Risk Assessment of Sulphites in Australian Canned Abalone

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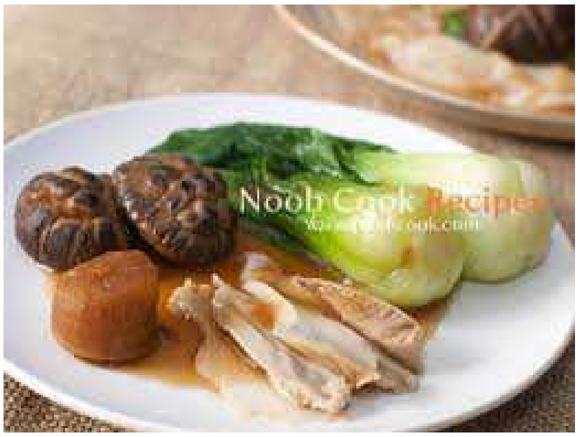

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INTRODUCTION

BACKGROUND

The permitted level of sulphites/SO_2 in canned abalone is 0 ppm in China's food regulations and 1000 ppm in Australia's food regulations. China is a major importer of Australian canned abalone, both directly and via Hong Kong, and enforcement of the 0 ppm sulphites/SO_2 in canned abalone has resulted in trade failures. A risk assessment to underpin a maximum level of 1000 ppm in canned abalone has not been undertaken, nor has evidence of the levels of sulphites/SO_2 in Australian canned abalone been collated. The purpose of this risk assessment was to collect information on current industry practices and to estimate the food safety risk of sulphites/ SO_2 in Australian canned abalone. This will provide the Australian Quarantine Inspection Service (AQIS) and Australian abalone industry an objective basis for negotiating import requirements for canned abalone into China.

RISK ASSESSMENT METHOD

Risk Analysis comprises Risk Assessment, Risk Management and Risk Communication. In 1995 a Joint FAO/WHO Expert Consultation on the Application of Risk Analysis to Food Standard Issues provided advice to the Codex Alimentarius Commission (CAC) Executive Committee on the application of risk analysis to food standard issues WHO/FNU/FOS/95.3 (http://www.who.int/foodsafety/publications/ micro/en/march1995.pdf). The Consultation focussed on risk assessment, and agreed upon a scientifically-based risk assessment model comprised of four steps defined as follows:

Hazard Identification

"The identification of known or potential health effects associated with a particular agent."

Hazard Characterisation

"The qualitative and/or quantitative evaluation of the nature of the adverse effects associated with biological, chemical, and physical agents which may be present in food. For chemical agents, a dose-response assessment should be performed. For biological or physical agents, a dose-response assessment should be performed if the data is available."

Exposure Assessment

"The qualitative and/or quantitative evaluation of the degree of intake likely to occur."

Risk Characterisation

"Integration of hazard identification, hazard characterization and exposure assessment into an estimation of the adverse effects likely to occur in a given population, including attendant uncertainties"

The risk assessment model proposed by the Consultation was adopted by the Codex Alimentarius Commission as outlined in the Working Principles for Risk Analysis of Food Safety CAC/GL 62-2007 (www.codexalimentarius.net/download/standards/ 10751/CXG_062e.pdf). This risk assessment model and the definitions agreed to in the Consultation have been applied in this risk assessment of sulphites in Australian canned abalone.

SURVEY OF CANNED ABALONE PROCESSORS

To gain an understanding of current industry practices a survey was designed to collect information on canned abalone production processes (Appendix A). The survey also collected information for another SARDI research project unrelated to this risk assessment. Information was received from seven Australian processors of canned abalone from four states (Western Australia, South Australia, Victoria and Tasmania). For commercial-in-confidence reasons some information and data requested was not provided. The data and information was obtained in confidence, and for that reason the participating processors are not identified in this report, and the information and data obtained are referred to in a summary form only.

HAZARD IDENTIFICATION

UTILISATION OF SULPHITES IN CANNED ABALONE

Sulphur dioxide and sulphites (E220, E221, E222, E223, E224, E225, E228) are reducing chemicals which are used as food additives in some foods to either prevent oxidative discoloration (e.g. dried apricots), for bleaching (e.g. flour) or to preserve against microbiological activity (e.g. wine). The range of foods in which sulphites are permitted to be added and the amounts permitted to be added varies significantly from country to country (Appendix B).

In canned abalone, sulphites are added to bleach the natural pigment on the foot of the abalone and to prevent a blue discolouration. The extent of natural pigmentation depends primarily on the species, and there is some within-species variation according to the place of harvest. Hemocyanin a copper containing protein carries oxygen in the abalone blood and is responsible for the blue discolouration. In the oxidised state the haemocyanin is blue, and in the reduced state it is colourless (Olley and Thrower, 1977). Other additives sometimes included in canned abalone are salts of diphosphates or polyphosphates (E450, E451, E452) and EDTA (ethylenediaminetetraacetic acid, E385), which is a chelator of metal ions and also contributes to the prevention of a blue discolouration.

Abalone quality is graded by size, texture and colour. Consumer preference is for canned abalone to have a creamy/yellow appearance without areas of discolouration (Brown et al, 2008).

The Australian wild abalone species are *Haliotis rubra* (black-lip), *H. laevigata* (green lip), *H. roei* and *H. conicopora* (brown lip) (Hahn 1989, http://www.fish.wa.gov.au/docs/cf/Abalone/index.php?0603). All these species are canned and the predominant canned species is *H. rubra*. A hybrid farmed species is also canned.

Prior to treatment with sulphites, physical processes are applied to remove surface pigment. Rumbling is the most effective physical process and is used by all the processors surveyed. Following rumbling other physical processes may be used including scrubbing, water blasting and trimming. These physical processes are often sufficient to remove the natural pigment from the abalone foot of the Australian wild caught and farmed species. Where physical processes are sufficient to remove the surface pigment, sulphites are added only for the purpose of preventing oxidation of any remaining hemocyanin, and this can be achieved at very low final concentrations of sulphur dioxide (<30 ppm). Some canned abalone is produced without the addition of any sulphites. It is understood this can be achieved by use of a combination of citric acid and EDTA, but this causes the abalone to have an acidic taste.

The New Zealand species *Haliotis iris* (paua or black paua) is imported to a limited extent for canning in Australia. The foot of this species is covered with a black pigment and the meat is generally dark (Hahn, 1989). For the black paua, physical processes are not sufficient to remove the pigment and high concentrations of sulphites are used to achieve a lighter colour.

Sulphites are applied after the physical pigmentation removal processes. Sulphites are applied either by dipping the abalone meat in a sulphite solution, or by inclusion of sulphites in the canning brine. The survey of processors found that the dipping method is the more commonly used approach.

