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Individual and total sugar contents of street foods in Malaysia – Should we be concerned?

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ABSTRACT

Street foods are often of poor nutritional quality with high sugar content, in which the overconsumption of sugar is associated with obesity. However, sugar content information on local street foods is scarce. Thus, the individual and total sugar contents of 94 types of street foods in Malaysia were analysed. Compared to snacks and main meals, desserts contained the highest amounts of sugar, sucrose, fructose, glucose, and maltose. Sucrose was predominant in 90% desserts, 79.3% snacks, and 68.6% main meals. Most desserts (93.3%) contained medium to high sugar content (≥5 g to >15 g/100 g), while 82.9% main meals and 65.5% snacks had low sugar content. When comparing the sugar contents of 39 foods with other local databases, 58.3% main meals, 55.6% desserts, and 33.3% snacks contained either significantly ($p < 0.05$) higher or lower sugar contents. Consumers can identify low and high-sugar foods, and policymakers can review health priorities to combat obesity.

1. Introduction

Sugar is commonly used to enhance the taste of food and beverages. However, excess sugar consumption has been linked to obesity, various types of non-communicable diseases such as cardiovascular diseases, diabetes, and hypercholesterolemia, as well as the development of dental caries (Te Morenga, Mallard, & Mann, 2013). The Institute for Public Health (IPH, 2014) found that Malaysian adults consumed approximately 18.5 g of sugar in a day, which is still within the World Health Organization's maximum recommended amount of 50 g/day (WHO, 2015). Nevertheless, there should be consistent efforts to reduce consumption, as the prevalence of overweight and obesity in Malaysia has risen from 30.0% and 17.7% in 2015 to 30.4% and 19.7% in 2019, respectively (IPH, 2019). Additionally, Malaysians consume an estimated 31.5 g of added sugar per day through only beverages such as tea, coffee, and chocolate-based drinks. This is an alarming statistic, as it does not include sugars from other types of sweetened beverages, *kuih* (Malaysian traditional cakes), and naturally occurring sugars in fruits and beverages, which will further contribute to a high daily total sugar intake (IPH, 2014).

A national survey (IPH, 2014) discovered that sweetened beverages and local *kuih* were the major sources of sugar consumption in Malaysia. To reduce sugar consumption in Malaysia, the government has introduced sugar reduction programs, such as a RM 0.40/l tax on sugar-sweetened beverages (SSBs) and mandatory sugar labelling for packaged foods and beverages (NCCFN, 2021). The effects of the tax implementation on sugar reduction have not yet been evaluated in Malaysia, but the initiative has reduced the consumption of SSBs in other countries in the region, such as Thailand and the Philippines (Clark-Hattingh & Lo, 2019). Except for SSBs and packaged foods and beverages, no sugar reduction programmes are being conducted in Malaysia for local out-of-home foods such as street food.

A review on nutritional issues concerning street food (Nonato, Minussi, Pascoal, & De-Souza, 2016) found that street food is generally

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of poor nutritional quality. Due to high levels of energy, saturated fats, and sugar, street food consumption may contribute to the development of chronic non-communicable diseases. Despite the dearth of data regarding the nutritional composition of street food in Malaysia, a systematic review (Steyn et al., 2014) reported that street food in developing countries was a major contributor to total intake of sugar, fat, and trans-fatty acids. Nonato et al. (2016) and Abrahale, Sousa, Albuquerque, Padrão, and Lunet (2019) acknowledged that street foods from different countries may differ in terms of their nutritional characteristics due to variations in ingredients and cooking methods. Therefore, they emphasised the importance of determining the nutrient content of street foods based on the specific country of origin.

In Malaysia, about 70% of the population consumes out-of-home foods regularly (IPH, 2014), including street foods as this food source is convenient, accessible, and affordable (Khongtong, Ab Karim, Othman, & Bolong, 2014). Thus, the sugar content in these foods needs to be determined. However, there is a limited number of ready-to-eat foods in the national nutrient database, also known as the Malaysian Food Composition Database (MyFCD) by the Ministry of Health Malaysia (MOH, n.d.). In addition to that, food labelling and nutrition labelling are not required for street stall types of food premises in Malaysia. This makes it difficult for consumers to identify low and high-sugar foods. Furthermore, local studies on the nutrient content of out-of-home foods, including sugar levels, are limited. Such recent studies available are ones that analysed total sugar contents in 10 restaurant dishes (Dora et al., 2018) and 70 foods from stalls and restaurants (Chong, Haron, Shahar, & Noh, 2019) located in three states of Malaysia. Given that the samples were limited to a few states of Malaysia, the current study included 94 different types of street foods that were sampled throughout the entire country. Further, we categorized the street foods into main meals, snacks, and desserts. We then analysed the individual and total sugar contents. Chong et al. (2019) found that foods from stalls and restaurants contained highly variable amounts of sugar, and the average sugar content in local desserts was the highest compared to snacks and cooked dishes. Moreover, the sugar content was mostly contributed by sucrose, followed by maltose, glucose, fructose, and lactose. A study by Dora et al. (2018) found that among 10 savoury types of restaurant dishes, the sugar content was the highest in plain paratha bread due to the sugar added when preparing the bread. However, the individual sugar contents were not studied.

Thus, the current study aims to determine the individual and total sugar contents in 94 different types of street food commonly available in Malaysia. Following that, this study aims to (i) compare the individual and total sugar contents between food categories; (ii) classify each food into low, medium, and high-total sugar according to the classification by the Food Standards Agency (2007); and (iii) compare the total sugar of similar foods with existing data in the MyFCD (MOH, n.d.), Energy and Nutrient Composition of Foods (ENCF) for Singapore (Health Promotion Board, n.d.), and local studies (Chong et al., 2019; Dora et al., 2018). We hypothesised that desserts would have a higher total sugar content than snacks and main meals, and that sucrose would be the main type of sugar found in most of the street foods.

Together with the findings from the two studies (Chong et al., 2019; Dora et al., 2018) and the identification of low, medium, and high-sugar foods, the data can be used to expand the MyFCD and empower consumers to make informed choices when purchasing street foods. Besides that, the amounts and trends of sugar content in local street foods can be monitored. Further, the data can act as a base study for policymakers to review potential health programs and priorities, especially to combat obesity.

2. Material and methods

This study is an extension of previous research undertaken to determine the most commonly available street food in all states of Malaysia while assessing the sodium levels (Haron et al., 2022). Data collection was carried out in two phases: (1) a survey of street foods across 13 states and one federal territory and Kuala Lumpur in Malaysia (2) sampling and analysis of sugar, sodium (Haron et al., 2022), fatty acid composition (Zainal Arifen et al., 2023), proximate and energy, and monosodium glutamate contents. This paper focuses on the analysis of individual and total sugar contents in selected street foods.

Fig. 1 shows the number of street foods involved in this study from the beginning of the survey to sampling, and results analysis. In Phase 1 of the study, a total of 10,520 street foods were surveyed across all states in Malaysia. In Phase 2, food sampling and analysis were conducted for 210 selected street foods (15 foods × 14 states). Following that, the individual and total sugar contents in the street foods were analysed from January 2022 to June 2023. Among the 210 analysed street foods, 41 were similar foods sampled from more than one state, and 53 were different types of street foods sampled from only one state. Since this study aims to identify the individual and total sugar contents in street food from Malaysia as a whole instead of individual states, the sugar contents of the 41 similar foods were presented as average values from the respective states. Thus, this study presents the average individual and total sugar contents for 94 selected street foods. The description of each street food is found in a supplementary file (Appendix A).

2.1. Survey of street foods from each state

In this study, the definition of street foods was adopted from the Food and Agriculture Organization (2007): "Ready-to-eat foods consumed without further processing or preparation, and sold by roadside hawkers such as trolleys, bicycles, markets, trucks, or stalls that do not have fixed building or four walls".

The detailed description of Phase 1 was described in another study (Haron et al., 2022). Briefly, this phase involved a survey of 10,520 street foods, which comprised 40% (n = 4234) snacks, 37% (n = 3887) main meals, and 23% (n = 2399) desserts. Among these, 15 most frequently available street foods from the main meal, snack, and dessert categories from each state were identified for sampling in the next phase. The definition of main meals, snacks, and desserts was based on the description by the International Scientific Committee (n.d.) as follows:

(1) Main meal: food commonly eaten during main mealtimes, i.e. breakfast, lunch, and dinner.
(2) Snack: savoury food eaten between the main mealtimes, i.e. morning tea and afternoon tea.
(3) Dessert: sweet food eaten at the end of a main meal or as part of the main meal.

