

Review Article

Intake of added sugar in Malaysia: a review

Maria Sofia V Amarra RD, PhD¹, Geok Lin Khor PhD², Pauline Chan MS¹

¹Scientific Programs, International Life Sciences Institute Southeast Asia Region (ILSI SEA), Singapore

²School of Health Sciences, International Medical University, Kuala Lumpur, Malaysia

The term ‘added sugars’ refers to sugars and syrup added to foods during processing or preparation, and sugars and syrups added at the table. Calls to limit the daily intakes of added sugars and its sources arose from evidence analysed by WHO, the American Heart Association and other organizations. The present review examined the best available evidence regarding levels of added sugar consumption among different age and sex groups in Malaysia and sources of added sugars. Information was extracted from food balance sheets, household expenditure surveys, nutrition surveys and published studies. Varying results emerged, as nationwide information on intake of sugar and foods with added sugar were obtained at different times and used different assessment methods. Data from the 2003 Malaysian Adult Nutrition Survey (MANS) using food frequency questionnaires suggested that on average, Malaysian adults consumed 30 grams of sweetened condensed milk (equivalent to 16 grams sugar) and 21 grams of table sugar per day, which together are below the WHO recommendation of 50 grams sugar for every 2000 kcal/day to reduce risk of chronic disease. Published studies suggested that, for both adults and the elderly, frequently consumed sweetened foods were beverages (tea or coffee) with sweetened condensed milk and added sugar. More accurate data should be obtained by conducting population-wide studies using biomarkers of sugar intake (e.g. 24-hour urinary sucrose and fructose excretion or serum abundance of the stable isotope ¹³C) to determine intake levels, and multiple 24 hour recalls to identify major food sources of added sugar.

Key Words: sugar, intake, added sugars, sources, Malaysia

INTRODUCTION

Sugars are the building blocks of carbohydrates. The primary function of carbohydrates is to provide energy for the body in the form of glucose (blood sugar). Sugars comprise monosaccharides, disaccharides, and polyols (sugar alcohols). Fructose and glucose are naturally occurring monosaccharides present in fruits and honey. Sucrose is a disaccharide extracted from sugar cane and beets, comprising 50% glucose, 50% fructose.^{1,2}

The term “sugars” is conventionally used to describe the mono- and disaccharides.³ “Sugar” or “refined sugar” is used to describe purified sucrose.³ WHO uses the term “free sugars” to refer to all monosaccharides and disaccharides added to foods by the manufacturer, cook or consumer, plus sugars naturally present in honey, syrups and fruit juices.⁴ The American Heart Association (AHA) uses the term “added sugars” to refer to sugars and syrup added to foods during processing or preparation, and sugars and syrups added at the table.⁵

The primary types of sugars used in the food supply are fructose- and nonfructose-rich corn syrups, cane and beet sugar (sucrose), honey and other edible syrups.⁶ These sweeteners are added as ingredients in processed foods, beverages, cereal and bakery products, dairy products, candy and other confectionery items. Names for added sugars on food labels include anhydrous dextrose, fruit juice concentrate, liquid fructose, crystal dextrose, confectioner’s powdered sugar, nectars (e.g. peach nectar), honey, brown sugar, molasses, corn syrup solids, invert sugar, evaporated corn sweetener, molasses, cane juice.⁷

Increased intake of foods high in sugar content is often seen as a major factor contributing to the rise of obesity. There is strong evidence that calorically sweetened foods and beverages contribute to obesity through their caloric load, and that the intake of these foods may not produce a corresponding reduction in the intake of other foods.⁸ Body weight is strictly dependent on energy balance, and studies indicate that free sugar intake increases body weight and body fat mass when energy intake increases.^{9,10} This may be due to a stimulation of reward-related pathways within the brain^{10,11} that leads to increased consumption of sweet foods even in the absence of hunger, resulting in subsequent distortion of energy balance. Due to the association of excessive caloric intakes with chronic disease conditions, there have been calls to limit the daily intakes of added sugars and its sources.

Varying recommendations exist for added sugar intake. WHO⁴ recommended that the intake of free sugars should not exceed 10% of total energy in order to prevent diet-related chronic disease. On a 2000 kcal diet, this trans-

Corresponding Author: Dr Maria Sofia V Amarra, Scientific Programs, International Life Sciences Institute Southeast Asia Region (ILSI SEA), 9 Mohamed Sultan Road #02-01 Singapore 238959.

Tel: 65 6352 5220; Fax: 65 6352 5536

Email: sofiaamarra@ilsisea.org.sg; amarra.sofia@gmail.org

Manuscript received 04 January 2015. Initial review completed 12 March 2015. Revision accepted 07 April 2015.

doi: 10.6133/apjcn.2016.25.2.13

lates into 50 grams added sugar per day. The American Heart Association (AHA)¹² recommended that intake of added sugars should not exceed 100 calories per day for women and 150 calories per day for men. The Institute of Medicine (IOM) recommended that added sugars consumption should not exceed 25% of total energy intake.¹³ The 2013 Malaysian Dietary Guidelines include the statement “Consume foods and beverages low in sugar” (key message 10), and dietary advice on how to achieve this goal.¹⁴

Excess intake of added sugars is associated with dental caries, especially in places with poor oral hygiene practice and public dental services.⁸ For prevention of dental caries, Moynihan and Petersen¹⁵ recommended that consumption of foods containing free sugars should be limited to a maximum of 4 times per day, at amounts ranging from 40-55 grams per day. A review commissioned by WHO¹⁶ found that while caries in children is lower when free sugars intake is <10 percent energy, restricting sugar intake to <5 percent energy may minimize the risk of dental caries throughout the life course.

The 2015 WHO guidelines on sugar¹⁷ give a *strong* recommendation (i.e., meaning that the benefits of adherence to the recommendation outweigh the disadvantages) to reduce the intake of free sugars throughout the life course and to maintain intake to less than 10% of total energy. The guidelines also give a conditional recommendation (i.e., meaning that there is less certainty “about the balance between the benefits and harms or disadvantages of implementing the recommendation) to further reduce the intake of free sugars to below 5% of total energy intake.

The 2013 World Health Statistics Report showed that in 2008, Malaysia had the highest obesity prevalence for adults aged ≥ 20 years among Southeast Asian countries (i.e., 10.4% among males; 17.9% among females).¹⁸ Escalating availability of sugar and sweeteners coupled with increasingly sedentary lifestyles are key factors attributed to the country’s rising problem of obesity and associated non-communicable disease problems, according to Khor.¹⁹ Malaysia’s past National Health and Morbidity Surveys showed that diabetes prevalence among adults aged ≥ 30 years continuously rose from 6.3% in 1986, to 8.3% in 1996, 14.9% in 2006 and to 20.8% in 2011. Obesity among children aged <18 years is also increasing, with corresponding prevalences of 6.7%, 6.3%, and 4.9% for the age groups of 5.0-9.9, 10.0-14.9, and 15.0-17.9 years respectively as of 2011.¹⁹

There is a need to understand the contribution of sweetened foods and beverages to total energy intakes in Asian diets. However, data on sugar intake among South-east Asian countries is limited.

The purpose of this review is to present the best available evidence regarding consumption of ‘free’ or ‘added’ sugars in Malaysia. The objectives are to:

1. Examine intake of sugar and foods with added sugar among different age and sex groups expressed in terms of
 - (1) grams/day
 - (2) kcal/day
 - (3) percentage contribution to total energy intake/day

- (4) percentage contribution to total carbohydrate intake/day

2. Identify the most common or frequently consumed sources of added sugars in the Malaysian population;
3. Identify gaps and provide recommendations for future research.

