needle mushroom	92 金針菇		

Table 6. Continued

*Food items listed for TDS (128)		*Food items listed for preservative analysis (97)	
93 Seaweed	93 海帶	59 Seaweed	59 海帶
	94 泡菜	60 Pickled vegetables	60 泡菜
94 Pickled vegetables		61 Dried pickled radish	61 菜脯
		62 Pickled cucumbers	62 醬瓜
		63 Fermented vegetables	63 醬菜
		64 Dried bamboo shoot	64 筍乾
95 Toast	95 土司	65 Toast	65 土司
96 Bread	96 麵包	66 Bread	66 麵包
97 Cakes	97 蛋糕	67 Cakes	67 蛋糕
98 Biscuit	98 餅乾	68 Biscuit	68 餅乾
99 Confectionery	99 甜點糖果	69 Confectionery	69 甜點糖果
100 Chinese pastry	100 糕點	70 Pastry	70 糕點
		71 Red bean cake	71 紅豆餅
101 Tea	101 茶類	72 Tea	72 茶類
102 Coffee	102 咖啡	73 Coffee	73 咖啡
103 Carbonated beverages	103 碳酸飲料	74 Carbonated beverages	74 碳酸飲料
104 Ice	104 冰	75 Ice	75 冰
105 Other beverages	105 其他飲料	76 Other beverages	76 其他飲料
106 Fresh juices	106 果汁	77 Fresh juices	77 果汁
107 Fruit vinegar	107 果醋	78 Fruit vinegar	78 果醋
108 Fruit teas	108 果茶	79 Fruit tea	79 果茶
		80 Fruit flavor enhancers	80 梅子粉
109 Beer	109 啤酒	81 Beer	81 啤酒
110 Rice wine	110 米酒	82 Rice wine	82 米酒
111 Sorghum liquor	111 高粱酒		
112 Grape wine	112 葡萄酒		
113 Other wine	113 其他酒		
114 Sugar	114 糖類	83 Sugar	83 糖類
115 Salt	115 鹽類		
116 Soya sauce	116 醬油	84 Soya sauce	84 醬油
117 vinegar	117 醋	85 vinegar	85 醋
118 Mono Sodium Glutamate (MSG)	118 味精		
119 Other seasonings	119 其他調味料	86 Other seasonings	86 其他調味料
		87 Tomato sauce	87 番茄醬
120 Dumplings and pot stickers	120 水餃、鍋貼	88 Dumplings and pot stickers	88 水餃、鍋貼
121 Meat balls	121 貢丸、丸子	89 Meat balls	89 貢丸、丸子
122 Steam buns	122 包子煎包	90 Steam buns	90 包子煎包
123 Steamed meatballs	123 肉圓	91 Steamed meatballs	91 肉圓
124 Oyster omelet	124 蚵仔煎	92 Oyster omelet	92 蚵仔煎
		93 Tempura	93 黑輪
125 Prepared soups	125 調理湯	94 Prepared soups	94 調理湯
126 Instant noodles	126 速食麵	95 Instant noodles	95 速食麵
127 Fast foods	127 速食店	96 Fast foods	速食店
128 Thick soups	128 羹	97 Thick soups	羹

*The sequence numbers in column 1 (128 items) and the sequence numbers in column 2 (97 items) are independently assigned.

ACKNOWLEDGMENTS

This TDS project was supported by the Department of Health (DOH) Contract TFDA-TC-103. The authors are indebted to many food safety colleagues in Taiwan as well as from abroad for their generous and professional help in completing this second TDS in Taiwan. The data used to derive exposure factors, BW and CR, were kindly provided by Dr. W. H. Pan, Principal Investigator of the National Nutrition and Health Survey in Taiwan (NAHSIT) funded by the DOH (DOH94-FS-6-4). However, the authors should be fully responsible for the accuracy and appropriateness of the values derived.