The maximum level of sulphur dioxide and sulphite permitted in canned abalone (paua) in the Australian Food Standards Code is 1000 ppm[1]. A survey of 7 Australian processors found the majority of canned abalone produced had a sulphur dioxide/sulphites concentration <30 ppm. In the survey results the maximum level in canned Australian abalone species was <300 ppm. Higher levels were utilised only for canned *H. iris*, the New Zealand species commonly known as paua or black paua.

DELETERIOUS HEALTH EFFECTS ASSOCIATED WITH SULPHUR DIOXIDE/SULPHITES

There are two forms of deleterious impacts associated with sulphur dioxide and sulphites on humans (WHO 1999). The first is a general toxicity that causes gastric lesions. A study of rats that had sodium metabisulphite added to their drinking water at levels equivalent to doses of 350 mg/kg bw[2] for 3 weeks followed by 175 mg/ kg bw for 5 weeks found lesions in the forestomach and stomach at the end of the 8 week period. Sulphite-related gastric lesions have not been reported in humans, who are not exposed to sustained high concentrations of sulphites in their diet.

The second and more important form of deleterious impact of sulphur dioxide/sulphites in humans is described as an “idiosyncratic intolerance” (WHO 1999). Idiosyncratic intolerance or hypersensitivity results in a range of allergy-like symptoms that include asthma, rhinitis (inflammation of the nasal passages often associated with discharge), rhinoconjunctivitis, urticaria (hives), angio-oedema (swelling of the tongue and throat), headache, gastrointestinal distress and anaphylaxis (Vally et al, 2009).

Intolerance to sulphites in food is most frequent among asthmatic people, and the risk of a severe reaction is considered to be greater among those who require steroidal medication to control their asthma, those with marked airway hyper-responsiveness and children with chronic asthma (WHO 1999, Vally et al, 2009). In Australia it is estimated that 14-16% of children and 10-12% of adults have asthma (The Asthma Foundation of Victoria, 2005). Rates of asthma in Asian countries may be lower but are increasing alongside increasing urbanisation. In South-East China the prevalence of asthma in 13-15 year olds increased from 1.9% in 1980 to 3.4% in 1995 (Zhong 1996). A review of prevalence studies in Asia, which have mainly determined rates in children and adolescents found rates in China, Hong Kong, India, Indonesia and Malaysia were < 9%; in Japan the prevalence was 17.3% in those aged 6-7 yrs and 13.4% in those aged 13-14 yrs in Fukuoka and 6.7% in those aged 12-15 yrs in Suita City. In Singapore the prevalence in children was 10.2%, and in central Taiwan the prevalence of asthma in children was 7.4% (Liao et al, 2009).

There may be some difference in predisposition to asthma between racial groups with higher rates of asthma found among Indian people (6.6%) and Malaysian people (6.0%) than among Chinese people (3.0%) in one study of people living in Singapore; but environment plays a greater role. The predominant populations in Hong Kong and Guangzhou City are Cantonese Chinese, but in Hong Kong the prevalence of asthma was 11.2% compared with 3.9% in Guangzhou City located only 250 km away (Zhong, 1996). It is estimated that among people who suffer with asthma 20-35% children and 4% of adults are sensitive to sulphites by oral ingestion (WHO, 1999).

HAZARD CHARACTERISATION

GENERAL TOXICITY

In rats which consumed sodium metabisulphite in drinking water there were no gastric lesions in rats that consumed 70 mg/kg bw/day over an 8 week period. Sulphites are metabolised in the liver to

[1] ppm = parts per million, ppm = mg/kg
[2] mg/kg bw = dose as milligrams per kilogram of body weight

sulphates by the enzyme sulphite oxidase. Rats have higher levels of sulphite oxidase in their livers than humans; 350 units/g in rat liver compared with 10-25 units/g in human liver (Johnson and Rajagopalan, 1976, WHO 1999). In rats treated with tungsten to effectively eliminate sulphite oxidase activity there were also no gastric lesions after consumption of 70 mg/kg bw/day sodium metabisulphite over an 8 week period (WHO 1999). After 4-5 weeks consumption of water dosed with sodium metabisulphite the sulphite oxidase-deficient rats had dried blood around their noses after 4-5 weeks, and on autopsy at 8 weeks were found to have white patches in their lungs. Based on the absence of gastric lesions at 70 mg/kg bw the Joint FAO/WHO Expert Committee on Food Additives (JECFA) applied a 100x safety factor and established the Acceptable Daily Intake (ADI) level for humans of 0-0.7mg/kg bw/day.

IDIOSYNCRATIC INTOLERANCE

The dose of sulphur dioxide/sulphites in food or drink that produces allergy-like reactions among susceptible people varies substantially among individuals, and also varies according to the nature of the food or drink containing the sulphur dioxide/sulphites. In the most extreme example of an adverse reaction one man, who had had severe asthmatic symptoms on exposure to sulphites in dried apricots and salad, suffered a fatal anaphylactic shock after a few sips of wine containing sulphites at a concentration of 92 ppm (WHO, 1999).

Individuals and small groups suspected of sulphite hypersensitivity have been tested in several single-blind and double-blind challenge studies (WHO, 1999). Doses in the range of <1-200 mg have produced symptoms (WHO 1999). One man developed an itchy rash and swelling in the face after consuming 100 ml of beer containing 3-4 ppm of sulphite (a dose of 0.3 -0.4 mg). In a single-blind challenge study of 29 children with chronic asthma no reactions were observed when 100 mg of sodium metabisulphite was ingested in a capsule, but when 50 mg was ingested in a citric acid solution there were reactions in 19 children (WHO, 1999). Acidic foods and drinks containing sulphites are more likely to elicit symptoms, and this is considered due to the release of sulphur dioxide (SO_2) at low pH. However reactions can occur when the sulphite is not delivered in an acidic medium. A woman who controlled her asthma with steroidal medication had an asthmatic reaction to 5 mg of a sulphite consumed in a capsule.

Sulphur dioxide (SO_2) is a common air pollutant, and studies have been performed to determine the concentrations of SO_2 in air that elicit lung function changes in people with asthma. The lowest concentrations of SO_2 in air that produce respiratory symptoms are in the range of 0.2–1 ppm (Goodman et al, 2010). Air quality standards in Australia require levels below the following:

- 0.20 ppm averaged over a one hour period
- 0.08 ppm averaged over a 24 hour period
- 0.02 ppm averaged over a one year period.
  (*Air Quality Fact Sheet, Department of Environment and Heritage, Australian Government 2005*)

Characteristics of food, other than pH can affect the likelihood of adverse responses. Foods which bind sulphites are less likely to produce symptoms. Sulphites may be bound irreversibly or reversibly. When SO_2 is measured in foods it is termed the total residual SO_2, and is the sum of the free SO_2, the SO_2 in sulphites and bisulphites, and the SO_2 in reversibly bound forms. This total residual SO_2 is indicated in this document as SO_2^*. Lettuce while not an acidic food, does not bind sulphites. Consumption of lettuce treated with sulphite solutions has been demonstrated to result in adverse reactions in sensitive individuals (WHO, 1999).