METHODS

Search strategy

Information on consumption of sugars and foods with added sugar was extracted from food balance sheets, household expenditure surveys, and nutrition surveys obtained from websites of the Malaysian government and international organizations (i.e., WHO, FAO). In addition, a search for published papers that included dietary intake as a study variable was conducted on PubMed and Google, as well as theses of postgraduate students in local universities. Search terms used were: sugar, added sugar, free sugar, diet, eating habits, dental caries, obesity, diabetes, food security, food consumption, processed foods, Malaysia. Since the study used data from published literature, ethics approval was not required.

Selection criteria

Studies were included if they (1) examined eating habits, food consumption, and/or dietary patterns among different age and population groups; (2) examined subjects’ intake of sugar and/or sweetened foods in terms of quantities and/or frequencies of consumption; (3) covered the period January 2000 to November 2013; (4) were conducted among non-institutionalized free-living populations. The studies were selected by two reviewers (authors 1 and 2) when they conformed to the following quality criteria: (1) the research question is clearly stated; (2) demographics and subject characteristics are adequately described; (3) nutrition measures are appropriate to the research question and outcomes of concern; (4) statistical analyses are adequately described; (5) conclusions are supported by results with biases and limitations taken into consideration. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) provides reporting guidelines for intervention studies,²⁰ that can also be used to guide the reporting of observational studies. In line with these guidelines, characteristics of studies for which data were extracted are described (Table 1), and the flow chart for selection of studies is shown (Figure 1).

Data synthesis

Proportions of subjects expressed as whole numbers were converted into percentages to provide a standard picture of the population consuming foods with added sugar at different frequencies. In studies that provided information on mean caloric intakes, the percentage contribution of foods with added sugar to total calories was estimated. This was done by calculating the energy content of each food item using food composition data (i.e., ASEAN food composition table,²¹ Malaysia food composition table,²² USDA nutrient database).²³ Calories ingested from each food item were then calculated based on the amount consumed and expressed as a percentage of total mean energy intake.

Table 1. Characteristics of studies included in the review

Type of data	Author (year published)	Sampling method	Age (sample size)	Method of measurement	Level of added sugar intake identified	Sources of added sugars identified
National level data	FAO Food Balance Sheet (2009) ²⁶	---	N/A	Per capita supply of sugar and sweeteners available for consumption (kcal/capita/day)	Yes	Yes
	Malaysian Adult Nutrition Survey 2003 Vol.7 Habitual Food Intake of Adults aged 18 to 59 years (2008) ²⁷	Multistage stratified random sampling	18 to 59 yrs (n=6,928)	Food frequency questionnaire; 24-hr diet recall and meal pattern	Yes	Yes
	Household Expenditure Survey 2009/10 (2011) ²⁸	---	N/A	Average monthly household expenditure on sugar and some food sources of added sugar	No	Yes
	Sheng et al (2008) ²⁹ Household Expenditure Survey 2004/2005	---	N/A (n=7,966 Malay households)	Average monthly household expenditure on sugar and some food sources of added sugar among Malay respondents	No	Yes
Studies on children	Zaini et al (2005) ³⁵	Random Sampling	9 to 10 yrs (n=1405)	Dietary practices, types and quantities of each food item consumed during each meal on a typical day were obtained by recall of students and confirmed where possible by mothers	No	Yes
	Chin et al (2010) ³¹	Random sampling	36 to 71 months (n=56)	24-hour dietary recall interview of parent or guardian	Yes	No
	Zahara et al (2010) ³⁴	Convenience sampling	5 to 6 yrs (n=50)	Structured questionnaire on frequency of sugary food and sugary drink consumption	No	No
Studies on adolescents	Foo et al (2006) ³⁶	Purposive sampling	12 to 19 yrs (n=199)	Food frequency questionnaire for foods eaten during breakfast and as snacks	No	Yes
	Boon et al (2012) ³⁷	Systematic random sampling	13 to 15 yrs (n=156)	Food frequency questionnaire for foods eaten as snacks	No	Yes
	Nurul-Fadhilah et al (2013) ³⁸	Convenience sampling	12 to 19 yrs (n=236)	Open-ended questionnaire on frequency of usual breakfast consumption, snacking practices, consumption of carbonated and sweetened beverages	No	Yes
Studies on adults	Boo et al (2010) ³⁹	Entire population of medical students enrolled in clinical school	--- (n=240)	Standardized questionnaire on eating habits	No	Yes

--- Not indicated

Table 1. Characteristics of studies included in the review (cont.)

Type of data	Author (year published)	Sampling method	Age (sample size)	Method of measurement	Level of added sugar intake identified	Sources of added sugars identified
Studies on adults	Gan et al (2011) ⁴⁰	Multistage stratified random sampling	18 to 24 yrs (n=584)	Eating Behaviours Questionnaire (EBQ) – a 9-item scale that assesses frequency of snacking between meals, types of snacks consumed, eating outside of home and take-away food	No	Yes
	Nik Shanita et al (2012) ³²	Convenience sampling	18 to 59 yrs (n=51)	One 24-hr food recall	Yes	Yes
	Saw et al (2012) ³³	Convenience sampling	20 to 59 yrs (n=168)	One 24-hr food recall & Sugar checklist to identify sugary food and beverages	Yes	Yes
	Zahara et al (2012) ⁴¹	Convenience sampling	19 to 24 yrs (n=150)	Food frequency questionnaire	No	Yes
	Shahril et al (2013) ⁴²	Random sampling	18 to 24 yrs (n=380)	Diet history consisting of questions about habitual intake of foods from the core food groups in the last seven days	Yes	Yes
Studies on elderly	Shahar et al (2000) ⁴³	Random sampling	60 yrs and above (n=350)	Diet history questionnaire with a food frequency checklist	No	Yes

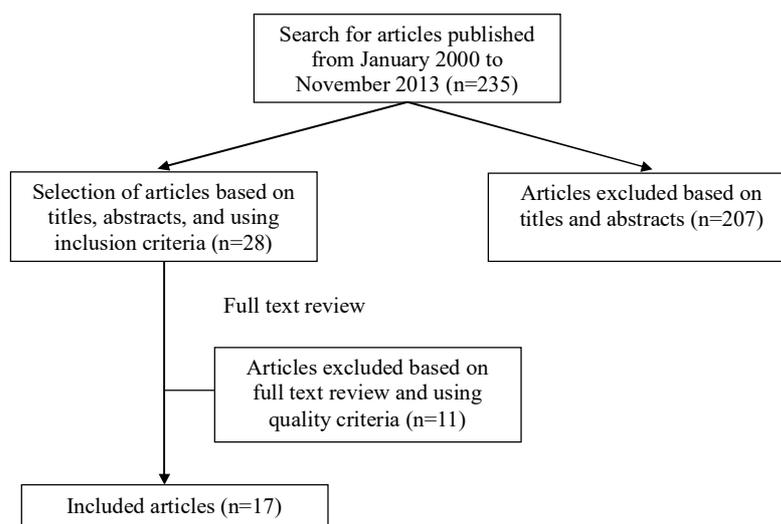


Figure 1. Flow chart for selection of published studies for inclusion in the review

