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ORIGINAL ARTICLE

Sulfites in the Filipino Diet: A Dietary Exposure Assessment Using the Harmonized Philippine Food Consumption Database

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KEYWORDS

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ABSTRACT: This study aimed to update the current consumption database for dietary exposure assessment based on the 2019 browser version of FoodEx2 – the internationally recommended harmonization tool for food code assignment. The updated food consumption database was utilized to estimate the dietary exposure of Filipinos to sulfites, a widely used food additive. A total of 1,541 food items were re-coded using the new FoodEx2 catalog browser. The dietary exposure assessment indicated that Filipinos' sulfite exposure varies from 27% to 109% of the Allowable Daily Intake (0.7 mg kg^{-1}) for mean and high-level per capita consumption, respectively. Water-based beverages were the main contributor to sulfite exposure across all ages and gender groups. In general, infants and children were highly exposed to sulfites compared with the adults due to their relatively low average body weight. An internationally harmonized national food consumption database in the Philippines was therefore developed, which can provide detailed food information that can assist in facilitating the national, regional, and international agricultural and food programs of food safety.

INTRODUCTION

The worldwide approach to dietary exposure assessment (DEA) is conducted to measure the likelihood of the adverse effects of a specific food hazard upon excessive consumption or intake. When assessing risk, one key aspect to take into account is data on food consumption. This data serves as vital indicator of how much food or beverages are being consumed by individuals or groups within a population. It is generated from a national consumption survey or approximates from food production statistics. Conduct of international dietary exposure assessment requires harmonization of consumption data among participating countries including data collection, sampling plans, dietary method, population groups, and age categories. The initiative for worldwide standardization of food consumption data is led by a partnership between the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) based in Italy. FAO and WHO started their harmonization efforts with the use of the FoodEx2 classification system - a tool used for describing and classifying foods [1].

FoodEx1, developed by the European Food Safety Authority (EFSA) in 2011, consists of 25 facets designed to describe food in data collections related to different areas of food safety. [2]. Facets are used to add further detail to the information provided by the food list term. FoodEx2, launched in 2015, is a revised and enhanced food classification and description system featuring 32 different facets. Additional features were incorporated to assist users in easily comparing food consumption

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information from various sources. [1,3]. New functionalities have been added to help users effortlessly compare food consumption data from different sources from 2016 to 2018. [4]. The existing version features eight levels, including the master hierarchy (which encompasses the complete terminology and is specifically designed for technical management) to oversee the terminology, along with the reporting hierarchy, exposure hierarchy, pesticide residues hierarchy, zoonoses hierarchy, feed hierarchy, veterinary drug residues hierarchy, and botanicals hierarchy. The continuous changes in the food market will be the basis for further updating and regular maintenance of the FoodEx2 system.

The Chronic Individual Food Consumption Database-Summary Statistics (CIFOCOss) serves as a resource offering individual food consumption data for dietary exposure assessments conducted by the FAO/WHO scientific committees. Accessible online, it includes summary statistics from food consumption surveys across 26 countries, encompassing all age demographics, organized into harmonized categories. [1, 5]. The database is continuously being updated with individual food consumption data from additional surveys for use in harmonized dietary exposure to all chemical hazards including veterinary drugs, pesticide residues, food additives, and contaminants. In 2018, the Member States were called to provide updated data to improve the accuracy of the shared information in the database [6]. The second call included the following: (1) Mapping of the Codex classification with the FoodEx2 Classification as recommended by Joint FAO/WHO Expert Committee on Food Additives (JECFA), (2) Separate statistics for males and females, and (3) Separate statistics for different age groups with the recommendation from JECFA. The FAO/WHO CIFOCOss utilizes FoodEx2 as the food categorization and description system [6].

In support to international harmonization efforts, the Department of Science and Technology - Food and Nutrition Research Institute (DOST-FNRI) aimed to develop a national food consumption database harmonized with EFSA FoodEx2 classification system and categorized in the FAO/WHO CIFOCOss template for dietary exposure assessment. The harmonized FCD was then applied in the estimation of sulfite exposure of Filipinos from commonly consumed foods. Sulfites are utilized as food additives for various purposes, including the inhibition of microbial growth, color enhancement, bleaching, antioxidation, and removal of oxygen [7]. Ingesting sulfites has been linked to negative outcomes and toxic reactions, such as triggering asthma attacks and causing allergic symptoms like skin rashes and irritation in those who are sensitive to sulfites [8].