2.2. Sampling of street foods from each state

The food sampling was done according to the method used by the Malaysian Food Composition Database, 1997 (Tee, Mohd. Ismail, Mohd Nasir, & Khatijah, 1997). The selection of food for sampling in Phase 2 was based on the 15 most frequently available main meals, snacks, and desserts from Phase 1 for every state, in which several types of street foods varied between states. Additionally, the selection was based on the availability of street food during the sampling since the sampling was executed during the COVID-19 pandemic which affected the operating hours of stalls. From the selection, seven main meals, five snacks, and three desserts were sampled from each state. Therefore, the analysis of sugar contents in this study involved a total of 210 street food samples from all states in Malaysia. This includes the same types of food sampled from a different state. Each selected street food was purchased from two different stalls within the respective states, and this was also applied to foods sampled from only one state. The purchased street food samples were transported in an ice box and stored in the freezer at −20 °C to prevent food spoilage before analysis.

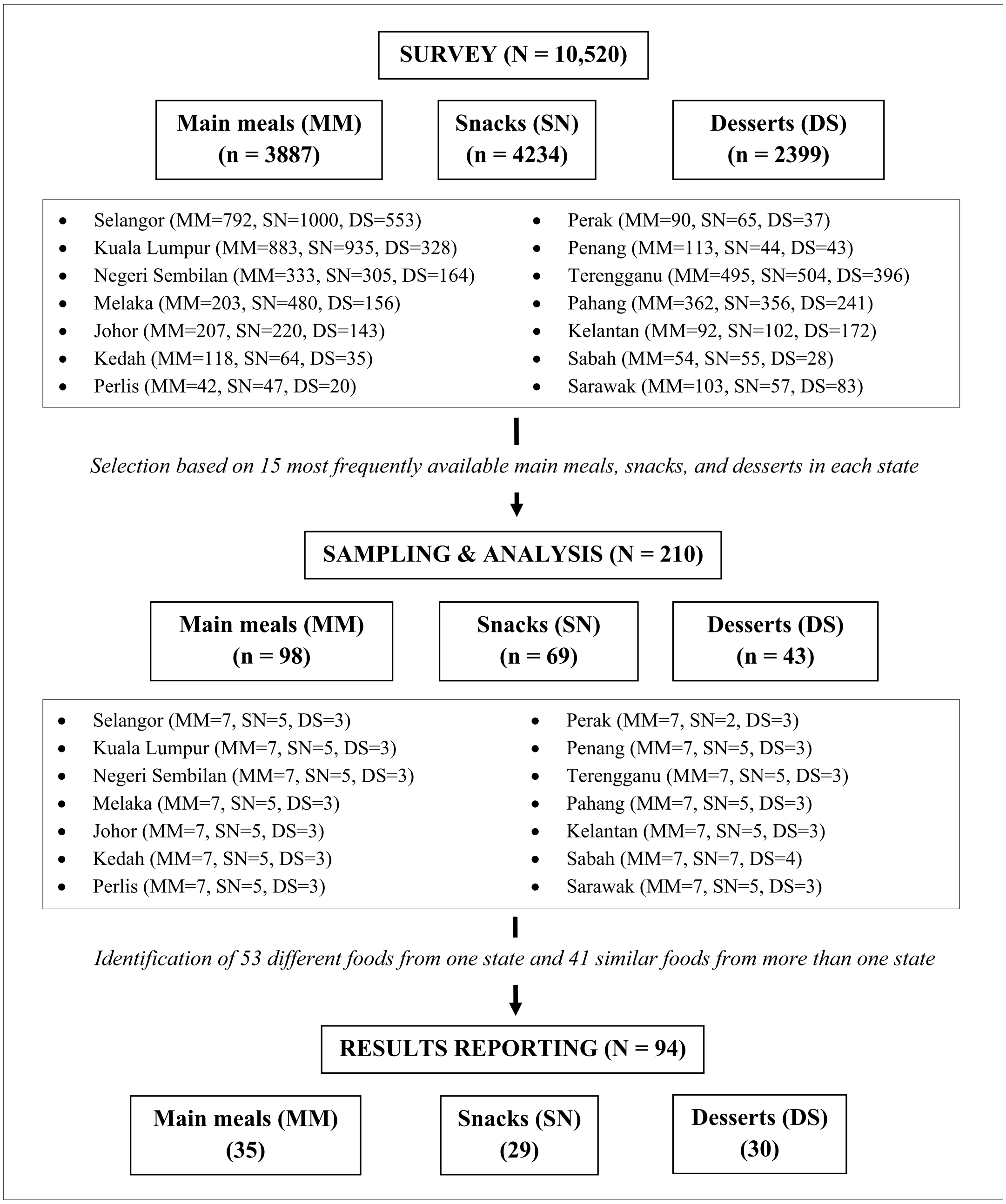

Fig. 1. Number of the street foods involved throughout the whole study.

2.3. Analysis of individual and total sugar contents in selected street

2.3.1. Sample preparation of street food samples

The 210 street food samples were prepared in the food analysis laboratory. Each purchased food sample was weighed with the packaging using a top pan balance (Mettler Toledo, Columbus, USA). The food was then removed from the packaging, weighed, and placed on a plate or in a bowl. Non-edible parts of food, such as bones, were removed, and the sample was reweighed. For the second sample, the same food was purchased from a different location and prepared using the same method. The two samples were then homogenized together in a food processor and scooped into an airtight container. At least two containers containing the homogenized sample were prepared for each type of food. One container was used for moisture determination using the oven drying method provided by the Association of Official Analytical Chemists (AOAC, 2007). Whereas, the other container was kept in the freezer at −20 °C before further sample preparation to analyse individual and total sugars.

During the further sample preparation, the frozen homogenized sample was transferred from the −20 °C freezer into a − 80 °C freezer and kept for one night. On the following day, the frozen sample was freeze-dried in the freeze dryer (Martin Christ, Osterode am Harz, German) for a week until the sample was completely dried. Then, the freeze-dried sample was blended into a powder form, kept in an airtight container, and stored in a refrigerator (0–4 °C) before analysis of sugar contents.

2.3.2. Preparation of mobile phase, stock standards, mixed standards, and working standards

Acetonitrile and triethylamine (TEA) of 100% and > 99% purity were used in the preparation of most of the solution in this analysis.

The mobile phase of acetonitrile/deionized water/triethylamine

(TEA) (75:25:0.2%) was prepared by measuring 750 mL of acetonitrile and deionized water in a 1000 mL measuring cylinder. Then, up to 2 mL of TEA was added. The solution was filtered using a 0.45 μm nylon membrane filter.

A 5% stock standard for each sugar (i.e. fructose, glucose, sucrose, maltose, and lactose) was prepared by dissolving 0.5 g of each standard with acetonitrile and deionized water (50:50) in a 10 mL volumetric flask. For lactose, the standard was dissolved with deionized water before topping up with acetonitrile and deionized water (50:50).

A 1% mixed standard was prepared by mixing 1 mL from each 5% stock standard in a 5 mL volumetric flask using a vortex created by the Wizard IR Infrared Vortex Mixer (VELP Scientifica, Usmate Velate, Italy).

A total of five working standards or standard solutions of 0.1, 0.2, 0.5, 0.8, and 1.0 ppm were prepared. As much as 100 μL, 200 μL, 500 μL, and 800 μL of 1% mixed standard were pipetted into a separate vial. Then, the vials were topped up with 900 μL, 800 μL, 500 μL, and 200 μL of acetonitrile and deionized water (50:50), respectively. The 1.0 ppm standard solution was prepared by pipetting only 1000 μL of 1% mixed standard into another vial. The prepared working standards were then examined before analysing the food samples.

2.3.3. *Quality control analysis*

Quality control analysis was conducted according to the Protocol for Sampling and Methods of Analysis for Malaysian Food Composition Database (National Technical Working Group of Malaysian Food Composition Database, 2011). The mean, standard deviation (SD), and coefficient of variation for all types of sugars and total sugars from ten replicates of biscuit crackers as quality control were determined following the standards of calibration, before the analysis of food samples. The total sugar of 14.2 g/100 g sample from the nutrition information labelling was used as a guide to determine the validity of the quality control analysis. The results from this analysis are presented in a supplementary file (Appendix B).