REFERENCES

1. Pennington, J. A. T. and Gunderson, E. L. 1987. History of the Food and Drug Administration's Total Diet Study-1961 to 1987. *J. AOAC Off. Anal. Chem.* 70: 772-782.
2. Moy, G. G. 2011. *Total Diet Studies*. 1st ed. pp. 1-400. Springer.
3. Chan, C. C. 2003. Guidelines for Health Risk Assessment. Project 91038, Bureau of Health Promotion, Department of Health, Taiwan, R.O.C.
4. Hsu, M. S., Hsu, K. Y. and Wang, S. M. *et al.* 2007. A total diet study to estimate PCDD/Fs and dioxin-like PCBs intake from food in Taiwan. *Chemosphere*. 67: S65-70.
5. Chen, H. L., Su, H. J., Hsu, J. F., Liao, P. C. and Lee, C. C. 2008. High variation of PCDDs, PCDFs, and dioxin-like PCBs ratio in cooked food from the first total diet survey in Taiwan. *Chemosphere*. 70: 673-681.
6. Tan, G. S., Lin, L. C., Fu, Y. M. and Shih, Y. C. 2005. Total diet survey of aflatoxin in Taiwan. *Ann Rept. BFDA Taiwan R.O.C.* 23: 289-301.
7. Wong, S. S. 2009. Total diet studies on food contaminants. Project Report, DOH97-FS038. Department of Health, Taiwan, R.O.C.
8. Tu, S. H., Chen, C. and Hsieh, Y. T. *et al.* 2011. Design and sample characteristics of the 2005-2008 Nutrition and Health Survey in Taiwan. *Asia Pac. J. Clin. Nutr.* 20: 225-237.
9. Hu, S. W. 2004. Total Diet Studies on Food Contaminants: Framework of Health Risk Assessment. Project Report, DOH92-FS012. Department of Health, Taiwan, R.O.C.
10. Joint Agencies (Department of Health, Environment Protection Administration, Council of Agriculture, Ministry of Education). 2008. White Paper on Food Safety and Nutrition 2008-2012, Department of Health, Taiwan, R.O.C.
11. WHO. 2007. GEMS/Food total diet studies: report of the 4th International Workshop on Total Diet Studies, Beijing, China, 23-27 October 2006. 1st ed. pp. 1-50.
12. Hsieh, D. P. H. 2011. Health Risk Assessment on Food Additives for Food Safety in Taiwan. Project Report, 100TFDA-TC-103. Food and Drug Administration, Department of Health, Taiwan, R.O.C.
13. World Health Organization Food and Agriculture Organization of the United Nations. 2011. Codex alimentarius commission procedural manual. 20th ed. pp. 112. Joint FAO/WHO Food Standards Programme, FAO, Rome.
14. U.S. Food and Drug Administration. Risk Assessment /Safety Assessment. <http://www.fda.gov/Food/ScienceResearch/ResearchAreas/RiskAssessmentSafetyAssessment/default.htm>
15. European Food Safety Authority. 2011. Towards a harmonized Total Diet Study approach: a guidance document. EFSA J.9: 2450.
16. Wu, S. J., Pan, W. H., Yeh, N. H. and Chang, H. Y. 2011. Trends in nutrient and dietary intake among adults and the elderly: from NAHSIT 1993-1996 to 2005-2008. *Asia Pac. J. Clin. Nutr.* 20: 251-265.
17. Pan, W. H., Wu, H. J. and Yeh, C. J. *et al.* 2011. Diet and health trends in Taiwan: comparison of two nutrition and health surveys from 1993-1996 and 2005-2008. *Asia Pac. J. Clin. Nutr.* 20: 238-250.
18. World Health Organization. 1997. Benzyl Acetate, Benzyl Alcohol, Benzaldehyde, Benzoic Acid and the Benzoate Salts, Forty Sixth Report of the Joint FAO/WHO Expert Committee on Food Additives, WHO Technical Report Series No. 868, WHO, Geneva.
19. US Environmental Protection Agency. 2012. Integrated Risk Information System (IRIS.) <http://www.epa.gov/iris/>
20. Cunningham, W. C., Anderson, D. L. and Baratta, E. J. 1994. Radionuclides in domestic and imported foods in the United States, 1987-92. *J. AOAC Int.* 77: 1422-1427.
21. Li, X. W., Gao, J. Q. and Chen, J. S. 2006. Chinese total diet study in 2000: the dietary mercuric intakes. *Wei Sheng Yan Jiu.* 3: 323-325.
22. Pennington, J. A. T. and Young, B. 1990a. Sodium, potassium, calcium, phosphorus, and magnesium in foods from the United States total diet study. *J. Food Compos. Anal.* 3: 145-165.
23. Egan, S. K., Tao, S. S., Pennington, J. A. and Bolger, P. M. 2002. US Food and Drug Administration's Total Diet Study: intake of nutritional and toxic elements, 1991-96. *Food Addit. Contam.* 19: 103-125.
24. Leblanc, J. C., Tard, A., Volatier, J. L. and Verger, P. 2005. Estimated dietary exposure to principal food mycotoxins from the first French Total Diet Study. *Food Addit. Contam.* 22: 652-672.
25. Gunderson, E. L. 1995a. Dietary intake of pesticides, selected elements, and other chemicals: FDA Total Diet Study, June 1984-April 1986. *J. AOAC Int.* 78: 910-921.
26. Gunderson, E. L. 1995b. FDA Total Diet Study, July 1986-April 1991, Dietary intake of pesticides, selected elements, and other chemicals. *J. AOAC Int.* 78: 1353-1363.
27. Ministry of Agriculture and Forestry(MAF). 2011. 2009 New Zealand Total Diet Study Agricultural compound residues, selected contaminant and nutrient elements. Ministry of Agriculture and Forestry, Wellington.