MATERIALS AND METHODS

The development of the harmonized food consumption database for use in dietary exposure assessment (FCD-DEA) involved food mapping of the Philippine commonly consumed food items using the FoodEx2 classification system, categorization, and statistical processing based on the data requirements of the FAO/WHO CIFOCOss. The exposure of Filipinos to sulfites was assessed for the pilot application of the updated database.

Food mapping using foodEx2 classification system

The harmonization of the food consumption data in the Philippines was conducted by describing and coding of food items from the 8th National Nutrition Survey (NNS) in 2013 using the FoodEx2 catalog browser version 1.2.5 (9.8 MTX FoodEx2 Matrix). Collaborative work of the Food Quality and Safety Section (FQSS) and the Nutrition Monitoring and Assessment Division (NAMD) from DOST-FNRI initiated the coding of food items using the FoodEx2.

The FoodEx2 catalogue browser was used to navigate and assign FoodEx2 code with translation to each PhilCode food item. FoodEx2 follows a systematic way of describing and categorizing foods to facilitate harmonization between datasets. Food groups were classified based on 3 hierarchical levels. Level 1 is the most aggregated (e.g. Fruits and fruits products) and it is not appropriate for reporting. Level 2 is intermediate (e.g. Berries and other small fruits) and level 3 the most precise, designating the items by a name (e.g. Blueberries) and a code. Codification in FoodEx2 uses 32 facets to describe a characteristic and to provide additional information on a specific food item. The facets that are already assigned to the food item are known as

the implicit facets while the assigned facets during coding of the food item in the catalogue browser are known as the added facets. After the codification, the assigned FoodEx2 codes were checked, verified, and finalized. During the team discussion, some comments and difficulties encountered while using the FoodEx2 catalogue browser per food item codified or mapped were listed down. The finalized coded food items against the FoodEx2 along with the comments and remarks were sent to FAO/WHO to verify mapping suggestions or modifications in codes, if applicable. The final codes were agreed upon by the FAO and FNRI team through thorough deliberations and constant communications.

Categorization into the FAO/WHO CIFOCOss template

The re-coded food items were categorized into 20 level 1 food groups in the FAO/WHO CIFOCOss template. For food items with unavailable specific detailed categories in the template, categorization was conducted in the closest generic item of the food item including the term "nes". The CIFOCOss data can be accessed at the WHO website.

Food consumption data processing

The FoodEx2-coded food items were integrated and harmonized into the FAO/WHO CIFOCOss template and were forwarded to the NAMD for descriptive statistical processing that includes percentiles parameters. Food consumption statistics were both processed for the Whole group (Consumers and Non-Consumers) and the Consumers only based on eight (8) age groups and gender classification.

Sulfites dietary exposure assessment

A total of fifty-six (56) food categories from the General Standard for Food Additives (GSFA) Codex Stan 192-1995 were allowed to contain sulfites with maximum levels ranging from 15 up to 1000 mg kg^{-1} [10]. The commonly consumed Philippine food items based on the 2013 National Nutrition Survey (NNS) were then mapped under each of the GSFA food categories according to the definition and description of each category within the standard.

The data on food consumption used in this study was sourced from the Philippine food consumption database, aligned with CIFOCOss standards, and included responses from 19,831 participants. On the other hand, the maximum levels of sulfites used in this study were also based on GSFA Codex Stan 192-1995.

The dietary exposure of Filipinos to sulfites in commonly-consumed foods was assessed using the Theoretical Maximum Daily Intake (TMDI) approach. The TMDI was calculated by multiplying the maximum level of foods containing sulfite by the daily food intake per capita and then summing the products. The sum of the products was then divided by the average body weight of the population group as shown in the equation below [11]:

$$\text{Dietary exposure} = \frac{\sum(\text{Concentration of food contaminant in food x food consumption})}{\text{Body weight (kg)}} \quad (1)$$

For the estimation of TMDI for extreme intake, the average per capita food intake from the highest food contributor was replaced with the 95th per capita intake of same food contributors modified from the methods detailed in the guidelines for the conduct of simple dietary exposure assessment since the high-level consumption per capita were known [11,12]. The average body weights used in the exposure calculation was based on the Philippine Dietary Reference Intake [13]. The estimated dietary exposure levels were compared to the acceptable daily intake (ADI) for sulfites, which is set at 0.7 mg per kg of body weight, to assess the risk of sulfite exposure among Filipinos.