2.3.4. *Individual and total sugar analysis*

The individual sugar content, comprising fructose, glucose, sucrose, maltose, and lactose, was determined using High-Performance Liquid Chromatography (HPLC) with a Refractive Index Detector (RID) (Waters, Breda, Netherlands). Next, sugar was extracted from the samples using the method suggested by Wills, Balmer, and Greenfield (1980). One gram (in four decimal places) of each powdered freeze-dried sample was weighed on an analytical balance (Sartorius, Göttingen, German) into a 50 mL centrifuge tube (Kirgen, Haikou, China). Then, 25 mL of acetonitrile/ deionized water (50:50) was added into the tube. The mixture was mixed on a vortex for 2 min at 16 rpm. Following that, the tube was centrifuged in a centrifuge machine (Sigma, Osterode am Harz, German) for 30 min at 3200 rpm. Then, 1000 μL of the supernatant from each tube was collected using a pipette (Eppendorf, Hamburg, German) and filtered into a 2 mL vial using a 0.45 μm nylon syringe filter. The vial with the filtered supernatant was placed on a vial rack and inserted into the HPLC machine. Each batch of the food samples analysis was analysed simultaneously with the five prepared working standards and the quality control sample. Each injection volume was 20 μL with a flow rate of 1.0 mL/min and a run time of 15 min. Sugar separation was carried out on an amino-bonded column using acetonitrile, deionized water, and TEA (75:25:0.2%). The sugar content was determined by RID against the five working standards. The results for all types of sugar in the analysed food samples were only accepted if the values were within the range (mean ± 2SD) of quality control results. The five individual sugars were summed up to determine the total sugar content. All analyses of each food sample were carried out in triplicates and reported as per cent mean ± SD.

2.3.5. *Limit of quantification (LOQ) and limit of detection (LOD)*

The LOQ and LOD for each sugar in this study were based on the values found in a previous local study (Chong et al., 2019) that used similar methods and standards. In the previous study, the LOQ and LOD were determined based on the SD of the Response and the Slope (Ederveen, 2010). The formulas used were as below:

$$\text{LOQ} = 10 \text{ x SD of lowest concentration/slope of the calibration curve}$$

$$\text{LOD} = 3.3 \text{ x SD of lowest concentration/slope of the calibration curve}$$

The LOQ for each sugar was as follows: fructose (0.05 g/100 g), glucose (0.12 g/100 g), sucrose (0.12 g/100 g), maltose (0.05 g/100 g) and lactose (0.10 g/100 g). Meanwhile, the LOD for each sugar was as follows: fructose (0.02 g/100 g), glucose (0.04 g/100 g), sucrose (0.04 g/100 g), maltose (0.02 g/100 g) and lactose (0.03 g/100 g). The low amounts of LOQ and LOD indicated that the HPLC method used was sensitive enough to detect even a negligible amount of sugar in the sample. In the current study, results were reported for values at and above the LOQ; whereas results with values less than the LOD were reported as not detected (ND), which refers to zero.

2.3.6. *Spiking and recovery tests*

Two different food samples from the main meal, snack, and dessert categories containing all five types of sugars were selected for spiking and recovery tests. On the same day of analysis, each centrifuged sample (similar sample from the first analysis) was spiked with a known amount of all five types of sugar. Similar to the procedure on the non-spiked sample previously, the spiked sample was mixed using a vortex and centrifuged for 30 min at 3200 rpm. Up to 1000 μL of the supernatant from each spiked sample was then pipetted and filtered into a 2 mL vial. The vial containing the filtered supernatant was placed in a vial rack and then inserted into the HPLC machine to determine all types of sugar and total sugar in the spiked samples. From the results, the percentage of recovery for each sample was determined using the formula below (Ederveen, 2010):

Recovery (%) = [(Amount in spiked sample – Amount in neat sample)/Amount spiked] x 100.

2.4. *Total sugar content classification*

There is no classification standard for low, medium, or high sugar content in ready-to-eat foods, such as street foods in Malaysia. Nevertheless, this study utilized the classification suggested by the Food Standards Agency (2007). Packaged foods are classified as ‘low sugar’ for foods containing below 5 g/100 g of total sugar, ‘medium sugar’ for foods containing between 5 g to 15 g/100 g of total sugar, and ‘high sugar’ for foods containing over 15 g/100 g of total sugar (Food Standards Agency, 2007).

2.5. *Statistical analysis*

Descriptive and statistical analysis was done using Statistical Package for Social Sciences (SPSS) version 25.0 (IBM, New York, USA). A descriptive test was used to determine the average and standard deviation of all individual and total sugar content for the 94 street foods and food categories. A statistical test, such as the one-way ANOVA, was used to compare the average individual and total sugar contents between three food categories. The Games-Howell post-hoc test was performed to identify the specific differences between the food categories if the homogeneity of variance was significant. In contrast, the Gabriel post-hoc test was used if the homogeneity of variance was not significant. One sample *t*-test was conducted to compare the total sugar content in this paper with similar types of food in the MyFCD (MOH, n.d), ENCF for Singapore (Health Promotion Board, n.d), and with two recent local studies (Chong et al., 2019; Dora et al., 2018). For all conducted statistical analyses, the significance level was set at $p < 0.05$.

3. Results

A total of 35 main meals, 29 snacks, and 30 desserts were included in the study. Table 1 displays the average contents of individual sugars and total sugar based on the three food categories. Between the categories, desserts had a significantly higher total sugar content (14.8%) ($p < 0.001$) compared to snacks (4.9%) and main meals (3.3%). For individual types of sugar, sucrose content was the highest in all three food categories, whereas lactose content was the lowest.

Between categories, fructose content in desserts (1.1%) was significantly higher ($p < 0.05$) compared to snacks (0.4%). Whereas, the fructose content of main meals (0.7%) did not differ significantly ($p > 0.05$) from either snacks or desserts. Glucose and sucrose contents were significantly higher ($p < 0.05$ and $p < 0.001$, respectively) in desserts than in main meals and snacks. Among the rest of the individual sugars, only maltose and lactose contents were not significantly different ($p > 0.05$) between the categories.

Table 2 shows the average individual and total sugar contents in 30 selected desserts that are commonly consumed in Malaysia. The data were arranged from high to low total sugar content. The table in which the foods are arranged from high to low values for each sugar can be found in Appendix C. As shown in Table 2, the highest total sugar content in desserts was found in *kuih tepung gomak* (34.2%), followed by *kuih akok* (26.3%), popcorn (24.9%), and *kuih peneram* (21.2%). Whereas, the lowest sugar content was seen in *tau fu fa* (0.8%). Based on the classification of sugar category (Food Standards Agency, 2007), 28 or 93.3% of desserts contained medium to high total sugar content. Within the dessert category, sucrose was present in nearly all 30 (or 96.7%) desserts except for *kuih angku*. Furthermore, except for *tau fu fa*, *kuih lepat,* and *kuih angku*, sucrose was the major type of individual sugar found in the rest of the desserts. Following sucrose, other types of individual sugars such as fructose, glucose, and maltose were detected in 86.7%, 73.3%, and 56.7% of the desserts, respectively. Meanwhile, lactose was not present in most of the desserts, except for trace amounts in *kuih cek mek molek*, *kuih lepat*, *apam balik*, banana fritters with cheese, egg tarts, doughnuts, and *cendol*.

Table 3 displays the average individual and total sugar contents in 29 selected snacks that are commonly consumed in Malaysia. Among all snacks, the savoury snack *apam balik* contained the highest sugar content (16.7%). Meanwhile, seaweed pickles contained the least sugar content (0.2%) compared to other snacks. Based on the classification for sugar content (Food Standards Agency, 2007), 19 out of 29 (or 65.5%) snacks had low total sugar content per 100 g of food. Similarly, the main types of individual sugars found in snacks were sucrose, followed by fructose, glucose, and maltose. Sucrose was also the main sugar found in all snacks except for french fries, fried fish balls, pizza, *murtabak,* seaweed pickles, and fried chicken. Only nine out of 29 snacks (or 31.0%) contained lactose in trace amounts. These were fried crab meatballs, fried chicken with cheese, fried sausage with cheese, takoyaki, savoury corn, *jering rebus*, fried chicken (non-meat parts), *kuih cara berlauk ayam*, and pizza.

Table 1
Individual and total sugar content (per 100 g) according to food categories ($n = 94$).