Due to variability in the dose-response reactions among sensitive individuals a safe level for sulphur dioxide/sulphites in foods has not been established. The view of JECFA is that "appropriate labelling is the only feasible means of protecting individuals who cannot tolerate certain food additives." (WHO, 1999). JECFA also recommends that "when a suitable alternative method of preservation exists, its use should be encouraged, particularly in those applications (e.g. control of enzymic browning in fresh salad vegetables) in which the use of sulfites may lead to high levels of acute intake which have most commonly been associated with life-threatening adverse reactions." (WHO, 1999).

ADVERSE EFFECTS ASSOCIATED WITH ABALONE

No reports were found of adverse reactions associated with the presence of sulphur dioxide/sulphites in canned abalone. Some people have an allergy to the protein tropomyosin in abalone and other molluscs, which is a less common than allergies to fish and crustacean shellfish proteins (Taylor, 2008).

Canned abalone has a pH in the range 6.0 – 6.5. In this pH range the majority of free sulphite is in the sulphite ion form (SO_3^{2-}), and a minor proportion in the bisulphite ion form (HSO_3^-). Sulphur dioxide (SO_2) does not occur in solution in this pH range, and is only found in sulphite solutions when the pH is below 4.0 and becomes the predominant form when the pH is < 2.0 (Green, 1976).

The extent of reversible and irreversible binding of sulphites in abalone has not been determined. A small preliminary study of changes in SO_2^* levels in canned abalone prior to and post retorting was conducted as part of this assessment. The results did not indicate a decrease in levels of SO_2^* associated with the heating process, suggesting that heating does not lead to irreversible binding of SO_2^* in abalone (Appendix C).

EXPOSURE ASSESSMENT

VOLUMES EXPORTED

The total weight of canned abalone meat exported from Australia in 2010 is estimated to be approximately 530 tonnes, and the number of 100g servings this represents is 5.3 million (Table 1). The largest importers of Australian canned abalone were China and Hong Kong (49%) and Singapore (33%). The next largest importer was Japan (7%). Smaller amounts were imported by Taiwan, the USA, Canada, Indonesia, Malaysia, Thailand, Vietnam and Korea.

Table 1 Number of Cartons of Canned Abalone Exported from Australia in 2010 by Country of Import and Estimated Amounts of Abalone Meat Exported and Serves by Country of Import

	Cartons [a]	Weight of Meat [b] (tonnes)	Serves [c] ('000s)
China and Hong Kong	49,204	260	2,598
Singapore	33,295	176	1,758
Japan	7,405	39	391
Taiwan	4,408	23	233
US	1,596	8	84
Canada	1,291	7	68
Indonesia, Malaysia, Thailand	3,491	18	184
Vietnam and Korea	74	< 1	4
Totals	**100,764**	**532**	**5,320**

a. Data on number of cartons exported supplied by Tony Johnston (Tasmanian Seafoods Pty Ltd). A carton contains 24 cans.
b. Using the author's approximation of 220 g of meat per can. Information obtained in the survey indicated weight of meat per can may vary in the range 210 – 260g
c. Using the author's approximation of 100g per serve.

CONSUMPTION PATTERNS

If estimated on a population basis the number of servings of abalone per person per annum is minor in the countries of import (< 1 serving per person per annum). However abalone is luxury food, whose consumption is restricted by price to high income earners. There are no data available on the number of people who include canned abalone in their diet, nor on the frequency of consumption, in the countries of import. Among the sub-populations that consume canned abalone there is no data to indicate consumption levels amongst children compared with adults.

For the extremely wealthy, it may be a matter of choice of how often they eat canned abalone, and they have the choice of eating the more expensive and desirable forms of abalone (e.g. fresh, frozen, vacuum packed, dried). For others canned abalone may only be consumed on special occasions (e.g. Chinese New Year). It may be reasonable to assume that among those who include canned abalone in their diet that consumption on any given day would be restricted to one meal.

Canned abalone is purchased for home consumption and for use in restaurants. There are no data on the proportion of canned abalone consumed in the home and the proportion consumed in restaurants.

COOKING PREPARATION

Canned abalone is prepared in a variety of ways including being sliced and warmed, added to stews or braises, added to soups, and being boiled in the can for 3-4 hours before being sliced for serving. No studies were found on the impact of cooking on the SO_2^* content of canned abalone. In the small study conducted as part of this risk assessment there was no indication of loss of SO_2^* in response to the heat of retorting, which may indicate that prolonged boiling in the can prior to consumption would have little impact on SO_2^* concentration in the meat (Appendix C). There may be some loss of SO_2 to the atmosphere during out of can preparation, if the abalone were prepared in an acidic medium or fried (Armentia-Alverez et al, 1993). As canned abalone is already cooked, its preparation for inclusion in braises or soups or serving slices on a platter often appears to be limited to reheating. There may be some loss of SO_2^* from the abalone meat during cooking preparation, but without data, for the purposes of this risk assessment, the conservative assumption of no loss from the meat during meal preparation is applied.

SERVING SIZE

No data are available on serving sizes of canned abalone in the countries of import, including different serving sizes among children and adults. There is likely to be some variation. If served as the single main dish a serving size of 100g may be a reasonable assumption for an adult or teenager. If served in soups or braises that include other seafood/other types of protein and vegetables, the quantity of abalone per serve is likely to be less. For example in a recipe for Seafood and Bean Curd soup 50 g of abalone is used (http://www.china.org.cn/english/food/69519.htm). Some recipes for soups and braises were found where the canning brine is included in the recipe, rather than discarded (e.g. http://www.cdkitchen.com/recipes/recs/231/Abalone-Soup80763.shtml, http://www.noobcook.com/braised-mushrooms-with-abalone/). The amount of SO_2^* consumed in these dishes would be the sum of the amounts in the meat and the brine.

SO_2^* EXPOSURE PER MEAL

As most producers were unwilling to give estimates of their total production for commercial reasons, the information obtained was not adequate to provide an estimate of the quantities of canned abalone produced within various ranges of SO_2^* concentrations in Australia,. The survey responses indicated that a small proportion of canned abalone has no sulphites added and that the largest proportion of canned abalone has SO_2^* in the range 1 to <30 ppm. Some canned abalone has SO_2^* in the concentration range 30–100 ppm and some in the range 101–300 ppm. Only canned New Zealand paua had SO_2^* levels in excess of 300 ppm. As the proportions of canned abalone in each category produced in Australia could not be established, exposures for individual meals were estimated for canned abalone from across a range of SO_2^* concentrations for illustrative purposes.