RESULTS

Food mapping using foodEx2 classification system

Table 1 shows the sample coding using FoodEx2 for Philippine food items.

Table 1. Example of the coding system using FoodEx2

PhilCode	Philname	FoodEx2 Code	FoodEx2 Translation
A019	Rice, well-milled	A003D	Rice grain, polished
A020	Rice, well-milled, boiled	A003D#F28.A07GL	Rice grain, polished, PROCESS = Boiling
A021	Rice, well-milled, fried	A003D#F28.A07GL$F28.A07GR	Rice grain, polished, PROCESS = Boiling, PROCESS = Frying

Whereas, the problems encountered during the codification of food items with FoodEx2 are summarized in Table 2. Some food items were not available in the browser and difficulties to further describe these food items were encountered due to the limit of available options. The facet "Generic-term" was used to indicate the absence of the description of a food item.

Table 2. List of food items that are difficult to code in the FoodEx2 browser

PhilCode	Philippine Name	Remarks
A072	Chips, corn, taco flvr	no facet descriptor for Taco flavour
G223	Tuna, adobo, cnd	no facet descriptor for Adobo flavour
G228	Tuna, mechado, cnd	no facet descriptor for Mechado flavour
H015	Egg, duck, century	no facet descriptor for fertilized egg
H016	Egg duck, fertilized, boiled	
H017	Egg, duck, fertilized, embryo	
H018	Egg, duck, fertilized, white	
H019	Egg, duck, fertilized, yolk	
H020	Egg duck, infertile, boiled	
A075	Chips, prawn crackers	no facet descriptor for prawn flavour
A076	Chips, prawn crackers, flvrd	
A121	Curls, prawn flvr	
E041	Lemon rind	no direct term for lemon rind used as an 'Ingredient'
F119	Duck gizzard	no facet descriptor for gizzard
F153	Pork Boston butt	no facet descriptor for butt
F189	Pork uterus	no facet descriptor for uterus
G224	Tuna fillet, in soya oil, cnd	no available descriptor for Soya oil under the facet 'Surrounding medium'
T008	Rice washing	no direct term for rice washing to be used as an 'Ingredient'
A079	Chips, squid crackers	no facet descriptor for squid flavour
Q057	Soy drnk, pwdr, pandanflvr	no facet descriptor for pandan flavour
A088	Cookies, camachili	no direct term for baking soda to be used as an 'Ingredient'
A179	Rice cake, cuchinta	no direct term for lye water to be used as an 'Ingredient'
A196	Rice water, ckd, thin	no direct term for rice water to be used as an 'Ingredient'
E102	Banana, saba, w/ sugar, wrapped, fried	no direct term for spring roll wrapper to be used as an 'Ingredient'
B039	Yam, nami, dried	No available base term for dried root crops
C009	Coconut sport	No available base term for coconut sport
D056	Niyogtumbong - Coconut (*Cocos nucifera*) cotyledon	No available base term for coconut cotyledon
C066	Taho, w/ arnibal& sago - Soybean curd/ Geerlig's cheese w/ syrup & sago	no direct term for sago (tapioca starch ball) to be used as an 'Ingredient'

Categorization into the FAO/WHO CIFOCOss template

The limitation on the availability of categories for the food items was encountered in this study that resulted to categorization to the closest generic item including the term "not elsewhere specified" ("nes") or insertion under

the category "other food" at the end of the template [6]. During the checking for finalization of the assigned categories in the FAO/WHO CIFOCOss template, some suggestions were listed (Table 3).

Table 3. List of suggestions generated after the food categorization in the FAO/WHO CIFOCOss template.