Description of information sources

Food balance sheets describe the amount of food available in a country for consumption (per capita basis), calculated by estimating the quantity of foodstuffs produced, added to the quantity imported and adjusted for any changes in stocks that have occurred.³ The limitation is that per capita consumption of foods or nutrients does not represent food actually consumed as waste or losses are not taken into account. The advantage of food balance sheets is that they are available on-line and regularly updated.³

National household expenditure surveys (HES) measure households' total monetary expenditures as a proxy for income.²⁴ Food data collected in HESs reflect the quantity of food "acquired" by a household, including their food purchases, foods consumed from their own farms or gardens, and foods received in kind. Estimated quantities serve as the basis for calculating indicators of food security such as diet quantity and diet quality.²⁵

Nutrition surveys represent the best way to assess food actually consumed. However, they are not available for all countries due to the large costs required to mount nationwide surveys.³ In such cases, small studies done on specific groups serve as the main sources of information on individual intakes.³

Dietary assessment methods used in nationwide food consumption surveys have limitations due to measurement errors. However they are lesser in magnitude and easier to interpret than errors in food balance sheets and household surveys.³ In terms of level of precision of obtained data, food consumption surveys rank higher than household expenditure surveys, and food balance sheets rank lowest.²⁵

RESULTS

Consumption of sugar and foods with added sugar from FAO food balance sheets and nationwide surveys

FAO food balance sheets

Table 2 summarizes findings from FAO food balance sheets and nationwide surveys. Based on food balance sheet data,²⁶ per capita supply of sugar (from sugar crops comprising cane and beet sugar, and sugar and sweeteners

comprising raw sugar, honey, other sweeteners) available for consumption in Malaysia increased from 297 kcal/day in 2005 to 385 kcal/day in 2009,²⁶ contributing 10.5 and 13.3 percent, respectively, of total available calories for these two periods.

Malaysian Adult Nutrition Survey 2003 (MANS)

The Malaysian Adult Nutrition Survey (MANS) is a cross-sectional nationwide survey conducted in 2002-2003, comprising a total of 6,928 subjects aged between 18 to 59 years old, and covering Peninsular Malaysia, Sabah and Sarawak. A validated food frequency questionnaire consisting of 126 food items was used to evaluate habitual intake.²⁷ Results showed that sugar was used daily by 58 percent of the population.²⁷

Table 2 shows the frequently consumed food sources of sugar based on the MANS, and their estimated contributions to daily energy intake. Sugar-containing foods that contributed most to energy intakes of Malaysian adults were beverages to which sugar is added (i.e., cordial syrup, tea, coffee, chocolate flavoured beverages), condensed milk (added to beverages) and local *kuih* (starchy traditional cakes). Less than 1.2% of the daily caloric intake was obtained from jam, carbonated drinks, and "ABC ice" (shaved ice topped with syrup, nuts and beans).

Report on Household Expenditure Survey, Malaysia

The Household Expenditure Survey, Malaysia shows food consumption patterns in terms of allocation of the household food budget for various food products.²⁸ In 2009/10, foods with added sugar given the highest level of household expenditure were breads and bakery products (Table 2). An estimated amount of RM6.30 (Malaysian Ringgit; USD1.00=RM3.50) per capita per month was spent on these items, followed by non-alcoholic beverages (mineral water, soft drinks, fruit and vegetable juices). Lesser amounts were spent on biscuits, tea, cocoa, condensed milk, ice cream, sugar, preserved fruit and jam.

Sheng et al²⁹ examined trends in food expenditure among Malay consumers using data from the 2004/2005 Household Expenditure Survey. The survey provided

Table 2. Findings on consumption of sugar and foods with added sugar in Malaysia from food balance sheet and nationwide surveys

Source	Year	Estimated level of intake of added sugars	Estimated percentage contribution of added sugars to energy intake (%)	Sources of added sugars
FAO food balance sheet ²⁶	2009	Available supply of 385 kcal/capita/day; ≈ 96.25 g sugar/capita/day	13.3% of per capita energy supply	Sugar and sweeteners (raw sugar, honey, other sweeteners)
Malaysian Adult Nutrition Survey 2003 ²⁷	2003	Average consumption of Malaysian adults - Condensed milk=3 tsp/day - Table sugar=4 tsp/day	Contribution of sweetened foods to median caloric intake/day - Cordial syrup=9.9% - Sweet condensed milk=6.6% - Kopi=5.8% - Teh tarik=5.8% - Sugar=5.4% - Kueh=4.6% - Chocolate beverage=3.2% - Jam=1.2% - Carbonated drink=1.1% - ABC ice=0.9%	Cordial syrup, sweet condensed milk, coffee/tea with condensed milk, table sugar, kuih, chocolate beverage, jam, carbonated drinks, iced dessert
Household Expenditure Survey, Malaysia ²⁸	2009/10	Average monthly household expenditure on sugar, jam, honey, chocolate & confectionery was RM 13 in 2009/10 (equivalent to approximately RM 3.15 per capita per month)	---	Sugar and food sources of sugar in descending order of per capita monthly expenditure - Bread and bakery products (RM 6.3) - Mineral water, soft drinks, fruit/vegetable juices (RM 3.2) - Biscuits (RM 2.7) - Tea, cocoa (RM 2.6) - Evaporated/condensed milk (RM 1.7) - Chocolate, sweets, ice cream (RM 1.4) - Sugar (RM 1.3) - Preserved fruit (RM 0.4) - Jam, honey, etc (RM 0.4)
Household Expenditure Survey Malaysia (Sheng et al, 2008) ²⁹	1999/2000 & 2004/2005	Percentage of per capita food budget allocations among Malay consumers - 1999/2000 Beverages=5.41% Sweets=2.67% - 2004/2005 Beverages=5.52% Sweets=3.81%	---	---

--- No data

Table 3. Carbohydrate content of foods with added sugar and their estimated contribution to carbohydrate intake of Malaysian adults (MANS 2003)

Sources of sugar	(a) Mean intake/day (gms)	(b) Approximate CHO content (gms)	Estimated percentage contribution of food source to median CHO intake/day (median CHO is 220.76 gm/d as shown in MAS) [†] (%)
Chocolate-flavored beverages	128	87.5	39.6
Sugar	21	20.7	9.4
Sweet condensed milk	30	14.9	6.7
Cordial syrup	102	13.1	5.9
Local <i>kuih</i>	21.6	5.66	2.6
Jam	6	4.54	2.1
Carbonated drinks	57	4.45	2.0
ABC ice	26	3.02	1.4

Source: (a) Malaysian Adult Nutrition Survey 2003²⁷

(b) Malaysian Adult Nutrition Survey 2003³⁰

[†]Computed as [(b)/220.76] x 100

Table 4. Estimated levels of sugar intake among Malaysian children and adults

Author	Age group examined	Estimated mean intake of total sugar/day (g/day)			Estimated contribution of total sugar to total calories/day (%)
		Men	Women	Both sexes	
Chin et al (2010) ³¹	36 to 71 months	---	---	94.7±65.1 (approx. 379 kcal/day [†]); mean exposure frequency=7.0±5.01 times/day	28.4 (both sexes) [‡]
Nik Shanita et al (2012) ³²	18 to 29 yrs	47.7±21.5	41.9±9.1	45.5±28.8 (approx. 181±115 kcal/day)	9.0 (men) 10.3 (women)
Saw et al (2012) ³³	20 to 59 yrs	56.9±27.5	37.9±23.4	43.7±26.2	13.5±6.6 (men) 10.3±5.6 (women) 11.3±6.1 (both sexes)

[†]Estimated by multiplying grams sugar by 4 kcal.