EXPOSURE FOR SO_2-TOLERANT INDIVIDUALS

For SO_2-tolerant individuals the acceptable daily intake (ADI) of SO_2^* is 0-0.7 mg/kg bw (WHO, 1999). For a 100 g serving of canned abalone containing 30 ppm SO_2^* [3], the dose of SO_2^* exceeds 0.7 mg/kg bw for individuals with a weight less than 4.3 kg (Table 2). Only infants less than 3 months old would have a body weight less than 4.3 kg, and they are not consuming solid food. A 100g serving of canned abalone containing 30 ppm SO_2^* would not exceed a dose of 0.7 mg SO_2^* /kg bw for children or adults.

Data are available for the body weight of Chinese children and for Chinese adults 40 years and older (http://fwcc.org/index.php?option=com_content&view=article&id=301:growth-charts-for-chinese-children&catid=15:health&Itemid=23, Gu et al, 2006). Data could not be accessed for younger adults, however, the data for the adults 40 years and older is likely to be a reasonable representation of the weight ranges among younger adults. The weight ranges applied in the simulation modelling for children (10–90 kg) overlapped the weight ranges for the adults aged 40 years and older (25-110 kg) (Appendix D). These data were used to model by simulation the weights of Chinese children and adults, and determine the dose of SO_2^*, from the consumption of canned abalone, as mg/kg bw. From this the probabilities of exceeding a dose of 0.7 mg/kg bw from the

[3] SO_2^* = total residual SO_2 measured in food which includes SO_2 in free SO_2+sulphites+bisulphites+reversibly bound forms

consumption of canned abalone across a range of possible SO_2^* concentrations were estimated (Tables 3-5), (Appendix D).

The probability of an intake of SO_2^* exceeding 0.7 mg/kg bw from consumption of a 50 g serving for 5 year old Chinese children was 0% when the SO_2^* concentration was 100 ppm or less. There was a small probability (3%) that the intake of SO_2^* would exceed 0.7 mg/kg bw in 5 year old Chinese boys when the serving size was 100 g (Tables 3 and 4).

The probability of an intake of SO_2^* exceeding 0.7 mg/kg bw from consumption of a 100 g serving for 10 and 15 year old Chinese children was 0.00 % when the SO_2^* concentration was 100 ppm or less (Tables 3 and 4).

The probability of an intake of SO_2^* exceeding 0.7 mg/kg bw from consumption of a 100 g serving of canned abalone for Chinese adults 40 years or older was 0% when the SO_2^* concentration was 150 ppm or less (Table 5).

The probability of an intake of SO_2^* exceeding 0.7 mg/kg bw from consumption of a 100 g serving of canned abalone with a SO_2^* concentration in the range 500–1000 ppm was 87–100% for all categories of children and adults modelled (Tables 3-5).

Table 2 Human weight thresholds below which the intake of SO2* would exceed 0.7 mg/kg bw from the consumption of 100g of abalone, for a range of SO2* concentrations

SO_2^* in Abalone (ppm)	SO_2^* Dose (mg) in 100g Serving of Canned Abalone	Human Weight Threshold (kg) Below Which an Intake of 0.7 mg/ kg bw is Exceeded
30 ppm	3	4.3
50 ppm	5	7.1
100 ppm	10	14.3
150 ppm	15	21.4
250 ppm	25	35.7
500 ppm	50	71.4
1000 ppm	100	142.9

For example for canned abalone meat with a SO_2^* concentration of 50 ppm, only individuals weighing less that 7.1 kg would exceed an intake of 0.7 mg/kg bw from a meal containing 100 g of canned abalone meat.

Table 3 Modelled probability (%) that the dose of SO_2^* consumed in an abalone serving would exceed 0.7 mg/kg bw for Chinese girls aged 5, 10 and 15 years, for a range of SO_2^* concentrations

	SO_2^* in Abalone (ppm)	Min Dose (mg/kg bw)		Mean Dose (mg/kg bw)		Max Dose (mg/kg bw)		Probability (%) Dose Exceeds 0.7 mg/kg bw	
		Serving Size		Serving Size		Serving Size		Serving Size	
		50 g	100 g	50 g	100 g	50 g	100 g	50 g	100 g
Girl 5 yrs	30 ppm	0.05	0.1	0.08	0.17	0.14	0.27	0%	0%
	50 ppm	0.09	0.17	0.14	0.28	0.23	0.45	0%	0%
	100 ppm	0.17	0.34	0.28	0.55	0.45	0.91	0%	0%
	150 ppm	0.26	0.52	0.41	0.83	0.68	1.4	0%	82%
	250 ppm	0.43	0.86	0.69	1.4	1.1	2.3	48%	100%
	500 ppm	0.86	1.7	1.4	2.8	2.3	4.5	100%	100%
	1000 ppm	1.7	3.4	2.8	5.5	4.5	9	100%	100%
Girl 10 yrs	30 ppm	0.03	0.06	0.05	0.09	0.08	0.15	0%	0%
	50 ppm	0.05	0.1	0.08	0.16	0.13	0.25	0%	0%
	100 ppm	0.1	0.19	0.16	0.31	0.25	0.5	0%	0%
	150 ppm	0.14	0.29	0.23	0.47	0.38	0.75	0%	1%
	250 ppm	0.24	0.48	0.39	0.78	0.63	1.2	0%	62%
	500 ppm	0.48	0.96	0.78	1.6	1.2	2.5	62%	100%
	1000 ppm	0.96	1.9	1.6	3.1	2.5	5	100%	100%
Girl 15 yrs	30 ppm	0.04	0.04	0.03	0.06	0.04	0.09	0%	0%
	50 ppm	0.03	0.07	0.05	1	0.08	0.16	0%	0%
	100 ppm	0.07	0.14	0.1	0.2	0.16	0.31	0%	0%
	150 ppm	0.1	0.2	0.15	0.3	0.23	0.47	0%	0%
	250 ppm	0.17	0.25	0.25	0.5	0.39	0.78	0%	2%
	500 ppm	0.25	0.68	0.5	1	0.78	1.6	2%	99%
	1000 ppm	0.68	1.4	1	2	1.6	3.1	99%	100%

For example: the probability of a 5 year old Chinese girl consuming a SO_2^* dose in excess of 0.7 mg/kg bw from the consumption of a 50g serving of abalone containing 250 ppm of SO_2^* is 48%.