Suggestions
▪ add pulses, legume-based snacks and processed legumes
▪ the pulses (dried) must be separated from legumes (fresh)
▪ add more level 3 items under grain and grain-based products and fine bakery wares
▪ add flavoured milks/dairy products
▪ add candied fruit under the processed fruit products
▪ add baking powder, which is a common ingredient for bakery product
▪ add rice cake, common snacks in Asian countries
▪ add glutinous rice flour, common ingredients for rice cakes
▪ add descriptors for instant foods
▪ addition of capacity of ingredients (currently max at 20) for processed food items having more than 20 ingredients in the nutrition panel

Food consumption data processing

The developed FCD database for the exposure assessment of Filipinos was designed based on the required information of each food category from the NNS (Table 4). This process included worksheets that were analyzed statistically by NAMD, focusing on the food consumption patterns of the entire population as well as specific age and gender groups within the Philippines. Whole group refers to the total number of respondents surveyed, whereas consumers refer to the respondents that consumed the food item of interest. The processed food consumption data were expressed in grams per day (g day^{-1}) as preparation for the conduct of dietary exposure assessment.

Table 4. Information to be extracted from the NNS for each food category

Population parameters	Statistical data extracted	
	Whole group	**Consumers only**
Population group	Number of subjects	Number of consumers
Age group	Mean Consumption (g day^{-1})	Mean Consumption (g day^{-1})
Sex (Females / Males)	Standard Deviation	Standard Deviation
	Median Consumption (g day^{-1})	Median Consumption (g day^{-1})
	5^{th} Percentile Consumption (g day^{-1})	5^{th} Percentile Consumption (g day^{-1})
	95^{th} Percentile Consumption (g day^{-1})	90^{th} Percentile Consumption (g day^{-1})
		95^{th} Percentile Consumption (g day^{-1})
		97.5^{th} Percentile Consumption (g day^{-1})

The development of a harmonized food consumption database has limitations due to differences among cultures and dietary patterns. In this study, certain difficulties were encountered specifically in the mapping using the FoodEx2 classification system and categorization with the FAO/WHO CIFOCOss as shown in Table 5.

Table 5. Problems encountered and corresponding actions taken

Problems encountered	Solution
No available facet descriptor in the FoodEx2 catalog browser	▪ Selected the closest food group and selecting [F26] - Generic term as the facet. ▪ List of the facets were sent to FAO/WHO for inclusion in the FoodEx2 browser
No available base term specifically for local food items in the FoodEx2 catalog browser	▪ Selected the closest base term ▪ Forwarded list of local food items to FAO/WHO for inclusion in the FoodEx2 browser
Regular updating and maintenance of the FoodEx2 catalog browser	▪ Checked for updated version the browser ▪ Recoded the food items using the updated version of the FoodEx2 catalog browser
Limited level 3 item in the FAO/WHO CIFOCOss template	▪ Chose the closest generic term including the term "nes"

Statistical processing of food consumption data through percentiles indicates the percentage of subjects that consume below that percentile. For the whole group, the percentile indicates the percentage of the subjects that consume below that percentile within the whole population of the study [6]. On the other hand, the percentile of the consumers only indicates the percentage of consumers who consume below that percentile [6].

Sulfites dietary exposure assessment

Around 538 Philippine food items were mapped into the 42 sulfite-containing food categories of the GSFA. The estimated TMDI of Filipinos to sulfites in commonly-consumed food is presented in Table 6 expressed as mg sulfites daily (mg day^{-1}), mg sulfites per kilogram body weight daily (mg kg^{-1} bw day^{-1}), and as a percentage of the acceptable daily intake (%ADI) as the hazard index (HI). The Acceptable Daily Intake (ADI) is described as the estimated quantity of a substance in food that can be safely consumed each day throughout a person's life without significant health risks to the individual. [15]. The Joint FAO/WHO Expert Committee on Food Additives (JECFA) has established an upper limit for dietary exposure to sulfites of 0.7 mg sulfites per kilogram body weight (mg kg^{-1} bw).