Sugar	Food categories			*p*-value
	Main meals	Snacks	Desserts	
	($n = 35$)	($n = 29$)	($n = 30$)	
Fructose (%)	0.7 ± 0.8^{ab}	0.4 ± 0.5^{b}	1.1 ± 1.5^{a}	0.039
Glucose (%)	0.5 ± 0.6^{b}	0.3 ± 0.4^{b}	1.0 ± 1.1^{a}	0.001
Sucrose (%)	1.8 ± 3.0^{b}	3.7 ± 4.5^{b}	12.0 ± 7.1^{a}	<0.001
Maltose (%)	0.2 ± 0.4^{a}	0.3 ± 0.4^{a}	0.7 ± 1.2^{a}	0.082
Lactose (%)	0.0 ± 0.1^{a}	0.1 ± 0.3^{a}	0.1 ± 0.2^{a}	0.180
Total sugar (%)	3.3 ± 3.8^{b}	4.9 ± 4.4^{b}	14.8 ± 6.6^{a}	<0.001

Results presented as Mean ± Standard Deviation.
Significant differences ($p < 0.05$) between food categories were indicated by not having the same letter within the same row based on Gabriel post-hoc test.

Table 4 shows the average individual and total sugar contents in 35 selected main meals that are commonly consumed in Malaysia. Concerning main meals, the highest total sugar content was found in glutinous rice with *rendang* (20.5%), whereas chicken porridge contained the lowest sugar content (0.1%). The majority (82.9%) of the main meals were considered low-sugar foods, except for glutinous rice with *rendang,* kebab, beef burger, *roti john*, cubed rice with peanut gravy, and fried noodles. The main type of individual sugar detected among the main meals was sucrose. Sucrose was the highest type of sugar found in 24 (or 68.6%) of the main meals compared to the rest of the individual sugars. The other types of individual sugar found in the samples were glucose, fructose, and maltose. Similar to desserts and snacks, most main meals (82.9%) did not contain lactose. Trace amounts were detected in chicken rice, *bakso*, *nasi minyak*, *kebab*, glutinous rice with *rendang*, and fried *kuey teow*.

Out of the 94 types of street foods examined in this study, the sugar contents in 55 types of foods have not yet been reported in the MyFCD (MOH, n.d), ENCF for Singapore (Health Promotion Board, n.d), or two previous local studies (Chong et al., 2019; Dora et al., 2018). Hence, Table 5 compares the total sugar content in the rest of the 39 types of street foods in the current study to those in the databases (MOH, n.d; Health Promotion Board, n.d) and previous studies (Chong et al., 2019; Dora et al., 2018). These foods comprised 18 desserts, nine snacks, and 12 main meals. The sugar content in the majority of the snacks (66.7%) and desserts (44.4%) between the current study with the databases and previous studies were not significantly different ($p > 0.05$) from one another. This was similar to 41.7% of the main meals. Meanwhile, the sugar content in 33.3% of snacks, 55.6% of desserts, and 58.3% of main meals in the current study was significantly different ($p < 0.05$) from the values found in the databases and previous studies. For instance, four desserts in the current study, i.e. *kuih akok*¸ *kuih peneram*, *kuih cek mek molek*, and *kuih sagu* had significantly ($p < 0.05$) higher sugar content compared to a local study (Chong et al., 2019), whereas three desserts, *cekodok pisang, kuih keria,* and *kuih apam,* had significantly ($p < 0.05$) lower sugar content. Compared to the ENCF for Singapore (Health Promotion Board, n.d), two desserts in this study, *putu piring* and banana fritters, had significantly ($p < 0.05$) lower sugar content. Compared to the MyFCD (MOH, n.d), this study found that only *tau fu fa* had significantly ($p < 0.05$) lower sugar content. As for snacks, this study found that only *pulut panggang* had a significantly ($p < 0.05$) higher sugar content, whereas fried *popiah* and *cakoi* had significantly ($p < 0.05$) lower sugar content compared to the findings in a local study (Chong et al., 2019). Finally, the sugar content in main meals, such as fried noodles and fried *kuey teow,* in this study was significantly ($p < 0.05$) higher than those in ENCF for Singapore (Health Promotion Board, n.d) and local studies (Chong et al., 2019; Dora et al., 2018). Compared to local studies, this study found that fried vermicelli, *nasi lemak,* and *kuey teow* soup were significantly ($p < 0.05$) higher in sugar content, whereas noodle soup was significantly ($p < 0.05$) lower in sugar content. Finally, the sugar content of chicken rice in this study was significantly ($p < 0.05$) higher than the one in ENCF for Singapore.

Spiking and recovery tests were carried out to evaluate the reliability of the results. According to Ederveen (2010), spiking and recovery results that fall within the range of 80–120% are acceptable. In this study, the recovery values of total sugar, fructose, glucose, sucrose, and maltose for foods in the snacks category were 95.6 ± 3.4%, 100.2 ± 0.6%, 95.6 ± 6.0%, 93.8 ± 3.6%, and 97.3 ± 3.5%, respectively. Meanwhile, lactose was not detected in the selected samples. For foods among the main meals category, the recovery values of total sugar, glucose, sucrose, and maltose were 96.7 ± 2.6%, 97.5 ± 3.7%, 96.1 ± 4.9%, and 98.0 ± 2.9%, respectively. Fructose and lactose were not detected in the selected samples. The recovery values of total sugar, fructose, and glucose for foods in the desserts category were 97.3 ± 2.5%, 94.3 ± 6.4%, and 97.9 ± 2.0%, respectively. Sucrose, maltose,

Table 2
Individual and total sugar contents in 30 types of desserts.

Types of street food (*n* = Number of replicates)	Sugar contents					
	Fructose	Glucose	Sucrose	Maltose	Lactose	Total sugar
	(%)	(%)	(%)	(%)	(%)	(%)
Kuih tepung gomak (*n* = 3)	0.4 ± 0.0	0.1 ± 0.0	33.1 ± 0.6	0.6 ± 0.1	ND	34.2 ± 0.7***
Kuih akok (*n* = 6)	0.7 ± 0.2	1.4 ± 1.1	23.7 ± 0.9	0.6 ± 0.0	ND	26.3 ± 0.3***
Popcorn (*n* = 3)	ND	ND	24.9 ± 0.7	ND	ND	24.9 ± 0.7***
Kuih peneram (*n* = 3)	0.8 ± 0.3	0.7 ± 0.2	19.6 ± 0.5	ND	ND	21.2 ± 1.0***
Kuih penjaram (*n* = 3)	ND	ND	20.4 ± 0.9	ND	ND	20.4 ± 0.9***
Cekodok pisang (*n* = 3)	2.6 ± 0.0	2.3 ± 0.0	13.8 ± 0.1	0.7 ± 0.0	ND	19.3 ± 0.2***
Kuih cek mek molek (*n* = 3)	0.9 ± 0.0	0.9 ± 0.0	11.8 ± 0.0	5.6 ± 0.0	0.1 ± 0.0	19.2 ± 0.1***
Kuih keria (*n* = 3)	1.8 ± 0.0	1.8 ± 0.1	10.5 ± 0.4	3.3 ± 0.1	ND	17.4 ± 0.6***
Kuih sagu (steamed sago cake) (*n* = 3)	0.1 ± 0.0	ND	17.1 ± 0.2	0.1 ± 0.0	ND	17.3 ± 0.2***
Kuih puteri ayu (*n* = 3)	1.7 ± 0.2	1.9 ± 0.1	12.4 ± 0.9	ND	ND	15.9 ± 1.3***
Kuih lapis (steamed layer rice cake) (*n* = 6)	0.1 ± 0.1	ND	15.5 ± 2.9	ND	ND	15.6 ± 2.8***
Apam balik with cheese (peanut pancake with cheese) (*n* = 3)	ND	ND	12.6 ± 0.2	3.0 ± 0.0	ND	15.5 ± 0.2***
Banana fritters with cheese (*n* = 3)	2.1 ± 0.0	2.1 ± 0.0	10.6 ± 0.1	ND	0.2 ± 0.0	15.0 ± 0.2**
Steamed baozi with sweet fillings (varieties) (*n* = 6)	1.3 ± 0.3	1.2 ± 0.2	11.4 ± 2.7	1.0 ± 0.0	ND	14.9 ± 2.1**
Kuih lepat (*n* = 5)	5.9 ± 2.6	3.3 ± 1.5	4.4 ± 6.2	1.1 ± 0.3	0.1 ± 0.2	14.7 ± 4.6**
Apam balik (*n* = 12)	0.4 ± 0.2	1.2 ± 1.3	11.6 ± 4.3	0.9 ± 1.3	0.3 ± 0.6	14.4 ± 5.0**
Putu piring (*n* = 3)	5.4 ± 3.3	0.7 ± 1.0	8.2 ± 0.9	ND	ND	14.4 ± 5.3**
Kuih seri muka (*n* = 6)	ND	0.1 ± 0.1	14.0 ± 3.3	ND	ND	14.2 ± 3.2**
Banana fritters (*n* = 11)	1.9 ± 0.7	1.6 ± 0.7	10.1 ± 2.6	ND	ND	13.6 ± 3.9**
Kuih apam (*n* = 3)	0.2 ± 0.0	1.5 ± 0.1	11.6 ± 0.7	ND	ND	13.3 ± 0.8**
Egg tart (*n* = 3)	0.1 ± 0.1	ND	10.9 ± 0.1	0.4 ± 0.1	0.8 ± 0.1	12.2 ± 0.4**
Donut (*n* = 12)	1.1 ± 0.7	0.8 ± 0.7	7.6 ± 3.1	0.8 ± 0.6	0.2 ± 0.2	10.5 ± 3.4**
Kuih calak kuda (*n* = 3)	1.2 ± 0.1	2.6 ± 0.0	6.1 ± 0.4	ND	ND	9.9 ± 0.5**
Kuih bom (*n* = 3)	0.3 ± 0.0	0.4 ± 0.0	8.5 ± 0.2	0.3 ± 0.0	ND	9.4 ± 0.2**
Kuih jelurut (*n* = 3)	0.1 ± 0.0	1.3 ± 0.0	7.9 ± 0.0	ND	ND	9.3 ± 0.1**
Kuih buah Melaka (*n* = 3)	2.1 ± 0.0	0.5 ± 0.0	6.3 ± 0.1	0.1 ± 0.0	ND	9.0 ± 0.1**
Kuih kacang (*n* = 3)	0.7 ± 0.0	ND	6.9 ± 0.1	0.6 ± 0.1	ND	8.3 ± 0.3**
Cendol (*n* = 6)	0.2 ± 0.2	0.3 ± 0.1	7.6 ± 2.6	ND	0.1 ± 0.2	8.2 ± 2.5**
Kuih angku (*n* = 3)	0.1 ± 0.0	3.9 ± 0.0	ND	0.2 ± 0.2	ND	4.3 ± 0.3*
Tau fu fa (soya bean curd) (*n* = 3)	0.4 ± 0.1	ND	0.2 ± 0.1	0.2 ± 0.0	ND	0.8 ± 0.2*

