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Food classification using daily sugar intake among Indonesian school-aged children

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ABSTRACT

Introduction: The increasing prevalence of diabetes and sugary snacking habits among schoolchildren in Indonesia is driving the need for a comprehensive food classification system, particularly based on sugar intake, with potential implications for sugar traffic light labelling. This study aimed to classify foods according to sugar intake in Indonesian children aged 5 to 9 years. **Methods:** Using cross-sectional design, the study used secondary data from the 2014 Individual Food Consumption Survey (IFCS), which included 24-hour recalls from 8007 school-aged children (5-9 years). The 1318 food items consumed were aggregated into 61 subgroups and Ward's hierarchical clustering method (HCWM) was used for classification. Principal component analysis (PCA) and BiPlot visualisation were used to analyse the similarity of the characteristic variables in each food level. **Results:** Four levels of food groups based on daily sugar intake: Level 1 (low sugar), Level 2 (moderate sugar), Level 3 (high sugar), and Level 4 (very high sugar). Notable items included instant noodles (Level 1), tea/coffee/cocoa drinks (Level 2), soft drinks/fruit drinks (Level 3), and added sugars/sugary milk (Level 4). Level 4 foods had highest sugar content and were among the most frequently consumed items, significantly contributing to daily sugar intake. **Conclusion:** This classification system highlighted the significant contribution of specific foods to daily sugar intake of school-aged children. Targeted nutrition interventions and strong food labelling policies are essential to reduce consumption of foods high in sugar and promote healthier dietary choices among children.

Keywords: clustering food, school-aged children, sugar intake

INTRODUCTION

Childhood obesity and its related health issues, such as diabetes, are growing concerns globally, including in Indonesia. The prevalence of these conditions has increased significantly in recent years, with the majority of childhood diabetes cases occurring in the 10-14 years age group (46.2%), followed by the 5-9 years age group (31.1%). Regarding gender distribution, 59.3% of these cases are found in females (Haeruman, 2023). This trend particularly worries developing countries, where lifestyle changes and dietary habits have shifted towards higher sugar consumption.

The consequences of untreated and unprevented obesity and diabetes mellitus in children are severe, including increased risks of cardiovascular diseases, metabolic disorders, and reduced quality of life. Direct factors

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contributing to obesity include high sugar intake from snacks and sugary beverages, which are prevalent in the diets of school-aged children (Neelakantan *et al.*, 2022; Nguyen *et al.*, 2023). Research has shown that excessive consumption of high-sugar snacks leads to an excess in energy intake, contributing to obesity and its related health issues (Fayet-Moore *et al.*, 2022).

On average, children consume 2.3 snacks per day, with fruits, salty/sweet snacks, and dairy products being the most common (Fayet-Moore *et al.*, 2022; Mireault *et al.*, 2023). These snacks contribute significantly to daily energy and nutrient intakes, with 39.9% of sugar intake coming from snacks, as reported in a study conducted in Canada (Mireault *et al.*, 2023). Sweet snacks, such as sweet biscuits, soft drinks, flavoured drinks, and sugary packaged milk, are trendy among school-aged children (Fayet-Moore *et al.*, 2022). The excessive consumption of added sugars is associated with cognitive impairments in children, emphasising the potential long-term negative effects on brain function and development (Gillespie *et al.,* 2023).

Given the high consumption of unhealthy snacks and its associated health risks, it is crucial to provide easy guidelines for schoolchildren to make healthier food choices. Nutrition labelling, such as the traffic light labelling system, can play a vital role in this regard. However, traffic light labelling has not yet been implemented in Indonesia, and research on its use is limited. A study found that Japanese university students exposed to Traffic Light Food (TLF) labels made healthier dietary choices, increasing nutritious selections by 20.6% and reducing high-sugar, high-fat food choices by 12.6% (Wakui *et al.,* 2024). Similarly, a study in Malaysia reported that 88% of university students viewed the Traffic Light Labelling (TLL) system positively, believing it supports healthier food choices and is suitable for cafeterias (Loo *et al.,* 2022). These findings suggest that implementing TLL in Indonesia could improve consumer awareness and promote healthier eating habits.