Table 4 Modelled probability that the dose of SO_2^* consumed in an abalone serving would exceed 0.7 mg/kg bw for Chinese boys aged 5, 10 and 15 years, for a range of SO_2^* concentrations

	SO_2^* in Abalone (ppm)	Min Dose (mg/kg bw)		Mean Dose (mg/kg bw)		Max Dose (mg/kg bw)		Probability (%) Dose Exceeds 0.7 mg/kg bw	
		Serving Size		Serving Size		Serving Size		Serving Size	
		50 g	100 g	50 g	100 g	50 g	100 g	50 g	100 g
Boy 5 yrs	30 ppm	0.05	0.1	0.08	0.16	0.15	0.3	0%	0%
	50 ppm	0.08	0.17	0.13	0.27	0.25	0.5	0%	0%
	100 ppm	0.17	0.3	0.27	0.5	0.5	1	0%	3%
	150 ppm	0.25	0.5	0.4	0.8	0.75	1.5	0.4%	73%
	250 ppm	0.44	0.8	0.67	1.3	1.2	2.5	37%	100%
	500 ppm	0.8	1.7	1.3	2.7	2.5	5	100%	100%
	1000 ppm	1.7	3.3	2.7	5.3	5	10	100%	100%
Boy 10 yrs	30 ppm	0.03	0.05	0.05	0.09	0.08	0.15	0%	0%
	50 ppm	0.05	0.09	0.08	0.16	0.13	0.25	0%	0%
	100 ppm	0.09	0.18	0.16	0.31	0.25	0.5	0%	0%
	150 ppm	0.14	0.27	0.24	0.47	0.38	0.75	0%	1%
	250 ppm	0.23	0.45	0.39	0.76	0.63	1.3	0%	63%
	500 ppm	0.45	0.9	0.76	1.6	1.3	2.5	63%	100%
	1000 ppm	0.9	1.8	1.6	3.1	2.5	0.5	100%	100%
Boy 15 yrs	30 ppm	0.02	0.03	0.03	0.05	0.04	0.09	0%	0%
	50 ppm	0.02	0.06	0.04	0.09	0.07	0.14	0%	0%
	100 ppm	0.06	0.11	0.09	0.18	0.14	0.29	0%	0%
	150 ppm	0.08	0.17	0.13	0.26	0.21	0.43	0%	0%
	250 ppm	0.14	0.28	0.22	0.44	0.36	0.71	0%	0.3%
	500 ppm	0.28	0.56	0.44	0.88	0.71	1.4	0.3%	80%
	1000 ppm	0.56	1.1	0.88	1.8	1.4	2.8	80%	100%

For example: the probability of a 5 year old Chinese boy consuming a SO_2^* dose in excess of 0.7 mg/kg bw from the consumption of a 50g serving of abalone containing 250 ppm of SO_2^* is 37%.

Table 5 Modelled probability that the dose of SO_2^* consumed in a 100 g abalone serving would exceed 0.7 mg/kg bw for Chinese adults aged 40 years or older, for a range of SO_2^* concentrations

SO_2^* in Abalone (ppm)	Min Dose (mg/kg bw)	Mean Dose (mg/kg bw)	Max Dose (mg/kg bw)	Probability (%) Dose Exceeds 0.7 mg/kg bw
30 ppm	0.027	0.054	0.12	0%
50 ppm	0.05	0.09	0.2	0%
100 ppm	0.09	0.18	0.4	0%
150 ppm	0.14	0.27	0.59	0%
250 ppm	0.23	0.45	0.99	1.4%
500 ppm	0.45	0.9	2	87%
1000 ppm	0.9	1.8	4	100%

For example: the probability of a Chinese adult 40 years or older consuming a SO_2^* dose in excess of 0.7 mg/kg bw from the consumption of a 100g serving of abalone containing 250 ppm of SO_2^* is 1.4%.

EXPOSURE FOR SO_2-INTOLERANT INDIVIDUALS

No data are available to estimate exposure of SO_2^* in canned abalone among individuals who have a susceptibility to allergy-like adverse reactions to SO_2/sulphites. The amount of exposure among this group of people is dependent on the level of avoidance of canned abalone consumption.

For canned abalone purchased for home consumption, avoidance is straightforward for those who are aware that they have an intolerance of SO_2/sulphites, as the label indicates the presence of sulphur dioxide, sulphites and metabisulphites by the listing of the food additive number/name.

It is not known if there is any listing of food additives in restaurant menus of importing countries, but if this is not the case, avoidance of canned abalone by SO_2-intolerant individuals would depend on their own knowledge and vigilance, or in the case of children, that of their parents/guardians.

TOTAL DIETARY EXPOSURE

The acceptable daily intake (ADI) for SO_2^* is the total daily intake of SO_2^* from all foods consumed. Therefore the intake of SO_2* from an individual food needs to be considered in the context of the intake from all dietary sources. The Joint FAO/WHO Expert Committee on Food Additives (JECFA) has conducted an exposure assessment for sulphites with residue and dietary data submitted by Australia, Brazil, Germany and the USA, and from data in the literature for France, Italy, Lebanon and the UK (FAO-WHO, 2009). In Australia the main contributions to dietary intake of sulphites were from beef sausages, dried apricots and cordial in children, and in adults from white wine, beef sausages and dried apricots. The mean consumption for all groups did not exceed the ADI of 0-0.7 mg/kg bw, but for a small proportion of the population the ADI was exceeded. Data were not available to the JECFA exposure assessment from the countries that are the major importers of canned abalone, and the dietary composition in these countries will be different from those in the JECFA assessment.

RISK CHARACTERISATION

There was insufficient information in regard to a number of factors including the consumption patterns in the countries of import to determine quantitative estimations of risk; however qualitative risk characterisations are provided.

RISK CHARACTERISATION FOR SO_2-TOLERANT INDIVIDUALS

For canned abalone containing 30 ppm SO_2^*, a 100 g serving of abalone would contribute <25% of the maximum acceptable daily intake of SO_2^*, and for an adult of average weight (approximately 60 kg) the contribution would be 9% (Table 6). In addition to the likely infrequent consumption of abalone as a luxury food, it is unlikely that canned abalone containing 30 ppm SO_2^* would make a substantial contribution to the overall SO_2^* intake in the diet of people in the importing countries.

For the New Zealand black paua, if SO_2^* concentrations are in the range 500-1000 ppm, a single 100g serving would exceed the maximum ADI of SO_2^*, and for those with a low body weight the dose consumed would represent multiples of the maximum ADI (Table 6). For children in particular, intakes at these levels may not be advisable, though the deleterious effects of an infrequent intake of SO_2^* greater than the maximum ADI have not been determined.