Coefficient of Variation (%): 0.5–36.5.
Results presented as Mean ± Standard deviation.
ND, not detected.
Classification of total sugar content (14): ***High (>15 g/100 g), **Medium (≥5 g to ≤15 g/100 g), *Low (<5 g/100 g).

and lactose were not found in the selected samples. These data are also displayed in Appendix D.

4. Discussion

This study demonstrates several important findings: (i) foods in the dessert category contained the highest total sugar, sucrose, glucose, fructose, and maltose contents compared to snacks and main meals; (ii) sucrose was the major contributor towards the total sugar content in most of the desserts, snacks, and main meals; (iii) most desserts contained medium to high amounts of sugar, while most snacks and main meals contained low amounts of sugar; (iv) certain desserts, snacks, and main meals contained higher or lower total sugar content compared to the values found in the MyFCD, ENCF for Singapore, and local studies. These findings are discussed below.

The high sugar content found among the desserts was mostly contributed by sucrose, indicating that local *kuih* or Malaysian traditional cakes are laden with added sugar. This was supported by the Malaysian Adult Nutrition Survey (IPH, 2014), where the survey found that local *kuih* was the second highest source of sugar consumption among Malaysians after SSBs. Although this survey did not specify the individual sugar that mostly contributed to the high sugar content, local *kuih* are described as traditional delicacies that are commonly made using various sugars such as white sugar, brown sugar, caster sugar, and palm sugar (Kamaruzaman, Ab Karim, Ishak, & Arshad, 2020). Bernstein, Schermel, Mills, and L'Abbé (2016) listed these different types of sugars as sources of sucrose. White sugars are commonly used in local desserts that were found to contain medium to high levels of sugar, such as *kuih tepung gomak, kuih sagu, kuih lapis, kuih seri muka, kuih apam*, and *kuih kacang.* Besides that, brown sugar is used in other medium to high-sugar desserts, such as *kuih peneram, kuih penjaram,* and cendol. Meanwhile, *kuih puteri ayu* and *kuih calak kuda* incorporate caster sugar in the recipes. Palm sugar, which contains around 84.6% sucrose (Chong et al., 2019), is mainly used in *kuih akok, putu piring,* and *kuih buah Melaka.* The majority of desserts were classified as high-sugar foods, most of which are probably due to added sugar. Therefore, consumers should control their consumption of these foods and opt for low-sugar desserts.

Besides sucrose, the highest amounts of glucose, fructose, and maltose were found in desserts compared to snacks and main meals. Furthermore, the high amounts of glucose and fructose in *kuih lepat, cekodok pisang,* and banana fritters could be due to the usage of bananas. Around 20% of sugars are naturally found in bananas, which also contain around 3% of fructose and glucose (Chong et al., 2019). The contents of fructose and glucose in *cekodok pisang* and banana fritters found in this study were around the same proportion as reported by Chong et al. (2019), i.e. around 2.8% and 3.0% in *cekodok pisang* and 1.8% and 1.9% in banana fritters, respectively. However, *kuih lepat* in the current study contained slightly more fructose and glucose. This

Table 3
Individual and total sugar contents in 29 types of snacks.

Types of street food (*n* = Number of replicates)	Sugar contents					
	Fructose (%)	Glucose (%)	Sucrose (%)	Maltose (%)	Lactose (%)	Total sugar (%)
Apam balik (savoury) (savoury peanut pancake) (*n* = 3)	0.7 ± 0.0	0.6 ± 0.0	15.5 ± 0.4	ND	ND	16.7 ± 0.5***
Satay (*n* = 6)	0.1 ± 0.1	ND	13.7 ± 3.7	ND	ND	13.8 ± 3.6**
Beh hua chee (*n* = 3)	ND	ND	12.4 ± 0.6	ND	ND	12.4 ± 0.6**
Satar (*n* = 3)	0.1 ± 0.0	ND	11.0 ± 0.3	0.1 ± 0.0	ND	11.3 ± 0.3**
Fried chicken (non-meat parts) (*n* = 3)	ND	ND	8.9 ± 0.1	ND	0.1 ± 0.1	9.1 ± 0.2**
Chee cheong fun (*n* = 3)	0.9 ± 0.6	0.5 ± 0.2	6.2 ± 0.2	1.2 ± 0.1	ND	8.9 ± 1.1**
Curry puff (*n* = 24)	0.5 ± 0.2	0.7 ± 0.5	5.5 ± 2.9	0.8 ± 0.4	ND	7.5 ± 2.9**
Corn (savoury) (*n* = 6)	0.4 ± 0.2	0.7 ± 0.1	5.8 ± 0.6	ND	0.1 ± 0.1	7.1 ± 0.9**
Fried crab meatball (*n* = 6)	0.1 ± 0.1	ND	4.5 ± 1.9	1.1 ± 1.5	1.2 ± 1.7	6.9 ± 2.3**
Takoyaki (*n* = 12)	1.4 ± 0.7	0.9 ± 0.5	3.3 ± 2.0	0.6 ± 0.2	0.3 ± 0.3	6.5 ± 1.3**
Jering rebus (*n* = 3)	1.1 ± 0.1	0.3 ± 0.0	2.4 ± 0.1	0.1 ± 0.1	0.1 ± 0.0	4.0 ± 0.3*
Pulut panggang (baked glutinous rice) (*n* = 3)	0.3 ± 0.0	0.1 ± 0.0	3.6 ± 0.4	ND	ND	4.0 ± 0.4*
Grilled chicken (small pieces) (*n* = 3)	0.4 ± 0.0	0.2 ± 0.0	3.4 ± 0.2	ND	ND	4.0 ± 0.2*
Fried *popiah* (fried spring roll) (*n* = 3)	0.8 ± 0.0	1.3 ± 0.0	1.5 ± 0.1	0.1 ± 0.0	ND	3.6 ± 0.2*
Fried chicken ball (*n* = 3)	ND	ND	1.7 ± 0.0	1.6 ± 0.0	ND	3.3 ± 0.0*
French fries with sauce (*n* = 3)	1.2 ± 0.0	1.0 ± 0.0	0.5 ± 0.1	0.5 ± 0.0	ND	3.1 ± 0.1*
Fried fish ball (*n* = 5)	1.4 ± 1.6	0.2 ± 0.3	1.3 ± 0.5	0.1 ± 0.2	ND	3.0 ± 0.6*
Pizza (varieties) (*n* = 3)	1.4 ± 0.0	0.9 ± 0.0	ND	0.4 ± 0.0	0.1 ± 0.0	2.9 ± 0.1*
Kuih cara berlauk (*n* = 3)	0.1 ± 0.0	0.2 ± 0.0	0.9 ± 0.0	0.9 ± 0.1	0.1 ± 0.0	2.1 ± 0.1*
Fried chicken with cheese (*n* = 3)	0.2 ± 0.0	0.2 ± 0.0	0.9 ± 0.1	ND	0.7 ± 0.0	2.0 ± 0.1*
Murtabak (*n* = 6)	0.4 ± 0.2	0.8 ± 0.1	0.3 ± 0.5	0.2 ± 0.2	ND	1.8 ± 0.8*
Chicken nuggets (*n* = 14)	ND	0.2 ± 0.3	0.6 ± 0.6	0.6 ± 0.2	ND	1.5 ± 0.5*
Kerepek (*n* = 3)	ND	ND	1.4 ± 0.1	ND	ND	1.4 ± 0.1*
Fried sausage (*n* = 9)	0.1 ± 0.1	0.2 ± 0.3	0.8 ± 0.3	0.1 ± 0.1	ND	1.2 ± 0.4*
Fried sausage with cheese (*n* = 2)	0.2 ± 0.0	0.2 ± 0.0	0.5 ± 0.0	ND	0.3 ± 0.0	1.2 ± 0.1*
Keropok lekor (fish sausage) (*n* = 17)	0.1 ± 0.1	0.2 ± 0.2	0.9 ± 0.4	ND	ND	1.1 ± 0.4*
Cakoi (*n* = 3)	ND	ND	0.6 ± 0.1	ND	ND	0.6 ± 0.1*
Seaweed pickle (*n* = 3)	0.1 ± 0.0	ND	ND	ND	ND	0.1 ± 0.0*
Fried chicken (*n* = 8)	ND	ND	ND	ND	ND	ND