To address these issues, there is a need for a comprehensive classification of foods based on sugar intake to guide school-aged children in Indonesia in making appropriate and healthy snack choices. This study aimed to classify foods according to sugar intake in Indonesian children aged 5 to 9 years, which can be specifically considered for sugar traffic light labelling of different types of foods and beverages. An innovative aspect of this study is the detailed classification of foods according to their sugar intake and other nutrient characteristics among Indonesian schoolchildren. By using advanced statistical techniques such as cluster analysis and principal component analysis (PCA), our study integrated dietary analysis to provide a comprehensive understanding of dietary patterns. This novel framework not only supports targeted nutrition interventions in child nutrition and public health, but also helps to develop more effective food labelling policies.

MATERIALS AND METHODS

Study design

This study adopted a cross-sectional design, using secondary data from the 2014 Individual Food Consumption Survey (IFCS), part of the Total Diet Survey, which was the latest national-scale survey conducted in Indonesia. The IFCS collected comprehensive individual consumption data and was administered by the Health Development Policy Agency, Ministry of Health Republic of Indonesia (HDPA MoHRI), in collaboration with various entities, including universities, Statistics Indonesia, and Provincial and District Health Offices, with technical assistance from the World Health Organization (WHO) and International Life Sciences Institute (ILSI) (HDPA MoHRI, 2014). Ethical approval for the IFCS 2014 study was granted by the Health Research Ethics Committee (Komite Etik Penelitian Kesehatan, KEPK) of the Health Development and Policy Agency (HDPA), MoHRI, under approval number LB.02.01/5.2/KE.189/2014, in accordance with the Declaration of Helsinki. The trial identifier was LB.02.01/2/KE.024/2018. Written informed consent was obtained from all participants.

Data collection

IFCS covered all provinces with 162,044 subjects from 46,238 households in 2,072 census blocks. In each census block, 25 households were chosen; all household members were interviewed by trained nutrition personnel (HDPA MoHRI, 2014). Data in the form of electronic files included subject code, employment status, education, economic quintiles, food code, food types, and total food intake in grams. Food consumption data were collected through 24-hour recalls with 5-step multiple passes, validated with repeated recalls in 10% of the sub-sample on non-consecutive days to observe potential variations in food consumption (HDPA MoHRI, 2014). These data were obtained from dietary recall interviews, which were conducted using a combination of direct interviews with the children and proxy interviews through their parents or guardians, particularly for younger children (5-7 years), to ensure the accuracy and reliability of the data collected. Parents or guardians, who were more aware of the foods consumed by their children, provided valuable assistance in the recall process.

Subjects

The study included a total of 8,007 school-aged children (5-9 years) after excluding 934 subjects with incomplete data and 291 subjects with implausible dietary intake data. Subjects who consumed one or fewer main meals per day were excluded due to insufficient dietary information and extreme intake values, which could introduce bias or inaccuracy into the analysis (Bromage *et al.*, 2018). In addition, participants with daily energy intake of less than 500 kcal or more than 3,500 kcal were excluded, as these thresholds are commonly used to ensure the plausibility of dietary data (Banna *et al.,* 2017).

Data processing and analysis

Data processing and analysis were conducted using Microsoft Excel 2010 (Microsoft Corp., Redmond, Washington, USA) and IBM SPSS version 27 for Windows (IBM Corp., Armonk, New York, USA). Macronutrient content was calculated based on the Indonesian Food Composition Table (IFCT), while sugar content was completed using nutrition values from packaging converted into a 100 g edible portion. For foods not listed in the IFCT, nutrient values from neighbouring countries, such as the Singapore, Australia, and United States Food Composition Tables were borrowed, because they have similar climates, soil conditions, and other factors that can influence components, including food nutrients. For non-raw foods, items were matched based on their preparation and ingredient profiles to ensure the accuracy of nutrient content. Limit of daily sugar intake (%) was calculated from the daily sugar intake in each food compared to the European Society for Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) Committee on Nutrition's maximum recommended daily free sugar intake for children (Fidler Mis *et al.*, 2017). For age classification, this study used the ESPGHAN Nutrition Committee's classification of maximum recommended daily free sugar intake (<5% of energy intake) by age group, specifically 4-7 years and 7-10 years, to align with existing guidelines and ensure comparability of our results with other studies using the same age groupings. Free sugars include all sugars added to foods and beverages, as well as sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates. The transformation of 24-hour dietary recall data into weekly food patterns involved two assumptions: that dietary patterns remain relatively consistent over seven days for each individual, and that overestimation errors balance out underestimation errors at the population level (Skau *et al*., 2014). The percentage of children who consumed the food was used to set the maximum number of servings per week (Skau *et al.,* 2014; Fahmida *et al.,* 2020). Expressly, the maximum number of servings per week was set at 1, 2, 3, 4, 5, 6 or 7 if 0-5%, 6-12%, 13-22%, 23-34%, 35-47%, 48-65%, and 66-100% of children consumed the food, respectively (Fahmida *et al.,* 2020).