[‡]Estimate based on mean energy intake computed from available information on mean carbohydrate, fat, and protein consumed per day.

--- No data

detailed expenditure information for 14,084 respondents consisting of 7,966 Malays, 3,200 Chinese, 810 Indians, and 2,108 respondents from other groups. The 1999/2000 and 2004/2005 surveys showed that per capita food budget allocations for sweets increased from 2.67% to 3.81%, respectively, among Malay consumers (Table 2).

Percentage contribution of foods with added sugar to carbohydrate intake among Malaysian adults

Median consumption of carbohydrates among Malaysian adults in 2003 was 221 grams.³⁰ Table 3 shows the estimated percentage contribution of sweetened food sources to carbohydrate intake. Chocolate flavoured beverages contributed the most (approximately 40% of intake), while jam, carbonated drinks, ice kacang contributed the least (1-2%).

Consumption of foods with added sugar from individual studies

Levels of intake of sugar and foods with added sugar

Table 4 summarizes the findings of studies regarding levels of intake of foods with added sugar among children and adults.

Children. Only one study³¹ examined dietary intake in children aged 36 to 71 months. Mean sugar consumption was 94.7±65.1 grams per child daily, contributing approximately 28.4% to total energy intake. This level exceeds the WHO recommendation of <10% of total energy

from added sugar in order to prevent dental caries and diet-related chronic disease in later life. Mean sugar exposure frequency was 7.0±5.01 times per day. More than 85% of children had sugar exposures more than 4 times a day.

Adults. One study showed that sugar consumption varied by ethnicity, with Malays having intakes that exceeded the WHO recommendation of 50 grams/day. Nik Shanita et al³² examined sugar intake among 51 adults aged 18 to 29 years using a single 24-hour dietary recall. Mean total added sugar intake was 45.4±28.8 gms/day (approximately 181±115 kcal/day). The Malay ethnic group was the highest consumer of added sugar (54.0±19.9 gm/day), followed by Indians (44.4±17.4 gm/day), and Chinese (29.8±15.4 gm/day). The greatest contribution to daily sugar intake came from self-prepared drinks to which sugar was added (i.e., tea, coffee, chocolate drinks, fruit juices). Saw et al's³³ study on intakes of sugar and foods with added sugar among 168 adults attending a university dental clinic found that these foods contributed 10.3±5.6% of calories among women and 13.5±6.6% of calories among men.

Sources of added sugars

Table 5 summarizes the findings of studies regarding frequently consumed sources of added sugars among children and adults.

Children. Very few studies exist on dietary sources of

sugar among children. Zahara et al's³⁴ study among pre-schoolers aged 5 to 6 years found that 46% consumed sugary drinks and 30% consumed sugary foods more than 3 times a day. As for schoolchildren, Zaini et al's³⁵ survey on eating habits of 1405 primary school children aged 9 to 10 years in Selangor state found that 91% drank canned/bottled drinks weekly. Of these, 10.5% ingested such drinks more than 4 times a week.

Adolescents. Studies among adolescents indicate that both traditional and modern processed sweet foods are frequently consumed by this group, particularly during breakfast and as snacks. Foo et al's³⁶ study among adolescents in a fishing community in Sabah showed that sweetened foods most frequently consumed for breakfast were coffee, chocolate drinks, and doughnuts, while frequent snacks were bread/biscuits, ice cream, and local cakes. Boon et al's³⁷ study on snacking patterns of 156 adolescents found that sweetened food items consumed frequently (3 or more times a week) were biscuits, fruit juices, and carbonated drinks. Other common snack foods were caffeinated drinks, chocolates, sweets/candy, yogurt drinks, ice cream, and traditional cakes. Nurul-Fadhilah et al's³⁸ analysis of breakfast consumption patterns among 236 adolescents aged 12 to 19 years showed that frequently consumed sweetened food items for breakfast were chocolate malt drinks, tea and coffee, and sweet traditional cakes.

Adults. Studies indicate that sweetened beverages are commonly consumed by adults. Boo et al's³⁹ study of intake patterns among 240 Malaysian medical students showed that 71% of subjects consumed soft drinks weekly as snacks. Consumption was 1.5 soft drinks and one soft drink per week for overweight/obese and normal weight subjects, respectively ($p=0.01$). For breakfast, sweetened cereals and sweet cakes were consumed by 19.6% and 7.4% of subjects, respectively. Gan et al's⁴⁰ study on eating behaviours of 584 university students showed that canned drink consumption was 2 or more times per day for 11.8% of males and 3.8% of females; 1 time per day for 9.3% of males and 4.1% of females; 4 to 6 times a week for 15.6% of males and 9.5% of females. Zahara et al⁴¹ examined tooth erosion and dietary habits of 150 university students. The sweetened food most frequently consumed at high levels (>4 to 5 times/week or >once/day) was tea or coffee. Saw et al's³³ study among adults attending a dental clinic found that, for 92% of participants, daily added sugar came from sugar and sweeteners added to tea, coffee or chocolate drinks. Other frequently consumed foods were biscuits/bun/pastry, and carbonated drinks/squash/cordial syrup. Shahril et al⁴² evaluated the effectiveness of implementing a multimodal nutrition education intervention to improve dietary intake among 417 university students. Dietary intake at baseline showed that, in both control and intervention groups, sweetened foods with the greatest number of servings consumed daily were beverages with sweetened condensed milk, biscuits, and beverages with added sugar.

Elderly. Shahar et al's⁴³ study on the food habits of 350 rural elderly Malays showed that 38% consumed condensed milk (in tea or coffee), 27% consumed biscuits, and 11% consumed traditional cakes (*kuih*) regularly.

DISCUSSION

Levels of intake of sugar and foods with added sugar

The results showed that nationwide information on intake of sugar and foods with added sugar were obtained at different times, used different assessment methods, and therefore showed varying results. Food balance sheet data showed that in 2009, the amount of sugar available for consumption in Malaysia was approximately 96 grams/capita/day, comprising 13.3 percent of total available calories per person per day.

In comparison, the 2003 nationwide food consumption survey among Malaysian adults showed lower levels of sugar intake. According to the Ministry of Health,²⁷ table sugar and sweetened condensed milk contributed about 6 percent of total daily caloric intake. This amount is below the WHO recommendation of less than 10 percent of calories from added sugar to minimize risk of dental caries in children, but above the recommendation of less than 5 percent of calories to minimize caries risk throughout the life cycle. The survey report also stated that on average, Malaysians consumed 30 grams (3 teaspoons) of sweetened condensed milk (equivalent to approximately 16 grams sugar), and 21 grams (4 teaspoons) of table sugar which were habitually added to beverages such as *teh tarik*, *kopi*, and chocolate flavoured beverages.²⁷ Thus, the total amount of sugar ingested daily is approximately 37 grams, which is below 50 grams for a 2000 kcal diet, recommended by WHO to reduce risk of chronic disease.

While the observed levels of sugar consumption may reflect actual intake, these results may also be due to the occurrence of mis-reporting among subjects. Studies showed that respondents in food consumption surveys can be classified as under-reporters, plausible reporters, and over-reporters.⁴⁴ Mirmalini et al⁴⁵ examined the validity of one day 24-hour diet recall data from the 2003 MANS by comparing energy intake against estimates of energy expenditure. Using the ratio of individual energy intake to basal metabolic rate derived for Malaysian adults (i.e., EI/BMR ratio), the investigators found that under-reporting occurred in half of the population studied. Thus sugar intake among Malaysian adults is most likely higher than that reported in the 2003 MANS.