Coefficient of Variation (%): 1.4–44.2.
Results presented as Mean ± Standard Deviation.
ND, not detected.
Classification of total sugar content (14): ***High (>15 g/100 g), **Medium (≥5 g to ≤15 g/100 g), *Low (<5 g/100 g).

could be due to the hydrolysis of sucrose into fructose and glucose during the preparation of the sample or variations in the level of ripeness of the bananas used (Mahmood, Anwar, Abbas, Boyce, & Saari, 2012). Maltose could be detected because of the cooking process in which hydrolyzation occurs. For instance, the use of starchy vegetables, such as boiled sweet potatoes as a main ingredient in *kuih cek mek molek* and *kuih keria,* could have explained the high maltose content compared to other desserts, due to the degradation of starch into maltose. According to Wei, Lu, and Cao (2017), cooked sweet potatoes contained an extra individual sugar in the form of maltose compared to raw sweet potatoes that had only sucrose, glucose, and fructose. Further, cooking methods such as baking, boiling, and steaming dramatically increase the sugar content in cooked sweet potatoes as they degrade starch into maltose.

It was interesting to note that sucrose was also the predominant type of sugar found in most snacks and main meals, although most of the foods were classified as low sugar and these categories are of the savoury types. A previous study (Chong et al., 2019) reported a high proportion of sucrose to the total sugar in savoury locally cooked foods, and the sucrose content in these foods was attributed to the use of sauces or table sugar. In Malaysian main meals, sauces and table sugar are often used to balance out the flavour profile of food. Sauces such as chilli sauce, soy sauce, and oyster sauce are commonly used in main meals such as fried noodles and in snacks such as *takoyaki* which is drenched with its own *takoyaki* sauce. Main meals of the sandwich type such as beef burgers and *roti john* are also topped with sauces. Besides sucrose, the widespread usage of sauces in main meals and snacks may have also led to the detection of other types of sugar such as fructose and glucose due to the hydrolyzation of sucrose, or due to the presence of high-fructose corn syrup (HFCS), which is a common sweetener in sauces (Aguirre, Mytton, & Monsivais, 2015). Although most of the main meals and snacks were classified as low-sugar foods, these findings revealed that sugar, although hidden, is present in most of the local snacks and main meals. Aside from that, the use of table sugar in the marination of *satay,* fish mixture of *satar,* and in the dipping sauce for *chee cheong fun* may have contributed to the sucrose content in high-sucrose snacks. In addition, sugars may be needed in certain foods for the browning effect, which imparts a characteristic flavour and aroma to the food (Murata, 2021). This is known as the Maillard reaction where a reaction between sugars and proteins occurs. This reaction often occurs in protein-based snacks such as *satay*. As main meals are defined as meals that are eaten during the three main mealtimes, and snacks are foods that are eaten in between mealtimes, consumers should still control their portion of main meals and snacks to stay within the maximum limit of sugar intake in a day (WHO, 2015).

Reducing sugar intake has been identified as a priority intervention to reduce overweight and obesity. Accordingly, many countries have carried out programs for sugar reduction in packaged foods and beverages. Starting in 2016 (HM Government, 2016), the United Kingdom

Table 4
Individual and total sugar contents in 35 types of main meals.

