Report of the Second Hong Kong Total Diet Study: Sulphites

December 2024
Centre for Food Safety
Food and Environmental Hygiene Department
The Government of the Hong Kong Special Administrative Region

Correspondence:
Risk Assessment Section
Centre for Food Safety
Food and Environmental Hygiene Department
43/F, Queensway Government Offices,
66 Queensway, Hong Kong.
Email: enquiries@fehd.gov.hk

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The Centre for Food Safety is conducting the Second Hong Kong Total Diet Study (2nd HKTDS) to estimate the latest dietary exposure of the Hong Kong population and various population subgroups to a range of chemical substances of potential food safety concern, and in turn assess the associated health risks. This report presents an analysis of sulphites level (sulphur dioxide and the salts of sodium/potassium/calcium and sulphite/bisulphite/metabisulphite), and the dietary exposure assessment results.

2. Sulphites have a long history of use in food production for their multifunctional properties, particularly as preservative and antioxidant. Acute toxicity of sulphites is low. Chronic excessive exposure to sulphites was found to cause local irritation of the stomach and induce adverse effects on the central nervous system in experimental animals. Sulphites are not classifiable as to their carcinogenicity to humans, and their use as food additives does not raise a concern with respect to genotoxicity. Exposure to sulphites may lead to bronchoconstriction and other adverse reactions in certain population subgroups such as asthmatic patients or people with allergic conditions.

3. The Joint Food and Agriculture Organization of the United Nations (FAO) / World Health Organization (WHO) Expert Committee on Food Additives (JECFA) allocated a group Acceptable Daily Intake (ADI) of 0-0.7 mg/kg body weight (bw), expressed as sulphur dioxide, to sulphites.

Results

4. Out of a total of 185 TDS food items tested for sulphites, only 17 TDS food items were found to contain detectable levels of sulphites. In other words,

sulphites were not detected in the majority (91%) of TDS food items tested. Dried fruits was the TDS food item detected with the highest mean concentration of sulphites (240 mg/kg), followed by several other TDS food items (including button mushrooms, red/white wine, and preserved vegetables) with about 10-fold lower in mean concentration (20-30 mg/kg). The remaining TDS food items with detectable levels of sulphites were found with a mean concentration of 10 mg/kg or below.

5. For the adult population (aged 18+), the estimated dietary exposure of the average consumers was 0.010-0.037 mg/kg bw/day (lower bound-upper bound (LB-UB)), which accounted for 1.5-5.3% (LB-UB) of the ADI allocated for sulphites. Among the high consumers of the adult population, the estimated dietary exposure was 0.021-0.055 mg/kg bw/day (LB-UB), which accounted for 3.0-7.9% (LB-UB) of the ADI. For the younger population (aged 6-17), the estimated dietary exposure of the average consumers was 0.012-0.051 mg/kg bw/day (LB-UB), which accounted for 1.8-7.3% (LB-UB) of the ADI. Among the high consumers of the younger population, the estimated dietary exposure was 0.028-0.078 mg/kg bw/day (LB-UB), which accounted for 3.9-11% (LB-UB) of the ADI.

Conclusion and Recommendations

6. The estimated dietary exposure to sulphites of the average consumers and high consumers of the local adult and younger populations were well below the ADI allocated for sulphites, indicating a low chronic health concern.

7. The trade is advised that the use of food additives, including sulphites, is justified only when such use serves the intended technological function and should not mislead the consumers. The trade should comply with the Preservatives in Food Regulation (Cap. 132BD) which specifies the maximum permitted levels of sulphites in specified foods. In addition, the trade should also

comply with the Food and Drugs (Composition and Labelling) Regulations (Cap. 132W) which stipulates the labelling requirements with regard to sulphites in the list of ingredients of prepackaged food.

8. The public is advised to maintain a balanced diet to avoid excessive exposure to chemical substances, including sulphites, from a small range of food. When purchasing prepackaged food products, consumers can refer to the list of ingredients on food labels to know whether sulphites have been used. In particular, susceptible individuals who are sensitive to sulphites should avoid foods that contain sulphites by paying close attention to the list of ingredients on food labels.

Chapter 1
Background

1.1 Total Diet Study (TDS) is a tool for estimating population chronic dietary exposure to a wide range of chemicals across the whole diet within one study, which is an internationally well-recognised approach for quantifying the presence of chemical substances in the food supply and for estimating dietary exposure. The Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) have been promoting and supporting the TDS approach since the 1970's. The Centre for Food Safety (CFS) conducted the First Hong Kong Total Diet Study (1st HKTDS) in 2010-2014.[1]

Introduction of the Second Hong Kong Total Diet Study (2nd HKTDS)

1.2 With the availability of an updated set of food consumption data as obtained from the Second Population-based Food Consumption Survey (2nd FCS) (2018-2020), the CFS has taken the opportunity to conduct the Second Hong Kong Total Diet Study (2nd HKTDS). The 2nd HKTDS aims to estimate the latest dietary exposure of the Hong Kong population and various population subgroups to a range of chemical substances of potential food safety concern, and in turn assess the associated health risks.

1.3 Similar to the 1st HKTDS, the 2nd HKTDS comprises selection of chemical substances, development of a TDS food list, food sampling, sample preparation, laboratory analysis, dietary exposure estimation and publication of results. The 2nd HKTDS covers the majority of foods normally consumed by the Hong Kong population, with laboratory analysis conducted for over 130 chemical substances, covering mainly contaminants and pesticide residues in food and, for the first time, some food additives of local concern.

Food Additives in the 2nd HKTDS

1.4 Food additive means any substance not normally consumed as a food by itself and not normally used as a typical ingredient of the food, whether or not it has nutritive value, the intentional addition of which to food for a technological purpose in the manufacture, processing, preparation, treatment, packing, packaging, transport or holding of such food results, or may be reasonably expected to result, in it or its by-products becoming a component of or otherwise affecting the characteristics of such foods.[2] With the globalization of trade and the advent of food processing, the application of food additives plays an important role in providing a variety of safe and wholesome food from different parts of the world to meet the consumers' need. There are many types of food additives in use with various technological functions, some examples are emulsifiers, stabilizers, thickeners, acidity regulators, preservatives, antioxidants, colours, colour retention agents.

1.5 In the 2nd HKTDS, two groups of food additives, namely, sulphites and nitrate/nitrite, have been included as selected chemical substances. This report focuses on the dietary exposure assessment of sulphites.

Sulphites

1.6 Sulphites in foods are monitored through the Food Surveillance Programme of the CFS. Unsatisfactory surveillance results have been noted from time to time, which mainly involved dried/preserved fruits and vegetables, fresh/chilled meats, and fresh/dried seafood products. Nevertheless, a comprehensive dietary exposure assessment on sulphites has not been conducted in Hong Kong. The results of this study can serve to fill such data gap and to provide a sound basis for the identification of any potential chronic health risks arising from dietary exposure to sulphites in the local population.