The 1318 food items consumed were aggregated into 61 food subgroups using the Food and Agriculture Organization of the United Nations (FAO)/WHO Global Individual Food Consumption Data Tool (GIFT) food grouping approach (Leclercq *et al*., 2019). Some food groups, such as spices and condiments, alcoholic drinks, foods for particular nutritional uses, food supplements, and similar food additives, were not included in the analysis because they were consumed in limited quantities among the subjects. Those 61 food subgroups converted into daily average and median sugar intake served as input values for clustering. Ward's method (HCWM), a hierarchical clustering method, was employed for clustering, producing food subgroup clusters in a dendrogram. This clustering method is suitable for highly heterogeneous data such as food consumption data.

The best number of clusters was determined using the smallest ratio of standard deviation within clusters (Sw) to standard deviation between clusters (Sb) (Humayrah *et al.,* 2019), which indicates the best clustering solution (Hikmah, Sumertajaya & Afendi, 2023). This method resulted in three food groupings consisting of 4, 3, and 2 clusters with SW/Sb ratio values of 0.37, 0.55, and 0.59, respectively. Using this approach, four distinct clusters were identified. These clusters allowed us to classify each food item based on its sugar content and impact on the children's daily sugar intake. This classification facilitated a better understanding of how different foods contribute to sugar consumption patterns in school-aged children aged 5-9 years, as shown in Table 2.

After clustering, the foods at each level were analysed for similarity of characteristic variables consisting of the limit of daily sugar intake (%), sugar content (per 100 g), food energy density (kcal/g), energy, carbohydrate, protein and fat content (per 100 g) using Principal Component Analysis (PCA), then visualised in BiPlot. These analyses displayed variables and observations on a plot of n objects and p characteristic variables in a two-dimensional graph, making it possible to examine their relationships (Hikmah, Sumertajaya, & Afendi, 2023). Kruskal-Wallis test was then used to identify differences in the means of those characteristic variables between levels.

RESULTS

A total of 8007 subjects were involved in this study. Demographic characteristics of the subjects and their parents are shown in Table 1. Most of the subjects

Table 1. Demographic characteristics of subjects and their parents (*N*=8007)

Demographic Characteristics	*n*	%
Sex		
Male	4390	54.8
Female	3617	45.2
Age (years)		
4-7	3001	37.5
> 7	5006	62.5
Maternal age (years)		
16-18	5	0.1
19-29	1499	18.7
30-49	5369	67.1
≥ 50	29	0.4
Not answered	1105	13.8
Maternal education		
Not graduated from primary school	813	10.1
Primary school graduate	2009	25.1
Junior high school graduate	1478	18.5
Senior high school graduate	2032	25.4
Diploma (DI/D2/D3) degree	298	3.7
Bachelor's degree	353	4.4
Not answered	1024	12.8
Maternal occupation		
Housewife	3848	48.1
Working	3135	39.2
Not answered	1024	12.8
Paternal age (years)		
16-18	0	0.0
19-29	438	5.5
30-49	5647	70.5
≥ 50	109	1.4
Not answered	1813	22.6
Paternal education		
Not graduated from primary school	743	9.3
Primary school graduate	1804	22.5
Junior high school graduate	1299	16.2
Senior high school graduate	2148	26.8
Diploma (DI/D2/D3) degree	223	2.8
Bachelor degree	462	5.8
Not answered	1328	16.6
Paternal occupational status		
Not working	229	2.8
Working	6450	80.6
Not answered	1328	16.6
Household economy class		
Lowest	1306	16.3
Low-middle	1431	17.9
Middle	1552	19.4
Middle-high	1800	22.5
Highest	1918	24.0

Table 2. Classification of sugar food level based on daily sugar intakes of school-aged children aged 5 to 9 years