Types of street food (*n* = Number of replicates)	Sugar contents					
	Fructose	Glucose	Sucrose	Maltose	Lactose	Total sugar
	(%)	(%)	(%)	(%)	(%)	(%)
Glutinous rice with *rendang* (meat cooked with spices) (*n* = 3)	0.8 ± 0.0	1.9 ± 0.0	17.1 ± 0.1	0.5 ± 0.0	0.2 ± 0.0	20.5 ± 0.1***
Kebab (*n* = 6)	2.2 ± 1.0	2.2 ± 0.8	4.0 ± 2.1	1.0 ± 0.1	0.1 ± 0.0	9.6 ± 3.9**
Beef burger (*n* = 3)	1.5 ± 0.0	1.0 ± 0.0	3.5 ± 0.1	1.8 ± 0.1	ND	7.9 ± 0.3**
Roti john (*n* = 3)	3.7 ± 0.3	2.4 ± 0.1	0.5 ± 0.0	ND	ND	6.7 ± 0.5**
Cubed rice with peanut gravy (*nasi impit*) (*n* = 3)	0.3 ± 0.0	0.1 ± 0.0	5.1 ± 0.2	ND	ND	5.6 ± 0.2**
Fried noodles (*n* = 21)	0.9 ± 0.8	0.5 ± 0.2	3.8 ± 1.6	0.1 ± 0.2	ND	5.4 ± 1.3**
Spaghetti (*n* = 3)	1.3 ± 0.0	1.4 ± 0.0	1.8 ± 0.1	ND	ND	4.5 ± 0.1*
Chicken burger (*n* = 6)	1.5 ± 0.0	1.1 ± 0.1	1.3 ± 0.7	0.6 ± 0.0	ND	4.5 ± 0.5*
Fried vermicelli (fried *mihun*) (*n* = 22)	1.0 ± 0.9	0.5 ± 0.2	2.9 ± 1.8	0.1 ± 0.1	ND	4.5 ± 1.3*
Fried *kuey teow* (fried flat rice noodle) (*n* = 21)	0.5 ± 0.2	0.6 ± 0.2	2.9 ± 1.7	0.2 ± 0.1	0.2 ± 0.4	4.4 ± 1.7*
Nasi tomato (*n* = 3)	2.5 ± 0.4	0.8 ± 0.0	0.9 ± 0.1	ND	ND	4.1 ± 0.5*
Roti canai (flat bread) (*n* = 6)	0.1 ± 0.1	0.1 ± 0.1	2.5 ± 0.5	0.9 ± 0.1	ND	3.5 ± 0.3*
Kolo mee (*n* = 3)	0.1 ± 0.0	0.2 ± 0.0	2.8 ± 0.1	0.1 ± 0.0	ND	3.2 ± 0.1*
Nasi kerabu (kerabu rice) (*n* = 6)	0.9 ± 0.1	0.7 ± 0.3	0.6 ± 0.8	1.0 ± 0.1	ND	3.2 ± 0.6*
Char kuey teow (fried flat rice noodle with gravy) (*n* = 5)	1.4 ± 1.4	0.4 ± 0.1	1.4 ± 0.4	ND	ND	3.1 ± 1.0*
Nasi lemak (regular) (coconut milk rice) (*n* = 26)	0.7 ± 0.7	0.5 ± 0.5	1.9 ± 1.1	0.1 ± 0.1	ND	3.1 ± 0.7*
Roti jala (net crepes) (*n* = 3)	0.2 ± 0.1	0.5 ± 0.0	1.4 ± 0.1	0.6 ± 0.1	ND	2.7 ± 0.3*
Laksa (*Penang* style) (*n* = 9)	1.1 ± 0.8	0.7 ± 0.7	0.5 ± 0.3	0.2 ± 0.4	ND	2.6 ± 1.3*
Kuey teow soup (flat rice noodle soup) (*n* = 3)	0.2 ± 0.1	0.3 ± 0.0	1.9 ± 0.1	ND	ND	2.5 ± 0.2*
Nasi lemak with fried chicken (coconut milk rice with fried chicken) (*n* = 12)	0.8 ± 0.6	0.2 ± 0.2	1.0 ± 0.7	ND	ND	2.1 ± 0.3*
Nasi minyak (oily rice) (*n* = 6)	0.8 ± 0.8	ND	1.1 ± 1.5	ND	0.1 ± 0.1	2.0 ± 0.7*
Chicken rice (*n* = 9)	0.6 ± 0.4	0.3 ± 0.1	0.7 ± 0.9	0.1 ± 0.2	0.1 ± 0.2	1.8 ± 0.6*
Laksam (*n* = 3)	0.7 ± 0.1	0.2 ± 0.1	0.5 ± 0.1	0.2 ± 0.2	ND	1.6 ± 0.6*
Noodles with gravy (varieties) (*n* = 6)	0.1 ± 0.1	0.4 ± 0.3	0.6 ± 0.8	ND	ND	1.1 ± 0.6*
Fried rice (regular) (*n* = 5)	0.2 ± 0.2	0.2 ± 0.3	0.5 ± 0.5	ND	ND	0.9 ± 0.0*
Rice porridge (*n* = 6)	ND	ND	0.6 ± 0.0	ND	ND	0.6 ± 0.0*
Soto (*n* = 3)	0.3 ± 0.0	ND	ND	0.2 ± 0.0	ND	0.5 ± 0.1*
Sianglag (*n* = 3)	0.1 ± 0.0	0.1 ± 0.0	0.2 ± 0.0	0.1 ± 0.1	ND	0.4 ± 0.2*
Laksa (*Perak* style) (*n* = 3)	0.1 ± 0.0	0.1 ± 0.0	0.1 ± 0.0	0.2 ± 0.0	ND	0.4 ± 0.0*
Putu (*n* = 3)	0.1 ± 0.0	0.1 ± 0.0	ND	0.3 ± 0.0	ND	0.4 ± 0.1*
Vermicelli soup (*mihun* sup) (*n* = 3)	0.1 ± 0.0	0.1 ± 0.0	0.2 ± 0.0	ND	ND	0.4 ± 0.0*
Noodle soup (*n* = 3)	0.1 ± 0.0	0.1 ± 0.0	0.1 ± 0.0	ND	ND	0.3 ± 0.0*
Bakso (*n* = 2)	ND	ND	ND	0.1 ± 0.1	0.1 ± 0.1	0.2 ± 0.1*
Chicken porridge (*n* = 3)	ND	ND	0.1 ± 0.0	ND	ND	0.1 ± 0.0*
Glutinous rice with fried fish (*pulut ikan*) (*n* = 3)	ND	ND	ND	ND	ND	ND

Coefficient of Variation (%): 0.2–57.9.
Results presented as Mean ± Standard Deviation.
ND, not detected.
Classification of total sugar content (14): ***High (>15 g/100 g), **Medium (≥5 g to ≤15 g/100 g), *Low (<5 g/100 g).

(UK) has taken the lead in the sugar reduction initiatives to curb obesity in the UK by placing a sugar tax excise on SSBs (Public Health England, 2015). While the tax excise activities in the UK and other countries have documented a reduction of sugar intake through lowered SSB consumption (Redondo, Hernández-Aguado, & Lumbreras, 2018; Institute for Fiscal Studies, 2019), the evaluation for Malaysia has yet to take place. Alongside SSBs, the UK has also placed a considerable focus on reformulation efforts involving other major sources of free sugar, such as confectionery, cakes and biscuits, and dairy desserts. However, this is not yet the case in Malaysia even though local *kuih* or desserts are the second major source of sugar intake after SSBs (IPH, 2014).

In food, sugar exists in two forms, namely, naturally occurring sugars and added sugars. Naturally occurring sugars are intrinsically present in food, such as lactose in dairy products and fructose in fruits and vegetables. Meanwhile, added sugars include all sugars that are added to food during manufacturing or preparation (Erickson & Slavin, 2015). The WHO recommendation for sugar intake refers to the consumption of free sugar, which is defined as added sugar including natural sugar from fruit juices and honey (WHO, 2015). Although the population-based survey (IPH, 2014) and the current study did not determine the proportion of added sugar and intrinsic sugar from the total sugar content, it is most likely that the proportion of added sugar in local desserts was larger than the natural sugar given that sucrose was the sources of the high total sugar content found in our study. High consumption of fructose-containing sugars, such as sucrose and HFCS, may play a role in the development of obesity (Tappy, 2018) by activating a process that leads to fat storage in the body (Johnson, Sánchez-Lozada, Andrews, & Lanaspa, 2017). A meta-analysis showed that adding fructose to the diet without excluding other sources of energy causes weight gain (Sievenpiper et al., 2012). A review study on suggestions to expedite sugar reduction to curb obesity in Malaysia (Goh, Azam-Ali, McCullough, & Roy Mitra, 2020) suggested that Malaysia should consider reformulating other sources of high sugar in addition to SSBs. Coupled with our findings that the high sugar levels in local desserts are most likely contributed by added sugar and that local desserts were among the major sources of sugar intake in Malaysia (IPH, 2014), local desserts are an important target for reformulation. The variation of the sugar content within similar types of desserts compared to the data currently in the MyFCD for Malaysia, ENCF for Singapore and two previous local studies (Chong et al., 2019; Dora et al., 2018) also indicates that reformulation

Table 5
Comparison of total sugar content in 39 similar foods with Malaysian Food Composition Database (MyFCD)[1], Energy and Nutrient Composition of Foods (ENCF) for Singapore[2], and local studies[3,4].

Types of food	Current study	MyFCD[1]		ENCF for Singapore[2]		Local study 1[3]		Local study 2[4]	
	Total sugar (%)	Total sugar (%)	*p*-value	Total sugar (%)	*p*-value	Total sugar (%)	*p*-value	Total sugar (%)	*p*-value
Desserts									
Kuih akok	26.3*	NL	–	NL	–	10.1	0.010	NL	–
Kuih peneram	21.2*	NL	–	NL	–	18.6	0.003	NL	–
Cekodok pisang	19.3	NL	–	NL	–	21.1*	0.002	NL	–
Kuih cek mek molek	19.2*	NL	–	NL	–	17.5	<0.001	NL	–
Kuih keria	17.4	NL	–	NL	–	24.8*	0.002	NL	–
Kuih sagu (steamed sago cake)	17.3*	NL	–	NL	–	15.8	0.005	NL	–
Kuih lapis (steamed layer rice cake)	15.6	NL	–	9.0	0.182	13.7	0.500	NL	–
Steamed baozi with sweet fillings (varieties)	14.9	NL	–	NL	–	19.2	0.214	NL	–
Kuih lepat	14.7	NL	–	NL	–	15.8	0.795	NL	–
Apam balik (peanut pancake)	14.4	NL	–	NL	–	16.0	0.573	NL	–
Putu piring	14.4	NL	–	22.7*	0.043	12.7	0.448	NL	–
Kuih seri muka	14.2	NL	–	NL	–	13.3	0.763	NL	–
Banana fritters	13.6	NL	–	20.9*	0.033	12.5	0.630	NL	–
Kuih apam	13.3	NL	–	NL	–	17.2*	0.014	NL	–
Donut	10.5	8.2	0.267	NL	–	NL	–	NL	–
Kuih buah Melaka	9.0	NL	–	NL	–	8.9	0.421	NL	–
Cendol	8.2	16.9	0.123	1.1	0.150	NL	–	NL	–
Tau fu fa (soya bean curd)	0.8	10.0*	<0.001	NL	–	NL	–	NL	–
Snacks									
Satay	13.8	15.3	0.671	19.1	0.288	NL	–	NL	–
Curry puff	7.5	7.1	0.694	NL	–	NL	–	NL	–
Corn (savoury)	7.1	NL	–	3.6	0.108	NL	–	NL	–
Fried crab meatball	6.9	NL	–	3.3	0.266	NL	–	NL	–
Pulut panggang (baked glutinous rice)	4.0*	NL	–	NL	–	2.2	0.019	NL	–
Fried *popiah* (fried spring roll)	3.6	NL	–	NL	–	5.8*	0.002	NL	–
Fried fish ball	3.0	NL	–	0.3	0.117	NL	–	NL	–
Murtabak	1.8	NL	–	2.6	0.366	3.0	0.264	NL	–
Cakoi	0.6	NL	–	NL	–	1.2*	0.007	NL	–
Main meals									
Kebab	9.6	NL	–	3.1	0.259	NL	–	NL	–
Fried noodles	5.4*	NL	–	1.7	<0.001	2.7	0.002	2.6	0.001
Chicken burger	4.5	NL	–	3.7	0.278	8.7	0.052	NL	–
Fried vermicelli (fried *mihun*)	4.5*	NL	–	NL	–	2.4	0.002	2.5	0.003
Fried *kuey teow* (fried flat rice noodle)	4.4*	NL	–	0.7	0.001	2.1	0.012	2.0	0.010
Roti canai (flat bread)	3.5	NL	–	NL	–	4.6	0.149	4.5	0.164
Nasi kerabu (kerabu rice)	3.2	1.5	0.147	NL	–	NL	–	NL	–
Char kuey teow (fried flat rice noodle with gravy)	3.1	NL	–	0.8	0.197	NL	–	NL	–
Nasi lemak (regular) (coconut milk rice)	3.1*	NL	–	NL	–	1.5	0.001	1.5	0.001
Kuey teow soup (flat rice noodle soup)	2.5*	NL	–	NL	–	1.1	<0.001	1.1	<0.001
Chicken rice	1.8*	NL	–	0.0	0.030	1.9	0.785	NL	–
Noodle soup	0.3	NL	–	NL	–	0.9*	<0.001	1.0*	<0.001