Nature and uses of sulphites, and their sources of exposure

1.7 Sulphur dioxide is a colourless, non-flammable gas with a strong pungent suffocating odour, and is soluble in cold water.[3] Sulphur dioxide is also used in the form of salts consisting of sodium/potassium/calcium and sulphite/bisulphite/metabisulphite. For the purposes of this report, sulphur dioxide and the sulphite, bisulphite and metabisulphite salts, are collectively referred to as sulphites.

1.8 Sulphites have a long history of use in food production for their multifunctional properties, particularly, in the preservation of a wide variety of products such as dried fruits and vegetables, fruit juices, acid pickles, syrups, semi-processed fruit products, wines, etc. Fumigation of sulphur dioxide can also help prevent fungal growth on the fruit surface (e.g. longan, grape, etc.) and some other plants during storage. In addition, sulphites can be used as antioxidants to prevent organoleptic changes due to oxidation of food during storage, to minimize oxidative colour loss of meat and vegetable tissues and to aid the retention of ascorbic acid and carotenes during storage.[4,5] In Hong Kong, the use of sulphites as preservative and antioxidant is regulated under the Preservatives in Food Regulation (Cap. 132BD), which stipulates their use in a wide variety of specified foods within specified maximum permitted levels.[6]

1.9 On the other hand, it is noted that endogenous sulphites can be generated as a consequence of the body's normal processing of sulphur-containing amino acids. Sulphites may also occur as a consequence of fermentation and are naturally present in a number of foods and beverages, even when not added deliberately.[3]

1.10 For the majority of people, exposure to sulphites occurs as a result of consumption of foods and drinks to which sulphites have been used as food additives. Food is a major source of exposure to sulphites, although exposure

may also occur through the use of cosmetic products and drugs, as well as through polluted air and certain industrial activities.[3]

Fate of sulphites in foods

1.11 Foods have different pH values and ingredient compositions, which may influence the fate of sulphites. The amounts of sulphites initially used to treat foods do not reflect residue levels after subsequent processing and storage, and in turn the final amount of sulphite exposure in the individuals consuming the sulphites-treated foods. Mechanisms of loss of sulphites in foods include volatilisation to sulphur dioxide gas in acidic conditions, leaching, auto-oxidation, as well as irreversible reactions with food constituents.[3,7]

1.12 In light of the aforementioned, it is beneficial to employ the TDS approach to generate dietary exposure estimates for sulphites, as it takes into account kitchen preparation and the losses of sulphites when assessing their levels present in foods, which is particularly relevant given their unstable nature.

Health effects of sulphites

Kinetics and metabolism

1.13 All sulphites, once ingested, may react with water to form bisulphite, sulphite and sulphur dioxide.[8] Various studies found that ingested sulphites would be oxidised to sulphate and eliminated in the urine mainly as sulphate. Sulphites do not accumulate in the tissues on chronic administration.[9]

Acute toxicity

1.14 Based on the available toxicological data, acute toxicity of sulfites was low.[3] In humans, it was reported that a single oral dose of 4 g of sodium sulphite caused toxic symptoms and 5.8 g caused severe irritation of the stomach and intestine.[9]

Chronic toxicity

1.15 Chronic excessive exposure to sulphites was found to cause local irritation of stomach in experimental animals, with inflammatory changes and hyperplasia and occult blood detected in the faeces.[10]

Carcinogenicity and genotoxicity

1.16 The International Agency for Research on Cancer (IARC) of the WHO (1992) classified sulphur dioxide, sulphites, bisulphites and metabisulphites as Group 3 agents, i.e. not classifiable as to their carcinogenicity to humans.[11] In addition, based on the available genotoxicity data, the use of sulphites as food additives does not raise a concern with respect to genotoxicity.[8]

Neurotoxicity

1.17 The European Food Safety Authority (EFSA), in its latest evaluation of sulphur dioxide and sulphites in 2022, noted that basing on the animal toxicity data reviewed, oral sulphite exposure could induce adverse effects on the central nervous system, such as delayed visual evoked potentials (i.e. delayed response of nerve cells to stimuli) and impaired learning and memory.[8]

Idiosyncratic intolerance

1.18 Exposure to sulphites may lead to bronchoconstriction and other adverse reactions in certain population subgroups such as asthmatic patients or people with allergic conditions. Susceptible individuals who are sensitive to sulphur dioxide may experience symptoms such as breathing difficulties, skin rashes and irritations, headache, diarrhoea, vomiting and nausea after exposure.[10]

Health-based guidance value

1.19 In the last safety evaluation on sulphur dioxide and sulphites conducted by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) in 1998, the Committee maintained the previously allocated group Acceptable Daily Intake (ADI) of 0-0.7 mg/kg body weight (bw), expressed as sulphur dioxide, to sulphur dioxide and sulphur dioxide equivalents arising from certain specified sodium/potassium/calcium metabisulphites, sulphites, hydrogen sulphites and thiosulphate.[10]

1.20 On the other hand, it is noted that according to EFSA's latest evaluation in 2022, it was considered that the available toxicity database was inadequate to derive an ADI for sulphites, and thus a margin of exposure (MOE) approach was suggested for assessing the risk of these food additives at the current exposure levels. EFSA considered that there are safety concerns if the MOE value is less than 80.[8]

Chapter 2
Methodology and Laboratory Analysis

Methodology of the 2nd HKTDS

2.1 Based on the 2nd FCS, 187 TDS food items (involving 15 food groups) were selected as representative foods to represent the majority of foods consumed by the local population. Six individual samples of each TDS food item were collected throughout Hong Kong and prepared individually to "as consumed" status on each of the two sampling occasions from February 2023 to January 2024. A total of 2,244 individual food samples were collected and prepared individually, and combined into 374 composite samples for laboratory chemical analysis.

2.2 The analytical results were combined with the food consumption data of the local population to estimate dietary exposure to the selected chemical substances included in this study. Dietary exposure estimation was performed with the aid of an in-house web-based computer system, the Exposure Assessment System 2 (EASY2), which involved food mapping and weighting of data. The mean and 90th percentile exposure levels were used to represent the dietary exposure of the average and high consumers of the local population, respectively. In this report, the estimated dietary exposure to sulphites of the average and high consumers were compared with the health-based guidance value, i.e. the group ADI allocated to sulphites, to assess the associated chronic health risks.

2.3 Details of the methodology are given in the same series of reports on Methodology.[12]

Laboratory analysis of sulphites

2.4 All TDS food items (except two items, i.e. bottled distilled/purified water and drinking water) taken from the two sampling occasions were tested for sulphites. In other words, 185 TDS food items subsequently processed to form 370 composite samples (2 composite samples for each TDS food item) were tested for sulphites.

2.5 Laboratory analysis of sulphites was conducted by the Food Research Laboratory (FRL) of the CFS. The sulphites level in samples, covering the free sulphites and sulphite-carbonyl adducts, was analysed by using High Performance Liquid Chromatography - Tandem Mass Spectrometry (HPLC-MS/MS) with reference to the US FDA Foods Program Compendium of Analytical Laboratory Methods: Chemical Analytical Manual (CAM); Method No.: C-004.04.[13] In brief, sulphites reacted with formaldehyde to form a stable adduct, hydroxymethylsulphonate (HMS). Then the HMS was extracted by shaking, sonication and centrifuging. C18 SPE cartridge was used to clean up the extract and the eluent was heated to convert any sulphite-carbonyl adducts to HMS. The HMS was separated by using HPLC column and finally quantified by MS/MS in the presence of chloroacetic acid as internal standard. The concentration of sulphites in sample was quantified and the result was expressed as sulphur dioxide. The limit of detection (LOD) of sulphur dioxide was 1.0 mg/kg.