Household expenditure data from 1998 to 2010 showed no change in the amount spent on sugars and confectionery products (data not shown) although there was an increasing trend for expenditure on coffee, tea, and other beverages to which sugar is added.²⁸ The implication of these findings is not clear, as these trends might not reflect actual increases in intake, but rather, an increase in price. Expenditure patterns also varied among ethnic groups, as shown in Sheng et al's²⁹ finding of increased expenditure for sweets among Malay consumers from 1999/2000 to 2004/2005, consistent with Nik Shanita's³² observation of higher sugar intake among Malays, compared with Indians and Chinese.

Individual studies on children and adults suggested high levels of sugar intake. One study on children aged 36 to 71 months suggested a 28.4 percent contribution of added sugars to daily energy.³¹ Among adults, two studies^{32,33} showed that sugar intakes exceeded 10 percent of total calories per day and that intake among men was

Table 5. Frequently consumed sources of added sugars among Malaysian children and adults

Age group examined	Author	Age (years)	Type of food eaten and consumption frequency	Percentage of subjects consuming (%)		
				Men	Women	Both sexes
Children	Zahara et al (2010) ³⁴	5-6	Sugary drink consumed >3 times/day	37.9	57.1	46.0
	Zaini et al (2005) ³⁵	9-10	Sugary food consumed >3 times/day Canned/bottled drinks consumed >4 times/week	31.0 ---	28.6 ---	30.0 10.5
Adolescents	Foo et al (2006) ³⁶	12-19	Sweetened items consumed frequently [†] for breakfast			
			- Coffee	44.7	39.0	41.7
			- Chocolate drinks	31.9	44.8	38.7
			- Doughnuts	31.9	32.4	32.2
			- Other drinks	18.1	9.5	13.6
			- Bread/biscuits	16.0	9.5	12.6
			Sweetened items consumed frequently [†] for snacks			
			- Bread/biscuits	75.5	64.8	69.8
			- Ice cream	24.5	27.6	26.1
			- Local cakes	24.5	23.8	24.1
	- Carbonated drinks	5.3	1.9	3.5		
	Boon et al (2012) ³⁷	13-15	Sweetened snacks consumed ≥ 3 times/week			
			- Biscuits	---	---	34.0
			- Fruit juices	---	---	33.3
			- Carbonated drinks	---	---	25.7
			- Caffeinated drinks	---	---	25.0
			- Chocolates	---	---	24.3
			- Sweets/candy	---	---	24.3
			- Yogurt drinks	---	---	19.3
			- Ice cream	---	---	17.4
- Traditional cakes			---	---	16.6	
Nurul-Fadhilah et al (2013) ³⁸	12-19	Sweetened foods consumed ≥ 5 times/week for breakfast				
		- Chocolate malt drinks	72.1	72.7	72.5	
		- Tea	57.7	60.6	59.3	
		- Sweet & fried traditional cakes	27.9	27.3	27.5	
		- Coffee	14.4	18.2	16.5	
		- Biscuits	7.7	21.2	15.3	
		- Fruit juices	10.6	7.6	8.9	
Adults	Boo et al (2010) ³⁹	Not specified	Sweetened foods consumed weekly			
			- Soft drinks for snacks	---	---	70.6
			- Nut-based breakfast cereal	---	---	19.6
	Gan et al (2011) ⁴⁰	18-24	Sweet cakes for breakfast	---	---	7.4
			Canned drinks consumed 4 to 6 times in the past week	15.6	9.5	12.0
			Canned drinks consumed daily in the past week (once a day)	9.3	4.1	6.2
			Canned drinks consumed daily in the past week (two or more times a day)	11.8	3.8	7.1
	Zahara et al (2012) ⁴¹	19-24	Sweetened beverages consumed 4 to 5 times/week or >once/day [‡]			
			- Tea/coffee	---	---	36.7
			- Dried fruit	---	---	12.0
			- Fruit-flavored drink	---	---	6.7
			- Fruit juice	---	---	5.3
- Fruit jam			---	---	3.3	
- Sour candy			---	---	3.3	
- Sugared carbonated drink	---	---	2.7			
- Sports drink	---	---	1.3			
- Yogurt	---	---	1.3			

[†]Consumption frequency not defined.

[‡]Computed from the respective study.

--- No data

Table 5. Frequently consumed sources of added sugars among Malaysian children and adults (cont.)

Age group examined	Author	Age (years)	Type of food eaten and consumption frequency	Percentage of subjects consuming (%)		
				Men	Women	Both sexes
Adults	Saw et al (2012) ³³	20-59	Sweetened foods consumed daily			
			- Sugar and sweeteners	---	---	92.9
			- Biscuits, bun, cake, pastry	---	---	48.8
			- Carbonated drinks/squash/cordial syrup	---	---	45.2
			- Confectionery	---	---	31.0
			- Traditional pastry	---	---	24.4
			- Jam	---	---	20.2
	Shahril et al (2013) ⁴²	18-24	Foods with added sugar consumed daily			
			- Beverages with sweetened condensed milk	5.7	5.9	5.8
			- Biscuits	5.4	4.8	5.1
			- Beverages with added sugar	3.6	3.2	3.4
			- Sweet dessert	1.3	1.3	1.3
			- Carbonated drinks	0.2	0.3	0.2
Elderly	Shahar et al (2000) ⁴³	60 & above	Sweetened foods consumed regularly			
			- Condensed milk (in tea or coffee)	---	---	38.0
			- Biscuits	---	---	27.0
			- Traditional cakes (<i>kuih</i>)	---	---	11.0

[†]Consumption frequency not defined.

[‡]Computed from the respective study.

--- No data

higher than that of women.

Foods with added sugar and their contribution to carbohydrate intake

Sugary foods that contributed relatively high proportions to median carbohydrate intake among Malaysian adults were chocolate beverages, table sugar, condensed milk, and cordial syrup. Foods with added sugar provide energy in the form of carbohydrates (glucose). Glucose is an important source of fuel for brain cells. Within an energy-sufficient diet, an RDA of 130 gm/day of carbohydrate for adults aged 19 years and above is considered sufficient to provide the brain with an adequate supply of glucose fuel.⁴⁶ However, FAO/WHO recommends that these carbohydrates be obtained from whole grains, legumes, intact fruits and vegetables, rather than foods with added sugars.⁴⁷ The 2013 Malaysian Dietary Guidelines¹⁴ also give the following recommendations: choose plain water rather than sugary drinks; limit intake of table sugar or sweetened condensed milk to one teaspoon per cup of drink; reduce the consumption of sweetened beverages such as cordial, carbonated drinks, *cendol*, and *air batu campur* (ABC); when ordering drinks, ask for less sugar or less sweetened condensed milk.