Table 6 Proportion (%) of the maximum recommended ADI for SO_2^* (0.7 mg/kg bw) in a 100g serving of canned abalone, across a range of SO_2^* concentrations

Body Weight (kg)	Concentration of SO_2^* (ppm) in Abalone						
	30	50	100	150	250	500	1000
20	21%	36%	71%	107%	179%	357%	714%
30	14%	24%	48%	71%	119%	238%	476%
40	11%	18%	36%	54%	89%	179%	357%
50	9%	14%	29%	43%	71%	143%	286%
60	7%	12%	24%	36%	60%	119%	238%
70	6%	10%	20%	31%	51%	102%	204%
80	5%	9%	18%	27%	45%	89%	179%

For example, a person weighing 50 kg consuming 100 g of abalone with a SO_2^* concentration of 100 ppm, would intake 29% of the maximum recommended ADI for SO_2^*.

RISK CHARACTERISATION FOR SO_2-INTOLERANT INDIVIDUALS

Those most at risk from exposure to SO_2^* in foods are those who require steroidal medication to control their asthma, those with marked airway hyper-responsiveness and children with chronic asthma (WHO 1999, Vally et al, 2009). Due to the variation in responses among individuals and the variation associated with the characteristics of the food type, no dose-response relationship has been established between concentrations of SO_2^* in foods and adverse reactions in susceptible individuals. It is possible that there may be a minimum SO_2^* concentration in a given food that would not elicit an adverse reaction in the most SO_2-intolerant individual, but this would be difficult to establish for each food type and such studies have not been undertaken for SO_2^* in canned abalone. Such an approach has been utilised to establish regulations for SO_2 concentrations in air.

Susceptible individuals avoid the risk of an adverse reaction by avoiding the consumption of foods that contain sulphites.

There are no reports in the English scientific literature of adverse reactions from SO_2^* in canned abalone. The lack of reports may be due to one or more of the following reasons: (i) adverse reactions have not occurred, (ii) that reactions have occurred but have been mild and have not required medical attention, (iii) that reactions have occurred but have not been associated with the abalone component of the meal and the SO_2^* in the abalone, or (iv) that susceptible individuals are successfully avoiding the consumption of canned abalone.

The available evidence would suggest that the risk of adverse reactions from the consumption of canned abalone containing SO_2^* is low among susceptible individuals. However, it would be expected that increasing concentrations of SO_2^* in any food would be associated with an increasing risk of adverse reactions among those who are SO_2^*-intolerant and who do not avoid consuming those food types. While the risk can not be quantified WHO (1999) recommends reducing the levels of sulphites in foods where possible.

ACKNOWLEDGEMENTS

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APPENDICES

APPENDIX A: INDUSTRY SURVEY QUESTIONNAIRE

SARDI ABALONE CANNING QUESTIONNAIRE

All Australian abalone processors that produce canned products are requested to complete this questionnaire and return it by 12th August 2011.

The information provided will be used for 2 projects, described below, which are being undertaken by SARDI for the benefit of the Australian abalone processing industry. **All information collected will remain confidential (Please note, if you would like to have a formal confidentiality agreement with SARDI this can be put in place; please contact Cath McLeod (cath.mcleod@sa.gov.au) to arrange this if required).**

The participation of all canning processors in this survey will ensure the results of the projects are valuable and productive for all involved in the production of canned abalone.

Project 1: Marine Biotoxins in Canned Abalone (Funded by the Australian Seafood CRC)

SARDI will be undertaking experiments to see whether the canning process can reduce levels of marine biotoxins. In the unfortunate event of marine biotoxins being detected at levels above regulatory limits, this information may be able to be used to support the continued production of canned abalone. The information obtained in this survey will be used to design experiments that represent the canning processes used in the Australian industry but will not follow the processing parameters of individual companies, which will remain confidential. Enquiries: Dr Cath McLeod, SARDI Food Safety mobile: 0429 814 217, email: cath.mcleod@sa.gov.au

Project 2: Technical Abalone Access China (Funded by the Australian Seafood CRC)

Currently China does not have a regulation for sulphites in canned abalone, which can lead to trade failures if a 0 ppm level is enforced. A risk assessment will be undertaken of sulphites in Australian canned abalone. The risk assessment may be then used to negotiate with China on allowable sulphite levels in canned abalone and reduce the risk of trade failures in the future. For the risk assessment to be valuable in these negotiations accurate information on the processes used in the canning of Australian abalone, and the levels of sulphites/sulphur dioxide in final products are required. Information provided in the questionnaire will be collated and grouped to produce a description of the Australian industry, and information from individual companies will remain confidential and not be identifiable in the risk assessment. Enquiries: Dr Sue Dobson, Food Safety Risk Consulting mobile: 0457 803 757, e-mail: dobson_sue@bigpond.com

All information that you provide will be kept confidential

Please return the questionnaire by mail, fax, or scanned in an e-mail to:

Name: Jo Slade
Postal Address: 2b Hartley Grove, Urrbrae, Adelaide 5064
Fax: 08 8303 9424
E-mail: jo.slade@sa.gov.au

Please return by Friday 12th August

Government of South Australia

SARDI ABALONE CANNING QUESTIONNAIRE

Name of Company:____

Name of Contact Person:_____________________________________

Phone Number:____

Notes on completing the questionnaire:

This page of the questionnaire is designed to determine whether you use more than one canning process for different product types (e.g. different species of abalone, country of export). If this is the case in your factory, please fill in a separate copy of the questionnaire on pages 3-5 <u>for each process variation</u>. (So for example, if you use different concentrations of sulphites in different products, then please fill in a set of answers to the questions on pages 3-5 for each concentration used). An additional copy of the questionnaire is provided so that you can do this, please photocopy as required.

1. Do your canning processes vary for different abalone products?
   - □ Yes (Go to Question 2)
   - □ No (Go to next page)
2. What do your canning processes vary according to? *(please tick each box that is applicable)*
   - □ Different species
   - □ Different sizes
   - □ Where product is shucked (e.g. on boat/factory)
   - □ Country exported to
   - □ Other *(please describe)* ________________________

   Please provide answers to the questions on the following pages for <u>each process variation</u> used.

<u>Process Variation 1</u>

Product Name/Description: _______________________________________

Abalone Species: ____

Abalone Size (length): ____

Shucked on Boat/Factory/Other *(Circle one)*

Countries exported to:____

Please answer the following questions for this canned product type:

1. Are abalone fresh or frozen then thawed at the start of processing? If both, please indicate what percentage of your total canned product is in each format.