Treatment of analytical results

2.6 In this study, data were treated with both lower bound (LB) and upper bound (UB) approaches. The approaches present the two extreme scenarios, considering that the true value for results below the LOD may actually be any value between zero and the achieved LOD. The LB scenario assumes that the chemical is absent; thus, a value of zero is assigned to results reported as <LOD.

The UB scenario assumes that the chemical is present at the level of the LOD; thus, a value of the corresponding LOD is assigned to results reported as <LOD.

Chapter 3
Results and Discussion

Concentrations of sulphites in TDS foods

3.1 A total of 185 TDS food items, covering 370 composite samples, were tested for sulphites. Sulphites were not detected in the majority (91%) of TDS food items tested. Only 17 out of 185 TDS food items, involving 8 TDS food groups, were found to contain detectable levels of sulphites in either one or both of the composite samples. The results in 15 TDS food groups are summarised in Table 1 and the detailed analytical results of all the 185 TDS food items tested are shown in Appendix 1. The concentration of sulphites is expressed as sulphur dioxide in this report.

Table 1: Sulphites contents (mg/kg) in TDS food groups of the 2nd HKTDS

TDS food groups		TDS food items within food group		Composite samples within food group [a]		Mean concentration of food group (mg/kg) [b c]	Range within food group (mg/kg) [b]
		Total number tested	Number with detectable levels	Total number tested	Number with detectable levels		
1	Cereals and their products	21	1	42	2	0.10-1.1	ND-2.6
2	Vegetables and their products	42	6	84	11	1.7-2.6	ND-59
3	Legumes, nuts and seeds and their products	9	0	18	0	–	ND-ND
4	Fruits	18	1	36	2	13-14	ND-380
5	Meat, poultry and game and their products	17	1	34	1	0.47-1.4	ND-16
6	Egg and their products	3	0	6	0	–	ND-ND
7	Fish, seafood and their products	24	5	48	8	0.98-1.8	ND-17
8	Dairy products	8	0	16	0	–	ND-ND
9	Fats and oils	2	0	4	0	–	ND-ND
10	Beverages, alcoholic	2	1	4	2	14-14	ND-30
11	Beverages, non-alcoholic	10	0	20	0	–	ND-ND
12	Mixed dishes	12	1	24	1	0.083-1.0	ND-2.0
13	Snack foods	1	0	2	0	–	ND-ND
14	Sugars and confectionery	5	1	10	1	0.10-1.0	ND-1.0
15	Condiments, sauces and herbs	11	0	22	0	–	ND-ND
	Total	185	17	370	28		

Notes:

[a] Two composite samples were tested for each TDS food item.

[b] Concentration levels are rounded to 2 significant figures. ND denotes non-detected, i.e. results less than limit of detection (LOD).

[c] Mean concentrations for those food groups with detectable levels in TDS food items are presented as a range (lower bound-upper bound). For those food groups with non-detected results in all TDS food items, mean concentrations are not calculated and are marked as "–".

Table 2: Sulphites contents (mg/kg) in TDS food items with detectable levels of sulphites

TDS food group	TDS food item [a]	Mean sulphites contents (mg/kg) [b c]
Fruits	Dried fruits	240
Vegetables and their products	Mushroom, button	30
	Preserved vegetables	23
	Bamboo fungus	9.4
	Garlic	4.6
	Mushroom, shiitake, dried	2.1
	Bamboo shoot	1.9-2.4
Beverages, alcoholic	Wine, red / white	27
Fish, seafood and their products	Shrimp / Prawn	10
	Shrimp / Prawn, dried	5.4
	Oyster	4.5-5.0
	Salted fish	2.3
	Squid	1.3-1.8
Meat, poultry and game and their products	Beef	8.0-8.5
Cereals and their products	Corn starch	2.1
Mixed dishes	Dim sum, beef ball, steamed	1.0-1.5
Sugars and confectionery	Sugar, brown / rock	0.50-1.0

Notes:

[a] Two composite samples were tested for each TDS food item.

[b] Concentration levels are rounded to 2 significant figures. ND denotes non-detected, i.e. results less than limit of detection (LOD).

[c] Mean concentrations for those TDS food items detected in both sampling occasions are presented as a single value, whereas those detected only in one of the two sampling occasions are presented as a range (lower bound-upper bound).

3.2 The food group "Vegetables and their products" was found to contain the largest number of food items (6 out of 42) with detectable levels of sulphites, followed by "Fish, seafood and their products" (5 out of 24). Among all the 185 TDS food items, dried fruits, which included individual samples of dried raisin, dried date, dried prune, dried apricot, and dried fig, was the TDS food item detected with the highest mean concentration of sulphites (240 mg/kg). Several TDS food items, including button mushroom* (30 mg/kg), red/white wine (27

* Button mushroom was composed of individual samples of fresh and canned button mushrooms.

mg/kg) and preserved vegetables† (23 mg/kg), followed with about 10 times lower mean concentrations of sulphites. Only low mean concentrations, i.e. at 10 mg/kg or below, were found for the remaining 13 TDS food items with detectable levels of sulphites (Table 2).

3.3 The analytical results of sulphites in the TDS food items tested in this study were generally in line with those levels reported in literature from other places. As sulphites have multifunctional properties and are permitted to be used in a wide variety of specified foods within corresponding maximum permitted levels both locally and internationally, the detected levels of sulphites found in the TDS food samples of dried fruits, certain dried/preserved/canned vegetables, fresh/processed fish, molluscs and crustaceans, grape wines, sugar and starch in this study were within expected ranges. These TDS food items, where appropriate, had gone through kitchen preparation steps to become "as consumed" status. For example, dried bamboo fungus was soaked, washed and then boiled in water before laboratory analysis was conducted. Therefore, it is not unexpected that the mean concentration of sulphites detected in the prepared samples of bamboo fungus (9.4 mg/kg) was found to be much lower than its corresponding maximum permitted level in dried form, i.e. 500 mg/kg in dried vegetables including mushrooms and fungi.

3.4 However, as regards the TDS food item, beef, which was composed of individual samples of fresh, chilled and frozen beef cuts, one of the two composite samples was detected with 16 mg/kg of sulphites whilst the other composite sample was non-detected. The Preservatives in Food Regulation (Cap. 132BD) in Hong Kong does not include provision for sulphites in beef cuts. The analytical data in the composite sample of beef detected with 16 mg/kg of sulphites indicated the possibility of addition of sulphites to individual sample(s)

† Preserved vegetables was composed of individual samples of preserved mustard greens (雪菜), preserved Sichuan mustard (榨菜), preserved turnip (大頭菜), preserved leaf mustard (鹹酸菜) and preserved mustard cabbage (梅菜).

of beef. Since the addition of sulphites to fresh, chilled and frozen beef cuts is not allowed under Cap. 132BD, the CFS followed up the above analytical result of the beef composite sample, including tracing the sources of the individual beef samples in question and taking follow up samples for testing. All the subsequent test results were satisfactory (i.e. sulphites were not detected). The CFS will continue the testing of sulphites in meat under the routine Food Surveillance Programme.