Table 6. Estimated Theoretical Maximum Daily Intake (TMDI) of Filipino population to sulfites from commonly-consumed foods based on the mean and high-level consumption per capita

Philippine Population		Exposure data					
		mg per day		mg per kg daily		% ADI	
Age group	Gender Group	Mean	95th	Mean	95th	Mean	95th
Total population (0- >75 y)	Female & Male	18	37	0.32	0.68	46%	97%
	Female	16	32	0.30	0.62	44%	89%
	Male	20	39	0.34	0.67	49%	95%
Infants (0-35 mos)	Female & Male	6	6	0.65	0.70	93%	100%
	Female	5	9	0.64	1.11	91%	158%
	Male	6	5	0.65	0.53	93%	76%
Young children (3-5 y)	Female & Male	12	25	0.71	1.46	102%	209%
	Female	11	25	0.66	1.45	94%	207%
	Male	13	27	0.76	1.52	109%	217%
Children (6-14 y)	Female & Male	16	31	0.47	0.88	68%	126%
	Female	16	29	0.47	0.83	67%	119%
	Male	17	32	0.48	0.93	68%	132%

	Female & Male	22	44	0.41	0.81	58%	115%
Adults (15-49 y)	Female	18	37	0.35	0.71	50%	101%
	Male	25	48	0.42	0.80	60%	114%
	Female & Male	20	39	0.36	0.70	52%	100%
Adults (15-75+ y)	Female	17	36	0.33	0.69	47%	98%
	Male	24	45	0.39	0.75	56%	108%
	Female & Male	16	29	0.29	0.51	42%	73%
Young old (50-74 y)	Female	14	27	0.26	0.51	38%	72%
	Male	19	32	0.32	0.53	46%	75%
	Female & Male	11	24	0.20	0.42	29%	60%
Elderly old (> 75 y)	Female	10	24	0.19	0.46	27%	66%
	Male	13	25	0.22	0.42	31%	60%

*mos = months; y = years

Figure 1, meanwhile, visually showed the hazard index (HI), expressed as %ADI, which measures the risk of the Filipinos to the negative effects of sulfites when taken in excess. The higher the levels compared with the ADI, the greater the risks for detrimental health effects caused by high sulfite exposure.