Food Clusters	*n*	*%*	*Frequency/ week*	*Daily consumption (g)*		*Daily sugar intake (g)*	
				Mean	*SD*	*Mean*	*SD*
Level 1: low (green)							
Drinking water	7963	99.45	35	903.12	422.84	0.00	0.00
Rice and its products	7875	98.35	21	168.21	87.69	0.13	0.09
Red palm oil	7266	90.75	21	19.53	14.00	0.00	0.00
Vegetables (including legumes): fresh	3938	49.18	3	34.54	37.84	0.98	1.92
Eggs: fresh/processed	3717	46.42	5	57.88	40.95	0.24	0.18
Wheat and its products	3216	40.16	4	41.06	38.82	0.44	0.88
Leafy vegetables: fresh	2960	36.97	2	39.55	39.45	0.37	0.74
Instant noodles and pasta	2836	35.42	3	124.65	80.19	2.14	3.72
Soybean and their products	2607	32.56	4	88.34	74.99	0.83	0.93
Marine fish fresh/processed	2564	32.02	2	125.98	104.23	0.00	0.00
Vegetable fats and oils	2111	26.36	3	47.07	45.00	0.94	1.04
Poultry fresh/processed	2020	25.23	3	117.27	80.74	0.57	1.72
Freshwater fish fresh/processed	1576	19.68	2	142.50	96.10	0.04	0.27
Mammals fresh/processed	1540	19.23	2	74.43	68.48	0.35	0.79
Yellow and orange vegetables: fresh	1228	15.34	2	28.33	38.73	1.59	2.14
Cassava and its products	1222	15.26	2	72.12	108.01	1.27	1.51
Other savoury snacks	1184	14.79	1	23.97	22.11	0.49	1.10
Nuts, seeds and their products	1153	14.40	2	21.30	25.56	1.88	3.57
Potato and its products	713	8.90	2	49.57	59.28	2.11	4.10
Fish and shellfish – mixed	575	7.18	1	38.18	67.43	0.02	0.20
Savoury crisps and curls	445	5.56	1	23.28	21.37	1.60	3.66
Clear broths	437	5.46	1	88.98	75.02	0.53	0.51
Pulses and their products	334	4.17	1	23.00	28.14	0.82	1.48
Shellfish of all types: fresh/processed	291	3.63	1	70.44	73.30	0.20	0.77
Other or mixed cereals and their products	199	2.49	1	60.35	75.29	0.15	0.40
Maize and its products	194	2.42	1	49.96	65.64	2.09	4.24
Diadromous fish fresh/processed	174	2.17	1	130.23	102.58	0.00	0.00
Offal fresh/processed	173	2.16	1	54.27	53.51	0.02	0.11
Other starchy roots/tubers and their products	133	1.66	1	56.71	74.96	0.90	2.63
Fish- and seafood-based dishes	82	1.02	1	60.84	51.45	0.32	0.48
Cheese	73	0.91	1	8.54	6.58	0.04	0.03
Meat-based dishes	67	0.84	1	53.07	43.35	0.57	0.65
Vegetables – mixed: fresh	22	0.27	1	29.49	23.78	0.43	0.46
Rice-based dishes	21	0.26	1	20.04	26.78	1.32	1.76
Meat – all types dried	19	0.24	1	17.59	10.77	0.91	1.36
Taro and taro-based products	18	0.22	1	135.70	122.94	0.63	0.54
Vegetables – all types, mixed: processed	15	0.19	1	41.89	35.49	0.47	0.50
Fish and shellfish – all types	14	0.17	1	68.87	70.92	0.00	0.00
Animal fats and oils	5	0.06	1	7.60	4.08	0.00	0.00
Vegetable-based dishes	5	0.06	1	17.70	12.61	0.33	0.38
Soups	5	0.06	1	18.20	11.12	0.96	2.08
Meat – mixed fresh/processed	3	0.04	1	79.00	9.64	0.00	0.00

Table 2. Classification of sugar food level based on daily sugar intakes of school-aged children aged 5 to 9 years (continued)