Dietary exposure to sulphites

3.5 Table 3 shows the overall dietary exposure estimates of the local adult and younger populations to sulphites. For the adult population, the estimated dietary exposure of the average consumers was 0.010-0.037 mg/kg bw/day (LB-UB), which accounted for 1.5-5.3% (LB-UB) of the ADI allocated for sulphites. Among the high consumers (90th percentile) of the adult population, the estimated dietary exposure was 0.021-0.055 mg/kg bw/day (LB-UB), which accounted for 3.0-7.9% (LB-UB) of the ADI.

3.6 For the younger population, the estimated dietary exposure of the average consumers was 0.012-0.051 mg/kg bw/day (LB-UB), which accounted for 1.8-7.3% (LB-UB) of the ADI. Among the high consumers of the younger population, the estimated dietary exposure was 0.028-0.078 mg/kg bw/day (LB-UB), which accounted for 3.9-11% (LB-UB) of the ADI (Table 3).

Table 3: Estimates of overall dietary exposure to sulphites for the average and high consumers of the local adult and younger populations and their contribution to Acceptable Daily Intake (ADI)

Population	Dietary Exposure (LB-UB) (mg/kg bw/day)		% ADI (LB-UB)	
	Average consumers	High consumers	Average consumers	High consumers
Adults aged 18+	0.010-0.037	0.021-0.055	1.5-5.3	3.0-7.9
Younger population aged 6-17	0.012-0.051	0.028-0.078	1.8-7.3	3.9-11

Exposure of the high consumers refers to the exposure at 90th percentile.
LB and UB denotes lower bound and upper bound respectively.
Figures for dietary exposure estimates and contribution to ADIs are rounded to 2 significant figures.

3.7 Further details on age-gender subgroup analysis on dietary exposure to sulphites are presented in Table 4 and Figure 1. Among all individual age groups, the dietary exposure estimates to sulphites of the average and high consumers were well below the ADI allocated for sulphites. A relatively higher exposure estimate was noted among the high consumers of children aged 6-11 (i.e. 0.032-0.092 mg/kg bw/day (LB-UB), accounting for 4.6-13% (LB-UB) of the ADI), which was not an unexpected finding, considering the fact that children have a higher food intake on a per-kg body weight basis.

3.8 The study findings revealed that dietary exposure to sulphites would be of low chronic health concern to the average and high consumers of the local adult and younger populations, at both the population level and age-gender subgroup level.

3.9 Taking note of EFSA's scientific opinion published in 2022, risk characterization basing on the MOE approach has also been conducted using the same set of dietary exposure estimates to sulphites. The subsequent finding does not alter the above conclusion of this study.

Table 4: Estimates of dietary exposure to sulphites for the average and high consumers of age-gender subgroups and their contribution to Acceptable Daily Intake (ADI)

Age-gender groups	Dietary Exposure (LB-UB) (mg/kg bw/day)		% ADI (LB-UB)	
	Average consumers	High consumers	Average consumers	High consumers
Adults				
Adults aged 18-49	0.013-0.039	0.024-0.056	1.8-5.5	3.4-8.1
● Male	0.012-0.038	0.024-0.055	1.7-5.4	3.4-7.9
● Female	0.013-0.040	0.024-0.058	1.9-5.7	3.4-8.2
Adults aged 50-64	0.0098-0.037	0.019-0.056	1.4-5.3	2.8-8.0
● Male	0.0097-0.037	0.019-0.056	1.4-5.3	2.7-8.0
● Female	0.010-0.037	0.023-0.056	1.4-5.3	3.3-8.1
Adults aged 65+	0.0058-0.032	0.012-0.049	0.83-4.5	1.7-6.9
● Male	0.0069-0.034	0.018-0.053	0.98-4.9	2.6-7.5
● Female	0.0049-0.029	0.0095-0.044	0.70-4.2	1.4-6.2
Adults aged 18+	0.010-0.037	0.021-0.055	1.5-5.3	3.0-7.9
● Male	0.010-0.037	0.020-0.056	1.5-5.3	2.9-7.9
● Female	0.011-0.037	0.022-0.055	1.5-5.3	3.1-7.8
Younger Population				
Children aged 6-11	0.015-0.061	0.032-0.092	2.2-8.8	4.6-13
Adolescents aged 12-17	0.0096-0.040	0.023-0.063	1.4-5.8	3.3-9.0
● Male	0.0096-0.041	0.023-0.063	1.4-5.9	3.3-9.0
● Female	0.0097-0.039	0.024-0.062	1.4-5.6	3.4-8.9

Exposure of high consumers refer to the exposure at 90th percentile.
LB and UB denotes lower bound and upper bound respectively.
Figures for dietary exposure estimates and contribution to ADI are rounded to 2 significant figures.