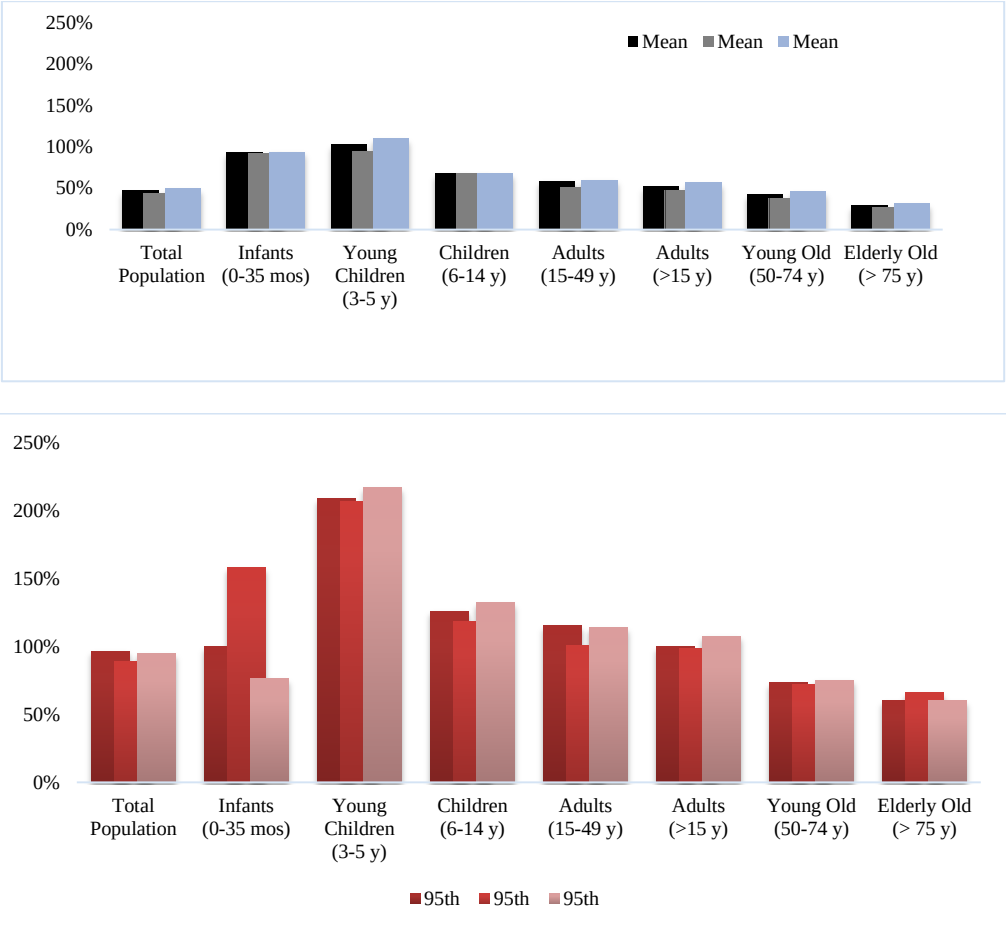

Figure 1. Estimated theoretical maximum daily intake of Filipinos to Sulfites from commonly-consumed foods, expressed as % of Acceptable Daily Intake (ADI) of 0.7 mg per kg of body weight daily.

Table 7 illustrates the percentage share of various food categories in relation to sulfite exposure across different age and gender groups in the Philippines.

Table 7. Major food group contributors to sulfites and their % mean contribution per age and gender group

Age group	Gender group	% Mean contribution					
		GSFA food groupings					
		Water-based flavoured drinks	Dried vegetables, seaweeds, and nuts and seeds	Fruit nectar	Distilled spirituous beverages containing more than 15% alcohol	Sauces and like products	Fine bakery wares (sweet, salty, savoury) and mixes
Total papulation (0 - >75 years)	F&M	31	13	7	7	6	5
	F	32	13	8	1	7	6
	M	30	12	6	11	5	4
Infants (0-35 months)	F&M	17	9	19	-	7	14
	F	18	9	19	-	7	13
	M	16	10	18	-	7	14
Young children (3-5 years)	F&M	24	7	20	-	7	11
	F	22	8	19	-	7	11
	M	25	7	20	-	6	11
Children (6-14 years)	F&M	28	12	13	-	7	7
	F	26	12	14	-	8	7
	M	30	12	12	-	7	7
Adults (15 - 49 years)	F&M	34	13	4	9	6	3
	F	36	14	6	1	7	4
	M	33	12	3	14	5	2
Adults (15 - 75+ years)	F&M	33	13	4	9	6	3
	F	34	14	6	1	7	4
	M	31	13	3	15	5	0
Young old (50 - 74 years)	F&M	26	16	3	0	6	5
	F	30	16	5	<0	6	5
	M	22	15	3	21	4	3
Elderly old (>75 years)	F&M	19	17	6	3	6	5
	F	23	18	9	<0	6	5
	M	15	15	3	5	5	5

*F&M - Female and Male; F- Female; M-Male

DISCUSSION

In 2017, the food items from the 2013 NNS were initially coded by the FQSS and NAMD of DOST-FNRI using the FoodEx2 classification and description system. Continuous review and re-coding of these food items

with the updated version of the browser were conducted due to the regular maintenance of the FoodEx2 system by EFSA. In 2020, a total of 1,541 food products were assessed and reclassified with the help of the most recent version of the FoodEx2 browser. Additional food items from NAMD were also coded and checked. The project team revisited and re-coded the food items in three batches which were sent to FAO for checking and comments. The FAO checked, verified, and proposed codes for some food items.

From the Master Hierarchies present in FoodEx2 revision 2 browser, the food items were mapped under the "Exposure Hierarchy." The said hierarchy facilitates the grouping of food items for exposure calculations and prefers reporting of food consumption data [1]. The browser consists of 4,445 entries, incorporating 134 hierarchy terms and 4,311 terms that can be reported. It is organized into six levels with 21 groups at the highest level.

The FoodEx2 coding system utilizes a single string format that incorporates the mandatory assignment of various coded information, each followed by a hashtag "#". Additionally, it allows for an indefinite series of facets, with each facet separated by a dollar sign "$". For example, the food item with a PhilCode of A019 designated for Rice, well-milled has a code already existed in FoodEx2 as A003D (Table 1). When extra details are provided in the food description, for instance, in A020 - Rice that is well-milled and boiled, the corresponding FoodEx2 code will be A003D#F28.A07GL. The code contains information that Rice, well-milled (A003D) and PROCESS = Boiling (F28.A07GL) separated by the hashtag (#) sign. The hashtag sign is used to separate base terms and added facets. Another example is the A021- Rice, well-milled, fried. It was recoded as A003D#F28.A07GL$F28.A07GR. The code contains information of Rice, well-milled (A003D) and PROCESS = Boiling (F28.A07GL), and PROCESS = Frying (F28.A07GR). The added facets were separated by a dollar ($) character.