Food Clusters	n	%	Frequency/ week	Daily consumption (g)		Daily sugar intake (g)	
				Mean	SD	Mean	SD
Level 2: moderate (yellow)							
Tea, coffee, and cocoa beverages	3235	40.40	4	96.44	128.32	4.36	7.18
Dough-based sweets	2451	30.61	3	37.50	35.91	4.71	6.47
Fruits: fresh	1138	14.21	1	65.17	103.71	6.95	12.31
Bread-based dishes	15	0.19	1	121.53	91.30	4.68	5.78
Legume-based dishes	6	0.07	1	34.55	21.57	4.25	4.46
Level 3: high (orange)							
Chocolate-based sweets	1047	13.08	1	22.17	24.55	8.23	10.62
Other sweets (candy, etc)	777	9.70	1	15.17	26.56	7.68	9.25
Unsweetened milk	742	9.27	2	132.04	148.12	7.58	8.61
Soft drinks	730	9.12	2	46.42	86.15	8.97	8.97
Fruit drinks (powder/liquid)	652	8.14	1	100.41	123.67	9.88	10.94
Fruit-based sweets (jam/jelly)	168	2.10	1	46.89	59.73	11.46	13.14
Ready-to-eat cereals for children	135	1.69	1	29.95	18.98	10.86	9.26
Fermented milk (sweet) products	68	0.85	1	91.35	53.79	11.07	7.15
Fruits: processed (canned)	26	0.32	1	67.10	101.09	11.63	20.63
Level 4: highest (red)							
Added sugars	4275	53.39	6	16.18	15.99	15.51	14.93
Sweetened milk (condensed, powder, flavoured UHT)	1863	23.27	2	50.45	56.85	17.09	16.86
Yellow and orange fruits: fresh	1581	19.75	1	108.61	97.77	16.47	17.51
Sweet potato and its products	142	1.77	1	281.36	380.70	16.66	24.10
Fruits: dried	13	0.16	1	30.71	15.50	15.18	12.44

n: number of subjects who consumed the specified food subgroups; % indicates the percentage of the total sample that consumed that food subgroups

in this study were males (54.8%) and aged >7 years old (62.5%). Maternal age, education, and occupation were predominantly 30-49 years (67.1%), senior high school graduate (25.4%), followed by primary school graduate (25.1%), and housewife (48.1%). Paternal characteristics were dominantly 30-49 years in age (70.5%), senior high school graduate (26.8%), and working (80.6%). Most of the subjects were in the middle, middle-high, and highest household economy groups (>60.0%).

The classification of foods based on daily sugar intake identified four distinct levels (Table 2). Level 1 (green) foods, which have the lowest sugar intake, include nutrient-dense staples such as rice, wheat flour, vegetables, fish, poultry, eggs, and vegetable fats (red palm oil, coconut milk). These foods provide essential energy, protein, and fat while containing minimal sugar. Drinking water, rice, and red palm oil were the most commonly consumed, with daily intakes of 903.12±422.84 g, 168.12±87.69 g, and 19.53±14.00 g, respectively. Meanwhile, Level 2 (yellow) foods, which have a moderate sugar intake, include tea, coffee, cocoa drinks, biscuits, and chocolate wafers. In addition, fresh fruits, such as watermelon, melon, and oranges, contributed natural sugars (6.95±12.31 g/day); however, they were consumed less frequently than processed foods. Notably, tea, coffee, and cocoa drinks provided 4.36±7.18 g of sugar daily and