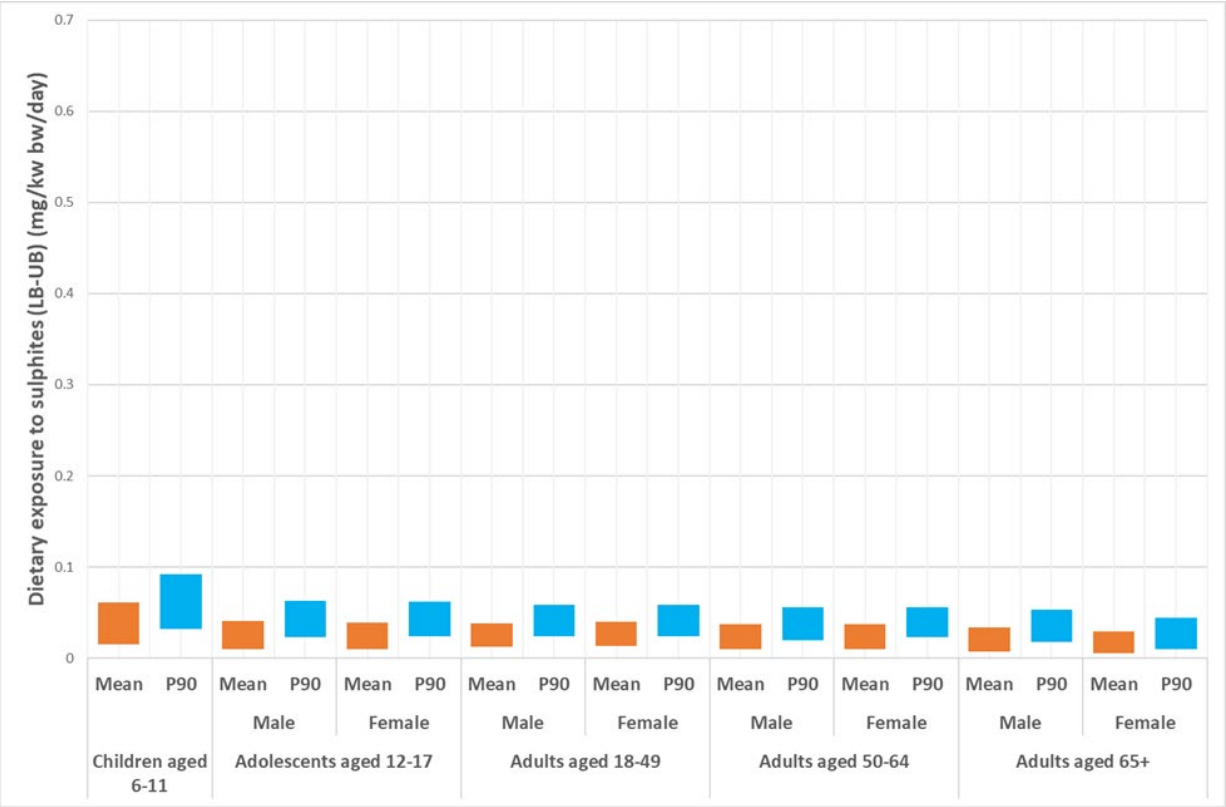

Figure 1: Dietary exposure to sulphites in age-gender subgroups (LB-UB) (mg/kg bw/day)

Major food contributors

3.10 Dietary exposure (based on LB exposure) to sulphites for the average consumer from the 15 TDS food groups are shown in Table 5. As mentioned in paragraphs 3.5 and 3.6, among the average consumers of both the adult and younger populations, the LB dietary exposure to sulphites only contributed to less than 2% of the ADI allocated for sulphites. With the rather small absolute dietary exposure estimates of sulphites as contributed by each of the different TDS food groups in this study, readers should be cautious when interpreting the relative importance of each of the dietary exposure contributors identified in this study.

Table 5: Dietary exposure to sulphites for average consumer and percentage contribution from TDS food groups

TDS food groups	Adults aged 18+		Younger population aged 6-17	
	Dietary Exposure (LB) (mg/kg bw/day)	% Contribution to total dietary exposure	Dietary Exposure (LB) (mg/kg bw/day)	% Contribution to total dietary exposure
Beverages, alcoholic	0.0026	25%	0.00016	1.3%
Cereals and their products	0.00016	1.5%	0.00020	1.6%
Fish and seafood and their products	0.00099	9.5%	0.0020	16%
Fruits	0.0024	23%	0.0023	19%
Meat, poultry and game and their products	0.0022	21%	0.0044	36%
Other food groups	0.00011	1.1%	0.00026	2.1%
Vegetables and their products	0.0020	19%	0.0031	25%

Figures for dietary exposure estimates and % contribution to overall dietary exposure are rounded to 2 significant figures.

Other food groups included "Legumes, nuts and seeds and their products", "Egg and egg products", "Dairy products", "Fats and oils", "Beverages, non-alcoholic", "Mixed dishes", "Snack foods", "Sugars and confectionery", and "Condiments, sauces and herbs".

3.11 For the adult population, the main dietary sources of sulphites found in this study were "Beverages, alcoholic" (25% of the total dietary exposure), followed by "Fruits" (23%), "Meat, poultry and game and their products" (21%), "Vegetables and their products" (19%), and then "Fish and seafood and their products" (9.5%). For the younger population, the main dietary sources of sulphites found in this study were "Meat, poultry and game and their products" (36%), "Vegetables and their products" (25%), "Fruits" (19%), and "Fish, seafood and their products" (16%). However, it should be noted that, as mentioned in paragraph 3.4, the analytical result indicated the possibility of addition of sulphites in the individual sample(s) of beef. If the contribution to dietary exposure to sulphites in beef is disregarded (i.e. only the contribution to dietary exposure to sulphites by their legitimate use in foods are considered), the top three major contributors of dietary exposure to sulphites would be "Beverages, alcoholic", "Fruits" and "Vegetables and their products" for the adult population

whereas "Vegetables and their products", "Fruits" and "Fish, seafood and their products" for the younger population.

Comparison with other places

3.12 The data on estimates of dietary exposure to sulphites locally and those reported from other places (including Australia, France, Ireland, New Zealand and the region of Taiwan)[14,15,16,17,18] using TDS or similar methodology, were summarized in Appendix 2. Overall, there is a wide range (up to some 40-fold difference) of estimated dietary exposure to sulphites among populations from different places. Apparently, dietary exposure to sulphites is the lowest in Hong Kong SAR as compared with the region of Taiwan, and the European and the Australasia counterparts. This could, at least in part, be explained by the fact that the local diet is composed of much smaller amounts of high-sulphite foods, in particular dried fruits and wines that are usually consumed as ready-to-eat products and without further sulphite-reduction kitchen preparation steps.

3.13 However, caution should be exercised in making any direct comparison of the data due to the differences in time when the reported studies were conducted, the approaches of capturing and handling food consumption data, the sampling strategies adopted, the analytical methods used and the methods of treating analytical results below detection limits, etc.

Limitations of the study

3.14 In the current study, the sampling of a limited number of individual samples of food items in which sulphites are allowed to be used as food additives, and the subsequent use of food mapping approach to assigning sulphite concentration in applicable foods, would inevitably introduce uncertainties in the dietary exposure assessment of sulphites for the local population.

3.15 For instance, dried lily flower was identified as one of the major food contributors of dietary exposure to sulphites in the Taiwanese population.[18]

Nevertheless, dried lily flower was only consumed by less than 2% of the local adult population (even less in the younger population) and the mean consumption amount was less than 0.1 g/person/day. In addition, dried lily flower is customarily washed, soaked and cooked thoroughly before consumption the processing steps of which, as advised by the Taiwan authority, would reduce any potential presence of sulphites by 70-90%.[19] Taking the above information into consideration, dried lily flower had not been included in this study as a TDS food item. Even if dried lily flower had been included as a TDS food item, it is expected that there would be insignificant contribution from this food item to the local dietary exposure estimates.

3.16 Regarding the method adopted for the laboratory analysis of sulphites in this study, it is acknowledged that false positive response might have occurred, due to extraction conditions that caused alliin and other similar sulphur-containing endogenous compounds in the *Allium* and *Brassica* genera, such as garlic, onion and cabbage, to release sulphur dioxide.[20] Specifically, garlic was found to contain low level (4.6 mg/kg) of sulphites in this study. Despite the analytical limitation, it is expected that the contribution from this false positive sulphite response to the dietary exposure estimates generated in this study is negligible.

3.17 Other limitations have been described in the Report on the 2nd HKTDS: Methodology.

Chapter 4
Conclusion and Recommendations

4.1. Out of a total of 185 TDS food items tested for sulphites, only 17 TDS food items, involving 8 TDS food groups, were found to contain detectable levels of sulphites. In other words, sulphites were not detected in the majority (91%) of TDS food items tested. "Dried fruits" was the TDS food item detected with the highest mean concentration of sulphites (240 mg/kg), followed by several other TDS food items (including button mushroom, red/white wine and preserved vegetables) with about 10-fold lower in mean concentration (20-30 mg/kg). The remaining TDS food items with detectable levels of sulphites were found with a mean concentration of 10 mg/kg or below.