[1]Ministry of Health Malaysia (n.d.); [2]Health Promotion Board (n.d.); [3]Chong et al. (2019); [4]Dora et al. (2018).
MyFCD, Malaysia Food Composition Database; ENCF, Energy and Nutrient Composition of Foods; NL, not listed.
*Indicates significantly higher ($p < 0.05$) total sugar content in the comparison between similar food from the current study and databases/local studies using one-sample t-test.

by gradual reduction in sugar content is possible, given that similar types of foods with much lower sugar levels already exist.

Nevertheless, it is important to note that sugar reformulation in food is more challenging compared to beverages. This is because sucrose in beverages can easily be replaced with low-calorie sweeteners (LCS) without affecting the overall palatability (Stanner & Spiro, 2020). Furthermore, the purpose of sugar in foods extends beyond giving sweetness and includes factors such as texture, mouthfeel, and overall palatability. Therefore, a method that combines different types of LCS with different properties, i.e. sweetening powers, aftertaste, and mouthfeel, is needed to reduce the sugar content in desserts, dairy products, and confectionary while maintaining their quality (Erickson & Carr, 2020). However, consumers may seek out reduced-sugar foods containing "natural" alternatives to sugar instead of LCS, as the latter can often seem "artificial" (Erickson & Carr, 2020). To overcome this issue, natural LCS, such as monk fruit extract or stevia, can be used as total or partial sugar substitutes in food (Mahato et al., 2020). Monk fruit extract is cheap and has high sweetening power (Itkin et al., 2016), and it has no reported adverse health effects. Meanwhile, the stevia compound of the Reb M type has a sucrose-like sensory property and does not produce a bitter aftertaste as compared to the Reb A type which is the common compound in stevia leaves (Prakash, Markosyan, & Bunders, 2014). Sugar reduction using these sweeteners has seen successful consumer acceptance for dairy-based products (Ozdemir, Arslaner, Ozdemir, & Allahyari, 2015). Therefore, trial and error for the usage of natural LCS in different types of foods, especially the sugary local *kuih,* and research on the long-term impacts on health should be conducted, as there is no universal sugar reduction solution that works for all types of foods.

Aside from the challenge of finding suitable sugar alternatives that suit local foods, food reformulation can also pose difficulties, especially for foods prepared by the retail out-of-home sector such as street foods. Further planning from various stakeholders is needed, as law enforcement for this particular sector in Malaysia only focuses on licensing and food safety and doesn't include the nutrition aspect (Zainal Arifen et al., 2024). Although sugar reformulation in the out-of-home sector in the UK has seen little progress, the types of food premises targeted were restaurants, pubs, and cafes. For these premises, the nutrition information is available on the restaurant's website, leaflets, or menus (Public Health England, 2022), thus making monitoring work much easier compared to street food stalls. At present, there is no enforcement to provide nutrition information labelling for street foods in Malaysia. Reformulation involving local street food would therefore necessitate a range of different actions and policies. This scenario is similar to the challenge of reducing salt in the dishes sold by street food vendors in Malaysia (Zainal Arifen et al., 2024). Therefore, future studies among street food vendors could be conducted to determine other types of challenges and potential strategies for sugar reduction in local street foods. Further, studies to determine the added sugar content in the reported medium to high-sugar street foods based on actual recipes should be conducted to support the need for reformulation. To the best of our knowledge, studies on the association between local street food consumption and overweight and obesity among Malaysians are yet to be conducted. This type of study could further address the need for sugar reduction in local foods. As of now, our findings on the list of foods containing low, medium, and high sugar should be made known to the public for them to make informed choices when purchasing street foods. As reformulation is challenging, encouraging consumers to choose lower-sugar alternatives could help reduce free sugar intake (Erickson & Carr, 2020).

The main limitation of this study is that the street food samples may not have represented the foods that were commonly available before the COVID-19 pandemic occurred. However, this study focuses on locally prepared street foods and reports the individual and total sugar contents in the widest options of available street foods in Malaysia compared to previous studies (Chong et al., 2019; Dora et al., 2018; Sharifah Azizah, Nik Shanita, & Hasnah, 2015) that included mixed samples from restaurants and stalls in certain states and regions. This study also reports the individual and total sugar contents in 55 new types of foods that have not yet been reported elsewhere. Another limitation is that the study did not analyse beverages prepared as street foods. Although the availability of these beverages is not known statistically, by observation, the number of street stalls selling beverages, especially the trending ones such as "bubble tea" is increasing (Goh et al., 2020). Furthermore, some desserts commonly consumed by Malaysians but not available as street foods due to storage difficulties, such as Western cakes, pastries and cookies, were also not included. Hence, future research should determine the sugar contents in beverages and these desserts as well.

5. Conclusions

Street food in the desserts category contained the highest amounts of total sugar, sucrose, fructose, glucose, and maltose compared to street food in the snacks and main meals categories. Sucrose was the main contributor of total sugar in 90% of desserts, 79.3% of snacks, and 68.6% of main meals. The majority (93.3%) of desserts, 34.5% of snacks, and 17.1% of main meals had medium to high sugar content based on a sugar classification (Food Standards Agency, 2007). In addition, the sugar contents of 39 foods of the same type (18 desserts, nine snacks, and 12 main meals) were compared to values found in the MyFCD, ENCF for Singapore, and two local studies (Chong et al., 2019; Dora et al., 2018). It was noted that 55.6% of desserts, 33.3% of snacks, and 58.3% of main meals had either significantly higher or lower sugar content. To be specific, as much as 50% of main meals, 22.2% of desserts, and 11.1% of snacks had more sugar. Meanwhile, 8.3% of main meals, 33.3% of desserts, and 22.2% of snacks were lower in sugar.

CRediT authorship contribution statement

Zainorain Natasha Zainal Arifen: Writing – original draft, Validation, Methodology, Investigation, Formal analysis. **Suzana Shahar:** Writing – review & editing. **Kathy Trieu:** Writing – review & editing, Investigation, Funding acquisition, Conceptualization. **Hazreen Abdul Majid:** Writing – review & editing. **Mohd Fairulnizal Md Noh:** Writing – review & editing. **Hasnah Haron:** Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare no conflic of interest

Data availability

The data that has been used is confidential.

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Ethical approval

This study was conducted in accordance with the Declaration of Helsinki and approved by the Research Ethics Committee of the National University of Malaysia with reference number UKM (PPI/111/8/JEP-2020-433, Date of approval: 10 March 2022–9 March 2025).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodchem.2024.139288.

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