Sources of added sugars in Malaysia

A few studies showed that, for pre-schoolers and school-children, frequent consumption of sweetened food and

beverages (i.e., >3 times/day) and canned beverages (i.e., >4 times/week), respectively, was common. Among adolescents, sweetened foods commonly consumed were breads and biscuits for snacks,^{36,37} chocolate malt drinks, tea, and traditional cakes for breakfast.³⁸

Among adults, computed estimates from the 2003 MANS suggested that sweetened beverages contributed significantly to energy intake, particularly cordial syrup, *kopi*, *teh tarik*, and chocolate flavoured beverage. Individual studies suggested that, for both adults and the elderly, frequently consumed sweetened foods were beverages (tea or coffee) with sweetened condensed milk and added sugar.^{33,42,43}

Limitations and gaps

Only a few studies examined levels of intake of sugar and foods with added sugar among different age groups in Malaysia. While there is more information regarding frequently consumed sources of added sugars, studies are few and samples are not nationally representative. There were also limitations in the methods used to examine the level of intake, most of which made use of dietary assessment methods utilizing food frequency questionnaires and to a lesser extent, 24 hour recalls.

Limitations of dietary assessment methods

The goal of dietary assessment is to capture "usual" or long term average intake because dietary recommenda-

tions are intended to be met over time and diet-health hypotheses are based on dietary intakes over the long term. There is no perfect dietary assessment tool to measure usual intake and all self-report dietary assessment instruments are prone to systematic and random sources of measurement error.⁴⁸

Frequently used methods of assessing dietary intake are the 24-hour recall and food frequency questionnaire (FFQ). While FFQs are easier to administer and less expensive, they fail to truly reflect a person's long-term average daily intake due to limitations of the food list and cognitive difficulties in recalling typical intake over a long period.⁴⁸ Twenty-four hour recalls are generally preferred to FFQs as they can capture rich details about daily intake of every item consumed (when, how, how much, with what). Studies have shown that the 24-hour recall is less prone to measurement error than the FFQ. Its limitation is that more than one day of recall is needed to estimate usual intakes and statistical methods are required to adjust for measurement error.⁴⁸

Use of biomarkers to estimate intake of added sugars

The use of dietary biomarkers has been shown to overcome the limitations of traditional dietary assessment methods in characterizing and quantifying eating behaviour. There is now an ongoing push to develop biomarkers that measure intake of specific foods rather than nutrients, in order to enhance nutritional research targeting compliance to national dietary guidelines.⁴⁹

Dietary biomarkers that have been examined for their ability to measure added sugar intake are 1) urinary sucrose, fructose and combined sucrose/fructose, and 2) the carbon stable isotope abundance of ¹³C. Under controlled conditions, Tasevska et al⁵⁰ showed that daily dietary (from food recalls/diaries) and urinary (from 24-hour urine samples) sugars were significantly correlated, indicating rapid time-related response of urinary sugars excretion to their intake. The combined measure of urinary sucrose and fructose was highly correlated with total sugar ($r=0.84$) and sucrose intake ($r=0.77$). Using a regression model, total sugar intake explained 70 percent of the variance in sugar excretion in subjects consuming their normal diet.

¹³C is a novel biomarker for cane sugar and high fructose corn syrup (HFCS), both of which are derived from C₄ plants. Fingerstick serum ¹³C showed high correlations with sugar sweetened beverage intake, added sugars, and cane sugar/HFCS, while random plasma ¹³C showed high correlations with consumption of cane sugar/HFCS from the previous meal.⁴⁹ The advantage of the measure is that it can distinguish low vs. high sugar consumers. The limitations are (1) it reflects only short-term intake; (2) beet, maple syrup, honey which come from C₃ plants are not included in the measure; (3) corn, corn derivatives, and meat from animals that consumed corn are reflected in the measurement; this requires correction for protein using ¹⁵N.⁴⁹ Among the studies in this review, none made use of biomarkers for sugar intake.

New findings and implications for future research

It is important to determine the sources and levels of added sugar intake in a population because of the potential

association with chronic disease risk. The health effects of added sugars are known to be mediated by their contribution to increased energy intake and subsequent weight gain, with most studies having been done among Caucasian, rather than Asian, populations. Recent studies suggest that there may be ethnic differences in the physiologic response to sugar, and that added sugar might affect health independent of calories or weight gain.

The Yup'ik are a group of indigenous peoples in Alaska and the Russian Far East who are phenotypically similar to Southeast Asians. Genetic analyses suggest that they originated most likely from east central Asia (e.g., Mongolia or Northern China) and migrated to North America, through the Bering Strait, approximately 30,000 to 43,000 years ago.⁵¹ A study among Alaskan native Yup'ik individuals⁵² found that isotopic estimates of sugar intake were not associated with measures of obesity (BMI or waist circumference), but were positively associated with blood pressure, triglycerides, insulin, insulin resistance and leptin, and inversely associated with HDL, adiponectin, LDL, and total cholesterol. Higher leptin and lower adiponectin levels indicate increased risk for cardiovascular disease, renal disease and type 2 diabetes. Although sugar intake was not associated with obesity, high levels of sugar were seen to adversely affect chronic disease risk in this Native American population.⁵²

Apart from increasing triglycerides, fructose is shown to generate intracellular uric acid that causes mitochondrial oxidative stress.⁵³ Some investigators suggest that fructose-induced hyperuricemia has a fundamental role in development of the metabolic syndrome and diabetes independent of an increase in calories.^{53,54} A study among Taiwanese adolescents⁵⁵ found that high intake of sweetened beverages was related to increased serum triglycerides and retinol-binding protein 4 (a protein whose serum concentration increases before frank diabetes develops) after controlling for BMI, and serum uric acid contributed to this effect.

It is now known that risk for chronic diseases such as diabetes starts at a lower BMI for Asians than for Europeans.⁵⁶ At the same BMI, Asian populations are more prone to abdominal obesity and low muscle mass with increased insulin resistance compared with Caucasians. A "metabolically obese" phenotype (i.e., normal weight by conventional BMI standards but increased abdominal adiposity) found in Asians, particularly South Asians, has been associated with increased risk of insulin resistance and diabetes.⁵⁶ Studies are needed to determine whether or not the intake of added sugar is associated with an increased health risk among normal, non-obese Southeast Asian populations.

Conclusion

The review shows that there is insufficient evidence to allow an estimation of intake levels of added sugar among different age groups in Malaysia, and to identify major sources of added sugar. National level data obtained from MANS in 2003 is outdated hence another national assessment of sugar intake is needed. A systematic effort consisting of combined dietary assessment and biomarker measures at the population level needs to be undertaken. The use of multiple 24 hour recalls to identify major

sources of sugar and 24-hour urinary sucrose/fructose or isotopic measures to determine levels of intake can improve the quality of information regarding consumption of added sugars in Malaysia. Based on limited studies involving relatively small samples, the intake of added sugar of Malaysian adults and children appears to exceed 10% of total calories. This exceeds the 2015 sugar intake recommendation of WHO, which indeed is advocating for further reducing the intake of free sugars to below 5% of total energy intake.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the assistance of Simon Toh in searching for additional articles, and the following individuals for providing feedback on the manuscript: Dr Tee E Siong (TES NutriHealth Strategic Consultancy), Prof Dr Mirnalini Kandiah (Faculty of Applied Sciences, UCSI University Kuala Lumpur), Mr Geoffrey Smith (ILSI SEA), and Ms Yashna Harjani (Pepsico Thailand) for editing of the article.

AUTHOR DISCLOSURES

None declared. Funding for the research was provided by International Life Sciences Institute Southeast Asia Region. The funding organization had no role in study design, collection, analysis and interpretation of data.

Disclaimer: the views expressed in the article are solely those of the authors and do not reflect the views of their respective institutions. All authors approved the final version of the manuscript.