Assignment of codes or mapping using the FoodEx2 is subjectively and manually conducted based on the best judgment of the user [14]. However, in this study, standard operating procedure (SOPs) was first established to serve as a guideline in FoodEx2 codification. The basis for the codification involves the properties of the food item such as consumption details, ingredients, packaging, intended consumers, among others. The description of the food items was derived from the Philippine Food Composition Tables, market surveys, interviews, and research. The describe feature in the FoodEx2 browser was used thoroughly in describing and generating complex codes using facets, which added more detail to the information associated with the food list term [3,4]. This food mapping using FoodEx2 enabled the Philippines to describe a large number of individual food items aggregated into food groups and broader food categories. Moreover, the access to the core list of food items or generic food descriptions as was demonstrated to be the fundamental level of detail required for assessing intake or exposure while the extended list was used for the more detailed terms. A parent-child relationship exists between a core list food item and its related extended list food items.

Categorization into the FAO/WHO CIFOCOss template

After the finalization of the assigned categories, nine (9) worksheets were prepared. The first worksheet is entitled "Presentation" where all the information about the survey should be declared such as general information, food report's detail, institutional information, population information, survey details, results, and average body weight of the population. The next eight worksheets were filled with food consumption data, and were classified by age group (Whole population, Infants 0-35 months, Young children 3-5 years, Children 6-14 years, Adults 15-49 years, Young old 50-74 years, Elderly >75 years, All adults >15 years).

The FAO/WHO CIFOCOss currently contains summary statistics from 37 food consumption surveys conducted for a duration of at least 2 days from 26 countries (including 17 EU countries). It was initially developed to be used by FAO/WHO scientific committees for dietary exposure assessment. It provides summary statistics at 3 levels of food categorization for a total of about 500 items presenting the mean, standard deviation, high and low percentiles (P5, P10, P50, P90, P95) in total population and consumers only at a refined level of food

categorization. CIFOCOss is being regularly updated using information gathered from new surveys. The current food categorization follows FoodEx2 classification as an internationally recognized classification system as shown in CIFOCOss template.

Processing of food consumption data

The development of a harmonized food classification and food consumption database at the national level in the Philippines allows the food safety authorities to provide a representation on the assessment of risk at the international level against other ASEAN consumers countries. Harmonization of data contributes significantly to the overall goal of safeguarding consumers in accordance with food safety regulations. It also supports organizations like FAO/WHO risk assessments bodies, in particular the JECFA and JMPR. The participation of DOST-FNRI to the harmonization of food consumption data may support the regional food safety strategy with ASEAN and above, in the context of the Codex Alimentarius. The harmonized classification with FoodEx2 allows the Philippines to contribute to the discussions among ASEAN countries and the international community and to allow access to the international trade market for food commodities produced in the region. The disaggregated food consumption data by sex and age assist in the dietary exposure assessment to food safety hazards, identify the main source of food hazards, and conduct efficient risk analysis. With the impact of the data harmonization to comparison among and across time intervals, seasons, and geographical locations, the generated and collected individual food consumption data at the national level can be utilized internationally.

Sulfites dietary exposure assessment

Results showed that the mean daily exposure of the Filipino total population to sulfites from 2013 commonly-consumed foods was at 0.30 to 0.34 mg kg^{-1} bw and 0.62 to 0.68 mg kg^{-1} bw for mean and high-level consumption, respectively. Across all population and gender groups, exposure ranges from 0.19 to 0.76 mg kg^{-1} bw and 0.42 to 1.52 mg kg^{-1} bw for mean and high-level per capita consumption, respectively, with elderly old (>75 years) having the lowest exposure and young children (3-5 years) having the highest exposure. In general, children have higher exposure to sulfites compared with other population groups, due to their lower average body weight.

Results showed that for mean capita consumption of commonly-consumed foods, most of the age and gender groups were exposed at levels below the ADI of sulfite, with the exception of female & male and male among young children (3 - 5 years) slightly above the ADI at 102 and 109% ADI, respectively.