4.2. For the adult population (aged 18+), the estimated dietary exposure of the average consumers was 0.010-0.037 mg/kg bw/day (LB-UB), which accounted for 1.5-5.3% (LB-UB) of the ADI allocated for sulphites. Among the high consumers of the adult population, the estimated dietary exposure was 0.021-0.055 mg/kg bw/day (LB-UB), which accounted for 3.0-7.9% (LB-UB) of the ADI. For the younger population (aged 6-17), the estimated dietary exposure of the average consumers was 0.012-0.051 mg/kg bw/day (LB-UB), which accounted for 1.8-7.3% (LB-UB) of the ADI. Among the high consumers of the younger population, the estimated dietary exposure was 0.028-0.078 mg/kg bw/day (LB-UB), which accounted for 3.9-11% (LB-UB) of the ADI. All in all, the study findings revealed that dietary exposure to sulphites would be of low chronic health concern to the average and high consumer of the local adult and younger populations, at both the population level and age-gender subgroup level.

4.3. The trade is advised that the use of food additives, including sulphites, is justified only when such use has an advantage or serves the intended technological function. Moreover, similar to other food additives, sulphites

should be used under conditions of Good Manufacturing Practice, when the amount added to the specified food is limited to the lowest possible level necessary to accomplish the desired technological effect. More importantly, such use should not present an appreciable health risk to the consumers at the intended level of use and the use should not mislead the consumers. The trade should comply with the Preservatives in Food Regulation (Cap. 132BD) which specifies the maximum permitted levels of sulphites in specified foods. The trade is reminded that, sulphites are not permitted to be added to fresh, chilled or frozen meat. In addition, the trade should also comply with the Food and Drugs (Composition and Labelling) Regulations (Cap. 132W) which stipulates the labelling requirements with regard to food additives in the list of ingredients of prepackaged food. Additionally, if a food contains sulphite in a concentration of 10 parts per million or more, the functional class and the name shall be specified in the list of ingredients.

4.4. The public is advised to maintain a balanced diet to avoid excessive exposure to chemical substances, including sulphites, from a small range of food. Members of the public should purchase meat from reliable suppliers, in particular, they should avoid buying or consuming meat which is unnaturally red. When purchasing prepackaged food products, consumers can refer to the list of ingredients on food labels to know whether sulphites have been used. In particular, susceptible individuals who are sensitive to sulphites should avoid foods that contain sulphites by paying close attention to the food labels. Examples of sulphites food additives with International Numbering System for Food Additives (INS) number and functional class are listed in **Appendix 3**.

References

1 Food and Environmental Hygiene Department (FEHD). The First Hong Kong Total Diet Study. [cited at 27 November 2024] Available from URL: https://www.cfs.gov.hk/english/programme/programme_firm/programme_tds_1st_HKTDS.html

2 FAO/WHO. General Standard for Food Additives (CAC/CXS 192-1995). Adopted in 2023. Available from URL: https://www.fao.org/fao-who-codexalimentarius/sh-proxy/en/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252FStandards%252FCXS%2B192-1995%252FCXS_192e.pdf

3 EFSA. Scientific Opinion on the re-evaluation of sulfur dioxide (E 220), sodium sulfite (E 221), sodium bisulfite (E 222), sodium metabisulfite (E 223), potassium metabisulfite (E 224), calcium sulfite (E 226), calcium bisulfite (E 227) and potassium bisulfite (E 228) as food additives. EFSA Journal 2016;14(4):4438. Available from URL: https://efsa.onlinelibrary.wiley.com/doi/pdf/10.2903/j.efsa.2016.4438

4 Gould GW and Russell NJ. Sulphite. In: Food preservatives (Chapter 5). Glasgow: Blackie and Son Ltd; 1991.

5 Lück E and Jager M. Sulfur dioxide. In: Antimicrobial food additives – characteristics, uses, effects (Chapter 12). 2nd Revised and enlarged edition. New York: Springer; 1997.

6 HKSAR. Preservatives in Food Regulation (Chapter 132BD). Hong Kong e-Legislation. [cited at 27 November 2024] Available from URL: https://www.elegislation.gov.hk/hk/cap132BD!en-zh-Hant-HK?INDEX_CS=N

7 FAO/WHO. Sulfites: Assessment of Dietary Exposure. WHO Food Additives Series: 60. Safety evaluation of certain food additives / prepared by the sixty-ninth meeting of the Joint FAO/WHO Expert Committee on Food Additives (JECFA). FAO/WHO; 2009. Available from URL: https://iris.who.int/bitstream/handle/10665/44063/9789241660600_eng.pdf;jsessionid=8A6BA7D5C2EA8F661093550D58A6AAE1?sequence=1

8 EFSA. Follow-up of the re-evaluation of sulfur dioxide (E 220),sodium sulfite (E 221), sodium bisulfite (E 222), sodium metabisulfite (E 223), potassium metabisulfite (E 224), calcium sulfite (E 226), calcium bisulfite (E 227) and

potassium bisulfite (E 228). EFSA Journal 2022; 20(11):7594. Available from URL: https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2022.7594

[9] FAO/WHO. Sulfur dioxide and sulfites. WHO Food Additives Series: 21. Toxicological Evaluation of Certain Food Additives and Contaminants / prepared by the thirtieth meeting of the Joint FAO/WHO Expert Committee on Food Additives (JECFA). FAO/WHO; 1987. Available from URL: https://inchem.org/documents/jecfa/jecmono/v21je15.htm

[10] FAO/WHO. Sulfur dioxide and sulfites (addendum). WHO Food Additives Series: 42. Safety evaluation of certain food additives / prepared by the fifty-first meeting of the Joint FAO/WHO Expert Committee on Food Additives (JECFA). FAO/WHO; 1999. Available from URL: http://www.inchem.org/documents/jecfa/jecmono/v042je06.htm

[11] International Agency for Research on Cancer (IARC). Summaries and evaluations, Vol. 54: sulfur dioxide and some sulfites, bisulfites and metabisulfites. Lyon: IARC; 1992. Available from URL: http://www.inchem.org/documents/iarc/vol54/02-sulfur-dioxide.html

[12] FEHD. The Second Hong Kong Total Diet Study: Methodology. Hong Kong: FEHD; 2024. Available from URL: https://www.cfs.gov.hk/english/programme/programme_firm/files/2nd_HKTDS_Report_e.pdf

[13] US Food and Drug Administration (FDA). FDA Foods Program Compendium of Analytical Laboratory Methods: Chemical Analytical Manual (CAM); Method No.: C-004.04; 2023. Available from URL: https://www.fda.gov/media/114411/download?attachment

[14] Food Standards Australia New Zealand (FSANZ). Supporting Document 1. Risk and Technical Assessment Report – Proposal P298 Benzoates & Sulphites Permissions in Food; 2016. Available from URL: https://www.foodstandards.gov.au/sites/default/files/food-standards-code/proposals/Documents/P298%20SD1%20Risk%20and%20Technical%20Assessmet%20Abandonment.pdf

[15] French Agency for Food, Environmental and Occupational Health & Safety (ANSES). Second French Total Diet Study (TDS 2) Report 2; 2011. Available from URL: https://m.anses.fr/en/system/files/PASER2006sa0361Ra2EN.pdf

[16] Food Safety Authority of Ireland (FSAI). Report on a total diet study carried out by the Food Safety Authority of Ireland in the Period 2001 – 2005; 2011.