REFERENCES

1. Tappy L, Le KA. Metabolic effects of fructose and the worldwide increase in obesity. *Physiol Rev.* 2010;90:23-46. doi: 10.1152/physrev.00019.2009.
2. Brand-Miller J. Carbohydrates. In: Mann J, Truswell SA, editors. *Essentials of human nutrition.* New York: Oxford University Press; 2002. pp. 11-30.
3. FAO. *Carbohydrates in human nutrition.* Rome: FAO; 1998.
4. WHO. WHO Technical Report Series 916. *Diet, nutrition and the prevention of chronic diseases.* Geneva: WHO Press; 2003.
5. Van Horn L, Johnson RK, Flickinger BD, Vafiadis DK, Yin-Piazza S, on behalf of the Added Sugars Conference Planning Group. Translation and implementation of added sugars consumption recommendations: a conference report from the American Heart Association Added Sugars Conference 2010. *Circulation.* 2010;122:2470-90. doi: 10.1161/CIR.0b013e3181ffdc0.
6. Sigman-Grant M, Morita J. Defining and interpreting intakes of sugars. *Am J Clin Nutr.* 2003;78:815S-26S.
7. USDA. What are added sugars? [cited 2013/10/07]; Available from: <http://www.choosemyplate.gov/weight-management-calories/calories/added-sugars.html>.
8. Bray GA. Energy and fructose from beverages sweetened with sugar or high-fructose corn syrup pose a health risk for some people. *Adv Nutr.* 2013;4:220-5. doi: 10.3945/an.112.002816.
9. Morenga LT, Mallard S, Mann J. Dietary sugars and body weight: systematic review and meta-analyses of randomised controlled trials and cohort studies. *BMJ.* 2012;346:e7492. doi: 10.1136/bmj.e7492.
10. Tappy L. Q&A: 'Toxic' effects of sugar: should we be afraid of fructose? *BMC (Biology).* 2012;10:42. doi: 10.1186/1741-7007-10-42.
11. Bellisle F, Drewnowski A, Anderson H, Westerterp-Plantenga M, Martin CK. Sweetness, satiation, and satiety. *J Nutr.* 2012;142:1149s-54s. doi: 10.3945/jn.111.149583.
12. Johnson RK, Appel LJ, Brands M, Howard BV, Lefevre M, Lustig RH et al. Dietary sugars intake and cardiovascular health: a scientific statement from the American Heart Association. *Circulation.* 2009;120:1011-20. doi: 10.1161/CIRCULATIONAHA.109.192627.
13. Dietary Guidelines Advisory Committee. Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans, 2010 to the Secretary of Agriculture and the Secretary of Health and Human Services. Washington D.C: U.S. Department of Agriculture. 2010/05/01 [cited 2013/10/13]; Available from: http://www.cnpp.usda.gov/sites/default/files/dietary_guidelines_for_americans/2010DGACReport-camera-ready-Jan11-11.pdf.
14. Ministry of Health, Malaysia. Malaysian dietary guidelines. 2013/11/27 [cited 2015/03/16]; Available from: <http://www.moh.gov.my/english.php/pages/view/536>.
15. Moynihan P, Petersen PE. Diet, nutrition and the prevention of dental diseases. *Public Health Nutr.* 2004;7:210-26. doi: 10.1079/PHN2003589.
16. Moynihan PJ, Kelly SAM. Effect on caries of restricting sugars intake: systematic review to inform WHO guidelines. *J Dent Res.* 2014;93:8-18. doi: 10.1177/0022034513508954.
17. WHO. *Guideline: sugars intake for adults and children.* Geneva: WHO; 2015.
18. WHO. *World health statistics 2013.* Geneva: WHO; 2013.
19. Khor GL. Food availability and the rising obesity prevalence in Malaysia. *IeJSME.* 2012 [cited 2013/10/17]; Available from: http://web.imu.edu.my/imuejournal/approved/8.Review_khor_s61-s68.pdf.
20. Moher D, Liberati A, Tetzlaff J, Altman DG, the PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Medicine.* 2009;6:e1000097. doi: 10.1371/journal.pmed.1000097.
21. ASEANFOODS Regional Centre and INFOODS Regional Database Centre. *ASEAN Food Composition Tables.* Thailand: Institute of Nutrition, Mahidol University. 2014/02/01 [cited 2014/04/12]; Available from: http://www.inmu.mahidol.ac.th/aseanfoods/doc/OnlineASEAN_FCD_V1_2014.pdf.
22. Siong TE, Noor MI, Azudin MN, Idris K. *Nutrient composition of Malaysian foods.* 4th ed. Kuala Lumpur: Malaysian Food Composition Database Programme c/o Institute for Medical Research; 1997.
23. USDA Agricultural Research Service. *USDA national nutrient database for standard reference.* c2011 [cited 2013/10/10]; Available from: <http://ndb.nal.usda.gov/>.
24. Smith LC. *The use of household expenditure surveys for the assessment of food insecurity.* Rome: FAO; 2003.
25. Smith LC, Subandoro A. *Measuring food security using household expenditure surveys.* Food Security in Practice technical guide series. IFPRI; 2007. doi: 10.2499/0896297675.
26. FAO. *FAOSTAT website.* [cited 2013/10/10]; Available from: <http://faostat3.fao.org/faostat-gateway/go/to/download/E/EE/E>.
27. Ministry of Health, Malaysia. *Malaysian Adult Nutrition Survey 2003.* Habitual food intake of adults aged 18 to 59 years. Putrajaya, Malaysia: Nutrition Section, Family Health Development Division, Ministry of Health, Malaysia; 2008.
28. Department of Statistics, Malaysia. *Report on Household Expenditure Survey Malaysia 2009/10.* Perak, Malaysia: Department of Statistics; 2011.
29. Sheng TY, Shamsudin MN, Mohamed ZA, Abdullah AM, Radam A. *Food consumption behavior of the Malays in Malaysia.* IJUM Journal of Economics and Management. 2008 [cited 2013/10/10]; Available from: <http://www.ijum>.