   Fresh _______%

   Frozen then thawed _______ %

2. What portions of the abalone are removed prior to canning? *(Please tick all that apply)*

   □ Viscera

   □ Mouth

   □ Other (*Please describe*) ______________________________

3. Is the pigmented layer of the foot removed by physical processes? *(Please tick)*

   □ Yes (Go to question 4)

   □ No (Go to question 5)

4. Which physical process(es) do you use to remove the pigmented layer? (*Please tick all that apply)*

   □ Rumbling

   □ Scrubbing

   □ Water blasting

   □ Trimming

   □ Other *(Please describe)* ______________________________

5. Do you use sulphites*/sulphur dioxide in the process? *(Please tick)* *sulphites include the food additives Sodium metabisulphite/ bisulphite/dithionate/sulphite, Potassium metabisulphite/bisulphite/sulphite (E220, E221, E222, E223 E224, E225, E228)

   □ Yes (Got to question 6)

   □ No (Go to question 9)

6. How do you apply the sulphite/sulphur dioxide to the abalone? (*Please tick all that apply*)

   □ Dipping

   □ Adding to the final brine in which the abalone is canned

   □ Other *(Please describe)*___________________________

7. What is the concentration of sulphites/sulphur dioxide in the final product after retorting?

   □ 0 ppm

   □ 1 to 30 ppm

   □ 31 to 100 ppm

   □ 101 – 300 ppm

□ 301 – 500 ppm

□ 501 – 1000 ppm

8. Please attach sulphite/sulphur dioxide testing results for May 2010, or if the product was not made in May 2010, the next month in which it was made.

9. Please name all other food additives included in the processing of this product.

	Name (e.g. citric acid)	Food Additive Code Number (e.g. E330)
1		
2		
3		
4		
5		

10. What temperature are the abalone when they are placed in the can (if there is a range of temperatures, please indicate minimum/maximum values)?

_______________ °C

11. What is the weight range (minimum/maximum) of the individual pieces of abalone that are placed in the can?

Weight of smallest piece = ________ g

Weight of largest piece = ________ g

12. What do you put in the liquid in the can with the abalone? *(Please tick each one used)*

□ Salt (sodium chloride)

□ Sulphite/Sulphur dioxide

□ EDTA

□ Other *(please name)* ____________________________

13. What is the pH of the liquid in the can (if known)?

Before retorting _________

After retorting _________

14. What is the time/temperature of the canning process?

Time: ________ minutes

Temperature: ________ °C

15. What are the 'start up' and 'cool down' time parameters?

‘start up’ time: ________ minutes

‘cool down’ time: ________ minutes

16. Amount of this product type produced in 2010

_____________kg

Comments on this Survey:

____

____

____

Please complete the set of questions for other product types

APPENDIX B: NOTES ON SO_2^* RISK MANAGEMENT IN COUNTRIES OF IMPORT

The countries that import canned abalone adopt a variety of approaches in their food safety regulations in regard to the range of foods to which it is permissible to add sulphur dioxide/sulphites and the maximum levels of SO_2^* permitted in those foods. The maximum levels permitted in canned fish and canned abalone in the major importing countries are summarised in Table 7.

CHINA

China's national standard for food additives is the "Hygienic Standard for the Use of Food Additives". An unofficial translation of the 2007 version of this standard (GB-2760-2007) shows that addition of sulphur dioxide/sulphites is limited to 20 categories of foods. Sulphur dioxide/sulphites are not permitted to be added to any meat or fish products, including canned abalone (USDA, 2008). A revised version of the standard was published by China in 2011 (GB-2760-2011). An unofficial translation of GB-2760-2011 obtained for this assessment indicates the range of food categories to which the addition of sulphur dioxide/sulphites is permitted has increased to 26, but as in the 2007 version of the standard no meat or fish product, including canned abalone, is permitted to contain added sulphur dioxide/sulphites.

HONG KONG

Hong Kong's food regulations permit addition of sulphur dioxide/sulphites to a much wider range of foods than China, including a range of seafood products and processed meat products. The permitted levels in canned fish (150 ppm) and canned abalone (1,000) reflect those in the Codex Alimentarius Commission's General Standard of Food Additives.

SINGAPORE

Singapore's food regulations permit the addition of sulphur dioxide/sulphites to a wider range of foods than China, but like China, sulphur dioxide/sulphites are not permitted additives in any seafood products including canned abalone.

JAPAN

Japan adopts a management strategy of permitting an SO_2^* concentration of <30 ppm in most foods including canned abalone. The addition of sulphur dioxide/sulphites is not permitted in only a small range of foods (legumes/pulses, sesame seeds, vegetables), and specified levels >30 ppm are permitted in a very limited range of foods.

TAIWAN

The approach in Taiwan is similar to that of Japan. A small number of foods are permitted to have SO_2^* concentrations in excess of 30 ppm, but with a few exceptions most processed foods, including canned abalone, are permitted to have SO_2^* concentrations <30 ppm.

USA

In the USA food safety regulations sulphur dioxide/sulphites are "Generally Recognised As Safe (GRAS)" with some exceptions. Food additives that are GRAS are permitted to be used under conditions of good manufacturing practice. The food categories which are exceptions, and to which it is not permitted to add sulphur dioxide/sulphites are meat; foods recognised as a source of Vitamin B1; fruits and vegetables intended to be served raw to consumers or sold raw to consumers, or to be presented to consumers as fresh.

CANADA

Canada's food safety regulations identify a range of foods to which it is permitted to add sulphur dioxide/sulphites and the maximum permitted levels in those foods. Canned sea snails (all species of class Gastropoda) are permitted to have a maximum SO_2^* concentration of $\leq$ 100 ppm. Abalone is a species of the class Gastopoda.

AUSTRALIA

Australia's food safety regulations identify a range of foods to which it is permitted to add sulphur dioxide/sulphites and the maximum permitted levels in those foods. Sulphur dioxide/sulphites additions are permitted to some processed meat products and some seafood products. Canned fish is permitted to have a maximum SO_2^* concentration of $\leq$30 ppm, and canned abalone (paua) is permitted to have a maximum SO_2^* concentration of $\leq$1,000 ppm.

CODEX ALIMENTARIUS COMMISSION (CAC)

The CAC's General Standards of Food Additives includes 56 food categories to which sulphur dioxide/sulphites can be added and the maximum levels of SO_2^*. The maximum concentration in canned fish is 150 ppm, and 1,000 ppm in canned abalone (paua). The Codex Committee on Food Additives (CCFA) is currently reviewing maximum levels of sulphites, particularly in food categories that are major contributors to SO_2^* exposure in some sub-populations. Recommendations of a working group were considered at the 43rd Session of the CCFA (Xiamen (Fujian Province), China, 14-18 Mach 2011), but did not contain any proposals to change the maximum levels of SO_2^* for canned fish or canned abalone.

Table 7 Maximum levels of SO_2^* (ppm) permitted in canned abalone in countries of import[d]

Food Category	China	Hong Kong	Singapore	Japan	Taiwan	USA	Canada	Australia	CAC[a]
Canned Fish	0	150	0	30	30	Not specified[b]	300[c]	30	150
Canned Abalone	0	1,000	0	30	30	Not specified[b]	100	1,000	1,000

a. CAC = Codex Alimentarius Commission, General Standards of Food Additives.
b. In the USA, addition of sulphites in most foods is generally recognised as safe (GRAS).
c. Flaked tuna only.
d. English translations of regulations in Indonesia, Thailand, Malaysia, Vietnam and Korea could not be accessed.