[17] P. Cressey & S. Jones. Levels of preservatives (sulfite, sorbate and benzoate) in New Zealand foods and estimated dietary exposure. Food Additives & Contaminants: Part A, 26(5), 604–613. 2009. Available from URL: https://doi.org/10.1080/02652030802669188

[18] Keng-Wen Lien et al. Food safety risk assessment for estimating dietary intake of sulfites in the Taiwanese population. Toxicology Reports; 2016, Vol. 3, 544-551. Available from URL: https://doi.org/10.1016/j.toxrep.2016.06.003

[19] Taiwan Ministry of Health and Welfare. [選用安全金針，讓您食在安心不煩心.] [article in Chinese] [cited at 27 November 2024] Available from URL: https://www.mohw.gov.tw/cp-2641-21061-1.html

[20] Carlos, K. S., Conrad, S. M., Handy, S. M., & de Jager, L. S. Investigation of food products containing garlic or onion for a false positive sulphite response by LC-MS/MS. Food Additives & Contaminants: Part A, 37(5), 723–730. 2020. Available from URL: https://doi.org/10.1080/19440049.2020.1727965

Appendix 1

Sulphite contents (mg/kg) in TDS food items of the 2nd HKTDS

TDS Food Item [a]	Sulphite Contents (mg/kg) [b]		
	Mean [c]	1st Sampling Occasion	2nd Sampling Occasion
Cereals and their products			
Biscuit / Cookie	–	ND	ND
Bread, plain	–	ND	ND
Bread, raisin	–	ND	ND
Breakfast cereals	–	ND	ND
Bun, with savoury filling, baked	–	ND	ND
Bun, with savoury filling, steamed	–	ND	ND
Bun, with sweet filling, steamed	–	ND	ND
Cake	–	ND	ND
Corn	–	ND	ND
Corn starch	2.1	2.6	1.6
Deep-fried dough, Chinese style	–	ND	ND
Noodles, Chinese / Japanese style	–	ND	ND
Noodles, instant	–	ND	ND
Noodles, rice	–	ND	ND
Oats / Oatmeal	–	ND	ND
Pasta, Western style	–	ND	ND
Pastries, Chinese style	–	ND	ND
Pie / Tart	–	ND	ND
Pineapple bun	–	ND	ND
Rice, unpolished	–	ND	ND
Rice, white	–	ND	ND
Vegetables and their products			
Bamboo fungus	9.4	13	5.8
Bamboo shoot	1.9-2.4	3.8	ND
Beet root	–	ND	ND
Bitter melon	–	ND	ND
Blanching chives	–	ND	ND
Broccoli / Cauliflower	–	ND	ND
Cabbage, Chinese (including Pe-tsai / Celery cabbage)	–	ND	ND
Cabbage, Chinese flowering	–	ND	ND
Cabbage, European variety	–	ND	ND
Cabbage, Pak-choi Chinese	–	ND	ND
Cabbage, Pak-choi Chinese, dried	–	ND	ND
Carrot / Radish	–	ND	ND
Celery	–	ND	ND
Chinese amaranth (Chinese spinach)	–	ND	ND
Chinese kale	–	ND	ND
Cucumber	–	ND	ND
Ear fungus	–	ND	ND
Eggplant	–	ND	ND
Garlic	4.6	4.6	4.6

TDS Food Item [a]	Sulphite Contents (mg/kg) [b]		
	Mean [c]	1st Sampling Occasion	2nd Sampling Occasion
Ginger	–	ND	ND
Hairy gourd / wax gourd	–	ND	ND
Leaf mustard	–	ND	ND
Lettuce, Chinese / European / Indian	–	ND	ND
Mung bean sprout	–	ND	ND
Mushroom, button	30	1.6	59
Mushroom, shiitake, dried	2.1	2.8	1.3
Onion	–	ND	ND
Pea shoots	–	ND	ND
Peppers (sweet pepper / chili pepper)	–	ND	ND
Potato	–	ND	ND
Potato, fried	–	ND	ND
Preserved vegetables	23	16	29
Pumpkin	–	ND	ND
Seaweed	–	ND	ND
Spinach	–	ND	ND
Sponge gourd	–	ND	ND
Spring onion	–	ND	ND
Sweet potato	–	ND	ND
Tomato	–	ND	ND
Water spinach	–	ND	ND
Watercress	–	ND	ND
Zucchini	–	ND	ND
Legumes, nuts and seeds and their products			
Fermented soybean products	–	ND	ND
Green peas	–	ND	ND
Green string beans (with pod)	–	ND	ND
Peanut	–	ND	ND
Peanut butter	–	ND	ND
Red bean	–	ND	ND
Soybean curd (Tofu)	–	ND	ND
Tree nuts	–	ND	ND
Vermicelli, mung bean	–	ND	ND
Fruits			
Apple	–	ND	ND
Banana	–	ND	ND
Cherry	–	ND	ND
Dragon fruit	–	ND	ND
Dried fruits	240	380	100
Durian	–	ND	ND
Grapes	–	ND	ND
Kiwi	–	ND	ND
Longan / Lychee	–	ND	ND
Mandarin / Tangerine	–	ND	ND
Mango	–	ND	ND
Melon	–	ND	ND
Orange	–	ND	ND
Papaya	–	ND	ND

TDS Food Item [a]	Sulphite Contents (mg/kg) [b]		
	Mean [c]	1st Sampling Occasion	2nd Sampling Occasion
Peach	–	ND	ND
Pear	–	ND	ND
Pineapple	–	ND	ND
Watermelon	–	ND	ND
Meat, poultry and game and their products			
Beef	8.0-8.5	ND	16
Beef tendon	–	ND	ND
Chicken meat, other than chicken wing	–	ND	ND
Chicken wing	–	ND	ND
Duck / goose, roasted	–	ND	ND
Ham, pork	–	ND	ND
Liver, goose	–	ND	ND
Liver, pig	–	ND	ND
Luncheon meat	–	ND	ND
Meat ball	–	ND	ND
Meat sausage	–	ND	ND
Mutton	–	ND	ND
Pork chop	–	ND	ND
Pork ribs	–	ND	ND
Pork, barbequed	–	ND	ND
Pork, other than pork chop and pork ribs	–	ND	ND
Pork, roasted	–	ND	ND
Egg and their products			
Egg, chicken	–	ND	ND
Egg, lime preserved	–	ND	ND
Egg, salted	–	ND	ND
Fish, seafood and their products			
Clam	–	ND	ND
Crab	–	ND	ND
Cuttlefish	–	ND	ND
Fish ball / fish cake	–	ND	ND
Fish fillet	–	ND	ND
Fish, Dace, minced	–	ND	ND
Fish, Golden thread	–	ND	ND
Fish, Grass carp	–	ND	ND
Fish, Grouper	–	ND	ND
Fish, Mandarin fish	–	ND	ND
Fish, Mangrove red snapper	–	ND	ND
Fish, Pomfret / Pompano	–	ND	ND
Fish, Salmon	–	ND	ND
Fish, Tuna	–	ND	ND
Fish, Yellow croaker	–	ND	ND
Lobster	–	ND	ND
Mantis shrimp	–	ND	ND
Mussel	–	ND	ND
Oyster	4.5-5.0	ND	8.9
Salted fish	2.3	1.2	3.4
Scallop	–	ND	ND