- edu.my/enmjournals/162art4.pdf.
30. Ministry of Health, Malaysia. Malaysian Adult Nutrition Survey 2003. Dietary intake of adults aged 18 to 59 years. Vol 5. Putrajaya, Malaysia: Nutrition Section, Family Health Development Division, Ministry of Health Malaysia; 2008.
 31. Chin SY, Shani AM, Soo KL. A study of dietary intake and its association with early childhood caries. 2010 [cited 2013/10/10]; Available from: apdsa.com/test/wp-content/uploads/2010/07/sample2010.pdf.
 32. Nik Shanita S, Norimah AK, Abu Hanifah S. Development and validation of a food frequency questionnaire (FFQ) for assessing sugar consumption among adults in Klang Valley, Malaysia. *Mal J Nutr.* 2012;18:283-93.
 33. Saw WS, Shanita N, Zahara BAM, Tuti NMD, Poh BK. Dietary intake assessment in adults and its association with weight status and dental caries. *Pakistan J Nutr.* 2012;11:1066-72. doi: 10.3923/pjn.2012.1066.1072.
 34. Zahara AM, Fashihah MH, Nurul AY. Relationship between frequency of sugary food and drink consumption with occurrence of dental caries among preschool children in Titiwangsa, Kuala Lumpur. *Mal J Nutr.* 2010;16:83-90.
 35. Zaini MZA, Lim CT, Low WY, Harun F. Factors affecting nutritional status of Malaysian primary school children. *Asia Pac J Public Health.* 2005;17:71-80. doi: 10.1177/101053950501700203.
 36. Foo LH, Khor G-L, Tee ES, Dhanaraj P. Dietary intake of adolescents in a rural fishing community in Tuaran District, Sabah. *Mal J Nutr.* 2006;12:11-21.
 37. Boon TY, Sedek R, Kasim ZM. Association between snacking patterns, energy and nutrient intakes, and body mass index among school adolescents in Kuala Lumpur. *Am J Food Nutr.* 2012;2:69-77. doi: 10.5251/ajfn.2012.2.3.69.77.
 38. Nurul-Fadhilah A, Teo PS, Huybrechts I, Foo LH. Infrequent breakfast consumption is associated with higher body adiposity and abdominal obesity in Malaysian school-aged adolescents. *PLoS One.* 2013;8:e59297. doi: 10.1371/journal.pone.0059297.
 39. Boo NY, Chia GJQ, Wong LC, Chew RM, Chong W, Loo RCN. The prevalence of obesity among clinical students in a Malaysian medical school. *Singapore Med J.* 2010;51:126-32.
 40. Gan WY, Mohd Nasir MT, Zalilah MS, Hazizi AS. Differences in eating behaviours, dietary intake and body weight status between male and female Malaysia university students. *Mal J Nutr.* 2011;17:213-28.
 41. Manaf ZA, Lee MT, Ali NH, Samynathan S, Jie YP, Ismail NH, Bibiana Hui Ying Y, Wei Seng Y, Yahya NA. Relationship between food habits and tooth erosion occurrence in Malaysian university students. *Malays J Med Sci.* 2012;19:56-66.
 42. Shahril MR, Dali WPEW, Lua PL. A 10-week multimodal nutrition education intervention improves dietary intake among university students: cluster randomised controlled trial. *J Nutr Metab.* 2013;2013:1-11. doi: 10.1155/2013/658642.
 43. Shahar S, Earland J, Rahman SA. Food intakes and habits of rural elderly Malays. *Asia Pac J Clin Nutr.* 2000;9:122-9. doi: 10.1046/j.1440-6047.2000.00147.x.
 44. Black AE. Critical evaluation of energy intake using the Goldberg cut-off for energy intake: basal metabolic rate. A practical guide to its calculation, use and limitations. *Int J Obesity.* 2000;24:1119-30. doi: 10.1038/sj.ijo.0801376.
 45. Mirnalini K, Zalilah MS, Safiah MY, Tahir A, Siti Haslinda MD, Siti Rohana D et al. Energy and nutrient intakes: findings from the Malaysian Adult Nutrition Survey (MANS). *Mal J Nutr.* 2008;14:1-24.
 46. IOM (Institute of Medicine) Food and Nutrition Board. Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids. Washington DC: National Academies Press; 2005.
 47. Mann J, Cummings JH, Englyst HN, Key T, Liu S, Riccardi G et al. FAO/WHO scientific update on carbohydrates in human nutrition: conclusions. *Eur J Clin Nutr.* 2007;61 (Suppl):132S-7S. doi: 10.1038/sj.ejcn.1602943.
 48. CDC. NHANES dietary web tutorial: modeling usual intake using dietary recall data. Task 1: key concepts about measurement error. c2014 [cited 2013/10/10]; Available from: <http://www.cdc.gov/nchs/tutorials/dietary/Advanced/ModelUsualIntake/Info1.htm>.
 49. Hedrick VE, Dietrich AM, Estabrooks PA, Savla J, Serrano E, Davy BM. Dietary biomarkers: advances, limitations and future directions. *Nutr J.* 2012;11:109. doi: 10.1186/1475-2891-11-109.
 50. Tasevska N, Runswick SA, McTaggart A, Bingham SA. Urinary sucrose and fructose as biomarkers for sugar consumption. *Cancer Epidemiol Biomarkers Prev.* 2005;14:1287-94. doi: 10.1158/1055-9965.EPI-04-0827.
 51. Bonatto SL, Salzano FM. A single and early migration for the peopling of the Americas supported by mitochondrial DNA sequence data. *Proc Natl Acad Sci USA.* 1997;94:1866-71.
 52. Nash SH, Kristal AR, Bersamin A, Choy K, Hopkins SE, Stanhope KL et al. Isotopic estimates of sugar intake are related to chronic disease risk factors but not obesity in an Alaska native (Yup'ik) study population. *Eur J Clin Nutr.* 2014;68:91-6. doi: 10.1038/ejcn.2013.230.
 53. Johnson RJ, Nakagawa T, Sanchez-Lozada LG, Shafiq M, Sundaram S, Le M et al. Sugar, uric acid, and the etiology of diabetes and obesity. *Diabetes.* 2013;62:3307-15. doi: 10.2337/db12-1814.
 54. Khitan Z, Kim DH. Fructose: a key factor in the development of metabolic syndrome and hypertension. *J Nutr Metab.* 2013;2013:1-12. doi: 10.1155/2013/682673.
 55. Chan TF, Lin WT, Chen YL, Huang HL, Yang WZ, Lee CY et al. Elevated serum triglyceride and retinol-binding protein 4 levels associated with fructose-sweetened beverages in adolescents. *PLoS One.* 2014;9:e82004. doi: 10.1371/journal.pone.0082004.
 56. Chan JCN, Malik V, Jia W, Kadowaki T, Yajnik CS, Yoon KH et al. Diabetes in Asia: epidemiology, risk factors, and pathophysiology. *JAMA.* 2009;301:2129-40. doi: 10.1001/jama.2009.726.

Review Article

Intake of added sugar in Malaysia: a review

Maria Sofia V Amarra RD, PhD¹, Geok Lin Khor PhD², Pauline Chan MS¹

¹Scientific Programs, International Life Sciences Institute Southeast Asia Region (ILSI SEA), Singapore

²School of Health Sciences, International Medical University, Kuala Lumpur, Malaysia

马来西亚添加糖摄入量：一篇综述

“添加糖”是指在食品加工或准备过程中添加的糖和糖浆，或在餐桌茶桌上添加的糖和糖浆。呼吁限制每日添加糖及添加糖的来源是源自 WHO、美国心脏协会和其他组织的证据分析。该综述分析了马来西亚不同年龄和不同性别人群中添加糖摄入水平及其来源的最佳可用的证据。信息是从食物平衡表、家庭消费调查、营养调查和已发表文献中提取的。全国范围内糖和添加糖的食物的摄入量在不同的时间、使用不同的评估方法得到的结果不同。2003 年马来西亚成人营养调查 (MANS) 使用食物频率调查问卷的数据表明，马来西亚成年人平均每天食用 30 g 加糖的浓缩牛奶（相当于 16 g 糖）和 21 g 的餐糖，二者合在一起低于 WHO 推荐的可以降低慢性病的患病风险的 2000 kcal/d 能量中 50 g 糖的标准。已发表研究表明，对于成年人和老年人，经常食用的含糖饮料（茶或咖啡）有加糖的浓缩牛奶和添加糖。更准确的数据应通过开展人群研究，检测糖摄入的生物标志物（如 24-h 尿蔗糖和果糖排泄，血清稳定同位素 ¹³C 的丰度）确定糖摄入水平，以及多个 24 小时回忆确定添加糖的主要食物来源。

关键词：糖、摄入、添加糖、来源、马来西亚