For the measure of exposure based on extreme intake, most of the gender group among infants, children, and adults exceeded or near the ADI. High exposure was especially observed among young children (3-5 years) and children (6-14 years), with exposure levels from 119% up to >200% ADI. Young old (50-74 years) and elderly old (>75 years), were below the ADI at levels ranging from 60 to 75% ADI.

In a study carried out in New Zealand, all population of dietary exposure in New Zealand were below the ADI, with the exception of estimates for sulfite exposure for 5-12 years old while in Philippine the highest exposure to sulfites was young children (3-5 years) and children (6-14 years) and also most of the gender group among infants, children and adults exceeded or near the ADI [16]. Both studies found that among young children and children ages 3-14 years old have the highest exposure to sulfites. Other studies have also shown that the children ages from 2-12 have a greater risk or exposure to sulfite associated with a greater consumption of food due to their body weight [17,18].

Based on the results presented in Table 7, the main contributors for dietary sulfite exposure among Filipinos were water-based flavoured drinks, dried vegetables, fruit nectar, distilled spirituous beverages, sauces and the like products, and fine bakery wares. Across all population groups, the top contributor was water-based flavoured drinks with mean contribution ranging from 15 – 36%, while mean contributions from other food groups mentioned varied across age and gender population groups.

For infants, one of the main contributors for sulfite exposure, along with water-based flavoured drinks, came from Fruit nectars with a mean contribution of 18-19%.

Fruit nectars, as per GSFA online, refer to the product produced through dilution of unfermented fruit juices/concentrates with or without the addition of sweeteners and other additives. Other significant contributors for infant sulfite exposure came from fine bakery wares, dried vegetables, and sauces and the like products, with mean contributions of 13-14%, 9-10%, and 7%, respectively.

Similarly, for young children and children, the 2nd main contributor came from fruit nectar with a mean contribution of 19-20%. Other significant contributors to the Filipino children's sulfite exposure came from fine bakery wares, dried vegetables, and sauces and the like products, with mean contributions of 7-11%, 7-12%, and 6-8%, respectively.

For adults, dried vegetables, seaweeds, and nuts, and seeds contributed significantly to the sulfite exposure among adults with mean contribution ranging from 12-14%. The male population group among adults, meanwhile, were also exposed to sulfite through consumption of distilled spirituous beverages at 14-15% contribution. The contribution from other sources mentioned above such as the fruit nectars, sauces, and fine bakery wares was below 7%.

For the young old and elderly old population group, dried vegetables, seaweeds, and nuts, and seeds constitute 15-18% of the exposure to sulfites. As with the adults, male young olds were exposed to sulfites through consumption of distilled spirituous beverages at 21%, whereas females consumed less distilled beverages and therefore were less exposed to sulfites in beverages with a mean contribution of <5%. The contribution from other sources mentioned above such as the fruit nectars, sauces, and fine bakery wares was below 9%.

According to the research and available literature, the primary sources of total dietary exposure to sulfites varied by country. This variation is attributed to differing food consumption rates, eating habits, and the distinct ways sulfites are utilized in food products, as highlighted in the assessments provided by the Joint FAO/WHO Expert Committee on Food Additives (JECFA)[19].

CONCLUSIONS AND RECOMMENDATIONS

The Philippine FCD was updated by utilizing the FoodEx2 browser - an internationally recommended tool for harmonized food description and classification among ASEAN countries; and by complying with the CIFOCOss requirements - the database designed for the conduct of dietary exposure assessment. Moreover, the updated FCDB was used to assess the exposure of Filipinos to sulfites from commonly-consumed foods using the TMDI approach. The sulfite exposure of Filipinos was found to be 27-109% and 60-217% ADI for mean and high-level per capita consumption, respectively. In general, children were highly exposed to sulfites compared with the adults. In light of the limitations and assumptions of the TMDI method, it is recommended to conduct further studies focusing on the identified priority food groups namely: water-based beverages, dried vegetables, and fruit nectars, among others. It is also important to coordinate with the Philippine FDA as the regulatory and monitoring agency in processed foods in identifying the reported maximum use level of sulfites in processed foods. Alternatively, the actual occurrence data of sulfites in Philippine foods could be generated as baseline data.

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CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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