TDS Food Item [a]	Sulphite Contents (mg/kg) [b]		
	Mean [c]	1st Sampling Occasion	2nd Sampling Occasion
Shrimp / Prawn	10	3.2	17
Shrimp / Prawn, dried	5.4	8.1	2.6
Squid	1.3-1.8	ND	2.6
Dairy products			
Cheese	–	ND	ND
Fermented / Cultured beverages, dairy based	–	ND	ND
Ice-cream	–	ND	ND
Milk beverages	–	ND	ND
Milk, condensed / evaporated	–	ND	ND
Milk, skim	–	ND	ND
Milk, whole	–	ND	ND
Yoghurt	–	ND	ND
Fats and oils			
Butter	–	ND	ND
Vegetable oil	–	ND	ND
Beverages, alcoholic			
Beer	–	ND	ND
Wine, red / white	27	24	30
Beverages, non-alcoholic			
Carbonated drink (including diet version)	–	ND	ND
Coconut water	–	ND	ND
Coffee	–	ND	ND
Fruit and / or vegetable juice	–	ND	ND
Malt drink	–	ND	ND
Soybean drink	–	ND	ND
Tea (including lemon tea)	–	ND	ND
Tea, chrysanthemum	–	ND	ND
Tea, with milk	–	ND	ND
Tea, with milk and tapioca pearls	–	ND	ND
Mixed dishes			
Dim sum, beef ball, steamed	1.0-1.5	2.0	ND
Dim sum, Siu Mai, steamed	–	ND	ND
Dumpling / spring roll, fried	–	ND	ND
Dumpling, boiled (including wonton)	–	ND	ND
Dumpling, steamed	–	ND	ND
Glutinous rice dumpling	–	ND	ND
Hamburger	–	ND	ND
Pizza	–	ND	ND
Rice-roll, plain, steamed	–	ND	ND
Soup, Chinese style	–	ND	ND
Soup, Western style	–	ND	ND
Turnip cake	–	ND	ND
Snack foods			
Potato chips	–	ND	ND
Sugars and confectionery			
Chocolate	–	ND	ND
Honey	–	ND	ND
Jam	–	ND	ND

TDS Food Item [a]	Sulphite Contents (mg/kg) [b]		
	Mean [c]	1st Sampling Occasion	2nd Sampling Occasion
Sugar, brown / rock	0.50-1.0	1.0	ND
Sugar, white, granulated	–	ND	ND
Condiments, sauces and herbs			
Chicken powder / cube	–	ND	ND
Chinese parsley	–	ND	ND
Curry sauce	–	ND	ND
Oyster sauce	–	ND	ND
Salad dressing	–	ND	ND
Sesame seed oil	–	ND	ND
Soya sauce	–	ND	ND
Table salt	–	ND	ND
Tomato paste / ketchup	–	ND	ND
Vinegar	–	ND	ND
White pepper	–	ND	ND

Notes:

[a] Two composite samples were tested for each TDS food item.

[b] Concentration levels are rounded to 2 significant figures. ND denotes non-detected, i.e. results less than limit of detection (LOD).

[c] Mean concentrations for those TDS food items detected in both sampling occasions are presented as a single value, whereas those detected only in one of the two sampling occasions are presented as a range (lower bound-upper bound).

Appendix 2

A comparison of dietary exposure to sulphites locally and those reported in other places

Country / place	Population subgroups	Average exposure (mg/kg bw/day)	High percentile exposure (mg/kg bw/day)	High percentile used	Reference
Hong Kong SAR*	18+ yrs	0.010-0.037	0.021-0.055	P90	This study
	6-17 yrs	0.012-0.051	0.028-0.078		
Australia	17+ yrs	0.4	1.0	P90	FSANZ (2016)
	6-12 yrs	0.2	0.6		
	13-16 yrs	0.2	0.4		
France*	18-79 yrs	0.164-0.170	0.599-0.601	P95	ANSES (2011)
	3-17 yrs	0.031-0.046	0.123-0.144		
Ireland*	18-64 yrs	0.15-0.63	0.66-1.32	P97.5	FSAI (2011)
New Zealand	19-24 yrs male	0.18	0.56	P95	P. Cressey & S. Jones (2009)
	19-24 yrs female	0.19	0.69		
	25-44 yrs male	0.18	0.67		
	25-44 yrs female	0.13	0.47		
	45-64 yrs male	0.14	0.55		
	45-64 yrs female	0.10	0.46		
	65+ yrs male	0.08	0.44		
	65+ yrs female	0.05	0.24		
	5-12 yrs male	0.16	0.91		
	5-12 yrs female	0.11	0.63		
	13-15 yrs male	0.12	0.56		
	13-15 yrs female	0.08	0.43		
	16-18 yrs male	0.15	0.58		
	16-18 yrs female	0.08	0.38		
The region of Taiwan	19-50 yrs male	0.2	0.8	P95	Keng-Wen Lien et al (2016)
	19-50 yrs female	0.2	0.7		
	51-65 yrs male	0.3	0.8		
	51-65 yrs female	0.3	0.6		
	66+ yrs male	0.2	0.6		
	66+ yrs female	0.4	0.9		
	7-12 yrs male	0.2	0.4		
	7-12 yrs female	0.2	0.3		
	13-18 yrs male	0.1	0.2		
	13-18 yrs female	0.2	0.4		

Note: * Lower bound-upper bound exposure were presented.

Appendix 3

Examples of sulphite food additives [a]

INS No.[b]	Food Additive	Functional class
220	Sulphur dioxide	Antioxidant, Bleaching agent, Flour treatment agent, Preservative
221	Sodium sulphite	Antioxidant, Bleaching agent, Flour treatment agent, Preservative
222	Sodium hydrogen sulphite	Antioxidant, Preservative
223	Sodium metabisulphite	Antioxidant, Bleaching agent, Flour treatment agent, Preservative
224	Potassium metabisulphite	Antioxidant, Bleaching agent, Flour treatment agent, Preservative
225	Potassium sulphite	Antioxidant, Preservative
226	Calcium sulphite	Antioxidant, Preservative
227	Calcium hydrogen sulphite	Antioxidant, Preservative
228	Potassium bisulphite	Antioxidant, Preservative
539	Sodium thiosulphate	Antioxidant, Sequestrant

Notes:

[a] Examples listed are not exhaustive nor complete. It should be noted that these are not recommended food additives or local standards, but merely serve as a reference.

[b] "INS" in full is "International Numbering System for Food Additives" adopted by the Codex Alimentarius Commission established by Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO) under the Joint FAO/WHO Food Standards Programme.