28. Food Standards Australia New Zealand (FSANZ). 2005. The 21st Australian Total Diet Study-A Total Diet Study of Sulphites, Benzoates and Sorbates. Food Standards Australia New Zealand, Canberra.
29. Food and Drug Administration, Department of Health, Taiwan, R.O.C. Scope and Application Standards of Food Additives: Preservatives. http://www.fda.gov.tw/eng/people_laws_list.aspx?pages=1&keyword=&classifysn=16
30. The International Programme on Chemical Safety (IPCS). Evaluations of the Joint FAO/WHO Expert Committee on Food Additives (JECFA)-Search for chemical. <http://apps.who.int/ipsc/database/evaluations/search.aspx>
31. Thomson, B. M., Vannoort, R. W. and Haslemore, R. M. 2008. Dietary exposure and trends of exposure to nutrient elements iodine, iron, selenium and sodium from the 2003-4 New Zealand Total Diet Survey. *Br. J. Nutr.* 99: 614-625.
32. USFDA. 2008. Pesticide Monitoring Program - FY 2008, annual report.
33. Pan, W. H. 2008. Nutrition and Health Survey in Taiwan 2004-2008. Project Report, DOH94-FS-6-4. Food and Drug Administration, Department of Health, Taiwan, R.O.C.
34. FAO/UNEP/WHO.1985. GEMS (Global Environmental Monitoring System). Guidelines for the Study of Dietary Intake of Chemical Contaminants: Report of the Joint FAO/UNEP/WHO Food Contamination Monitoring Programme, WHO Offset publication No.87. World Health Organization, Geneva.
35. Food Standards Australia New Zealand (FSANZ). 2003. The 20th Australian Total Diet Survey- A total diet survey of pesticide residues and contaminants. Food Standards Australia New Zealand, Canberra.
36. WHO, 2009. Principles and methods for the risk assessment of chemicals in food: Chapter 6 dietary exposure assessment of chemicals in food. *Environmental Health Criteria.* 240: 19-21.