APPENDIX C: IMPACT OF RETORTING ON SO_2^* IN CANNED ABALONE

The purpose of this investigation was to provide an indication of the impact of retorting on the SO_2^* concentration in canned abalone, over a range of SO_2^* concentrations.

METHOD

The processing and retorting of the abalone was undertaken at a commercial abalone processing facility. The live abalone, a farmed hybrid species, were killed in an ice-water slurry, shucked, machine rumbled and hand scrubbed to remove pigment. The abalone was dipped in metabisulphite solutions of various concentrations and for various periods of time to achieve a range of SO_2^* concentrations (Treatments 1-3). Treatment 4 was the metabisulphite treatment applied to a commercial batch of the farmed hybrid species. The metabisulphite concentrations in the dipping solutions and the dipping times cannot be disclosed for commercial reasons.

Following dipping the abalone were sorted and placed in cans; the cans were filled with brine and lidded. Pre-retort samples were taken. The remaining canned abalone was retorted to achieve commercial sterility and samples were taken the following day. The samples of canned abalone were drained of brine and the abalone meat homogenised. The homogenates were frozen, and transported to DTS Technical Services Ltd (DTS, Kensington, Victoria) for analysis. DTS thawed the homogenates, mixing in any thaw drip, and determined their pH and SO_2^* concentrations.

RESULTS AND CONCLUSIONS

The mean pH of the pre-retort samples was 6.2 (range 6.1-6.3, SD=0.1) and the mean pH of the post-retort samples was 6.3 (range 6.1-6.4, SD=0.1). The results indicate minimal pH variation in abalone meat in association with the SO_2^* concentrations examined or heating.

The results did not indicate a reduction in SO_2^* concentrations associated with retorting, suggesting that heat does not cause irreversible binding of the SO_2^* in abalone meat. The mean levels of SO_2^* were higher post-retorting, but the sample sizes were not large enough to determine if this was a significant difference. Any increase in SO_2^* concentration may be absorption associated with either/or the heat treatment or the 24 hour time difference between pre-retort and post-retort sampling.

Table 8 Mean SO_2^* (ppm) in abalone pre- and post-retorting for 4 metabisulphite treatments

Treatment No	Pre-Retort Samples			Post-Retort Samples		
	n	Mean SO_2^* (ppm)	SD[a] (ppm)	n	Mean SO_2^* (ppm)	SD (ppm)
1	3	<10	nd[b]	3	<10	nd
2	3	42	6	3	73	7
3	3	197	31	3	253	15
4	6	49	8	6	54	6

a. SD=standard deviation; b. nd=not determined

APPENDIX D: SIMULATION MODELLING OF THE WEIGHT OF CHINESE CHILDREN (5, 10, 15 YRS) AND ADULTS (40+ YRS)

CHILDREN

Survey data for the weights of Chinese children were not directly accessible. Growth charts of the weights of Chinese boys and girls were found at a website containing information for people who have adopted Chinese children (http://fwcc.org/index.php?option=com_content&view= article&id =301:growth-charts-for-chinese-children&catid=15:health&Itemid=23). The data presented in graphical form on this website was from a translation of an article by Li et al, 2009[4], which is also referenced in the NCBI PubMed database (http://www.ncbi.nlm.nih.gov/pubmed/) . The 3rd, 50th and 97th percentiles of body weights for boys and girls aged 5, 10 and 15 years were measured from the graphs (± 1 kg). Cumulative distributions for the weights of boys and girls were defined using the 3rd, 50th and 97th percentiles, and minimum and maximum weights estimated by the author (Table 9).

The weights of Chinese children were modeled by simulation in @Risk 5.5 (Palisade Corporation) using cumulative distributions (100,000 iterations). These were applied to estimate the minimum, mean and maximum SO_2^* doses (as mg/kg bw) and the % doses exceeding 0.7 mg/kg bw for abalone servings of 50g and 100g across a range of SO_2^* concentrations.

Table 9 Parameters of the cumulative distributions used to model the weights of Chinese children

	Age (yr)	Body Weight (kg)					
		3rd Percentile (± 1 kg)	50th Percentile (± 1 kg)	97th Percentile (± 1 kg)	Minimum[a]	Maximum[a]	Mean[b]
Girls	5	15	18	23	11	29	21
	10	23	32	47	20	52	47
	15	38	50	66	32	74	54
Boys	5	15	19	24	10	30	26
	10	24	34	50	20	55	38
	15	42	57	80	35	90	45

a. Estimated by the author.
b. Estimated from simulation modeling.

ADULTS

Some survey data were available for the weights of Chinese adults aged 40+ (Gu et al, 2006). These data were available as means and standard deviations for 10 Body Mass Index categories. Normal distributions were used to model the weight of adults for each category and the minimum and maximum weights for each category were estimated as 3 x standard deviations (SD) below and

[4] Li, H.*, Ji C. Y., Zong X. N., Zhang Y. Q. 2009 Height and weight standardized growth charts for Chinese children and adolescents aged 0 to 18 years. *Zhonghua Er Ke Za Zhe (Chinese Journal of Pediatrics)* **47**:487-92. [Article in Chinese] *Department of Growth and Development, Capital Institute of Pediatrics, Beijing 100020, China.

above the mean value (Table 10). A discrete distribution was used to model the proportion of the survey sample (n=154,736) in each category. The weights of Chinese adults were modeled by simulation in @Risk 5.5 (Palisade Corporation) using the normal and discrete distributions (100,000 iterations). These were applied to estimate the minimum, mean and maximum SO_2^* doses (as mg/kg bw) and the % doses exceeding 0.7 mg/kg bw for abalone servings of 100g across a range of SO_2^* concentrations.

Table 10 Parameters applied to distributions to model by simulation the weights of Chinese adults (40+)

Category ID	Proportion of Sample (n=154,736)	Mean Body Weight (kg)	SD (kg)	Minimum[a] (kg)	Maximum[b] (kg)
1	0.116	42.8	5.9	25.1	60.5
2	0.134	49	5.6	32.2	65.8
3	0.111	52.6	5.9	34.9	70.3
4	0.113	55.3	6.2	36.7	73.9
5	0.108	58.1	6.5	38.6	77.6
6	0.095	61	6.6	41.2	80.8
7	0.086	63.6	6.9	42.9	84.3
8	0.119	67.6	7.5	45.1	90.1
9	0.085	72.7	8.1	48.4	97
10	0.033	80.3	10.1	50	110.6

a. Estimated by the author as the mean minus 3xSD.
b. Estimated by the author as the mean plus 3xSD.