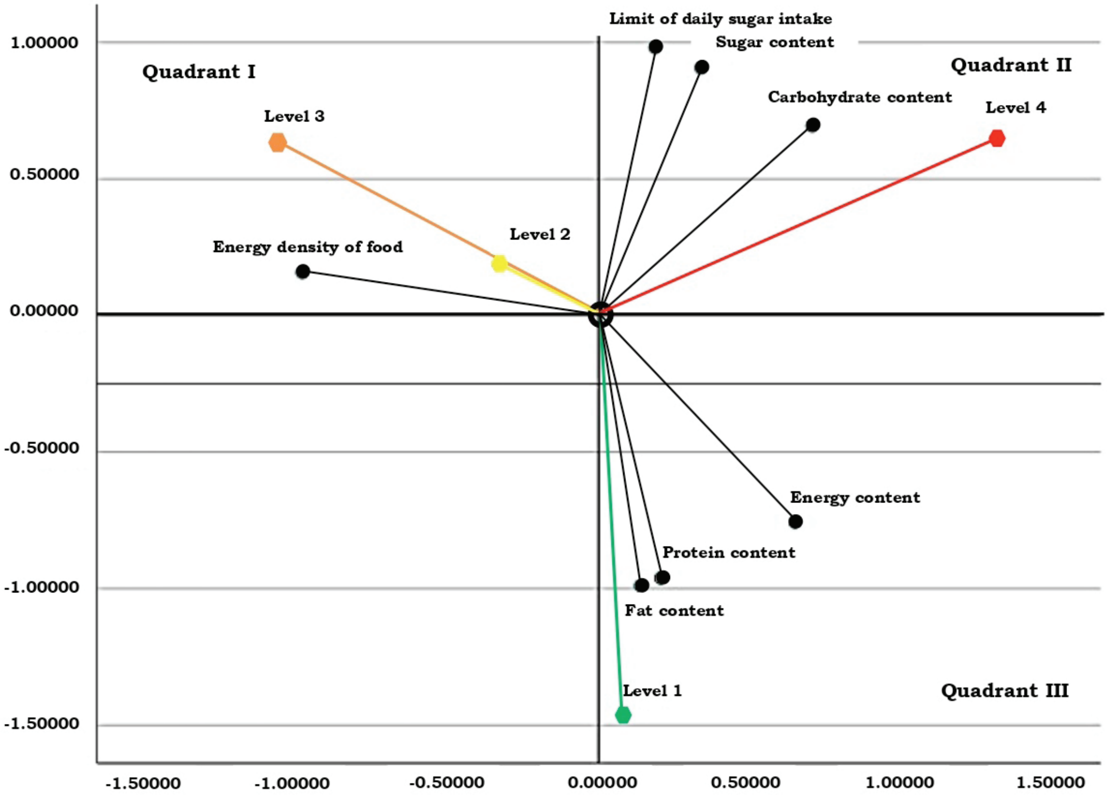

Figure 1. BiPlot visualisation of sugar food levels based on daily sugar intake in school-aged children aged 5 to 9 years

were consumed 3-4 times per week, whereas fruit and legume dishes were eaten only once a week. This pattern highlighted a dietary trend in which processed foods were favoured over natural food sources.

Level 3 (orange) foods, including chocolate confectionery, soft drinks, and processed fruit, have the highest energy density and significantly contributed to sugar intake, despite being consumed only 1-2 times per week. Processed fruit contributed the most sugar in this group (11.63±20.63 g/day), while unsweetened fruit contained less sugar. Level 4 (red) foods, with the highest sugar content, include sweetened dairy products and added sugars. Sweetened milk contributed the most sugar (17.09±16.86 g/day from 50.45±56.85 g consumed daily), while added sugars, consumed six times a week, provided 15.51±14.93 g/day. This category also includes yellow and orange fruits, such as bananas and mangoes, which, although consumed less frequently, still influenced sugar intake. Both levels 3 and 4 significantly increased daily sugar intake, particularly through sugary drinks, processed snacks, and confectionery, which were widely consumed by school-aged children.

Figure 1 shows the clustering of food groups based on sugar content and other nutrient characteristics. Level 1 foods are nutrient-dense, high in protein, fat and energy, but low in sugar. Level 2 foods are moderate in sugar but include a mix of processed and natural sources of sugar, such as beverages,

Table 3. Median, lowest quintile (Q1), and upper quintile (Q3) for limit of daily sugar intake, sugar content, food energy density, energy content, carbohydrate content, protein and fat content of sugary foods level

Characteristics	*Level 1* ‡*n=689*	*Level 2* ‡*n=185*	*Level 3* ‡*n=204*	*Level 4* ‡*n=112*	*p-value*†
	Median (Q1-Q3)	*Median (Q1-Q3)*	*Median (Q1-Q3)*	*Median (Q1-Q3)*	
Limit of daily sugar intake (%)	0.33 (0.00-2.78)	23.10 (4.50-42.39)	28.12 (12.83-60.47)	34.92 (15.72-69.38)	<0.001*
Sugar content (per 100 g)	0.20 (0.00-1.50)	3.45 (0.81-9.64)	6.00 (0.87-14.90)	8.44 (5.30-21.98)	<0.001*
Food energy density (kcal/g)	2.15 (0.89-4.29)	2.55 (0.66-4.44)	3.27 (0.63-4.56)	1.49 (0.90-3.18)	0.158
Energy content (per 100 g)	107.00 (35.00-270)	60.00 (26.40-216)	40.38 (10.00-205.00)	84.12 (51.75-189.83)	<0.001*
Carbohydrate content (per 100 g)	4.70 (0.88-18.00)	11.08 (4.52-34.00)	8.15 (1.59-31.29)	18.73 (8.97-31.25)	<0.001*
Protein content (per 100 g)	5.90 (1.40-14.46)	0.55 (0.17-3.04)	0.15 (0.00-0.70)	1.15 (0.41-2.46)	<0.001*
Fat content (per 100 g)	1.88 (0.42-9.40)	0.63 (0.16-2.80)	0.11 (0.00-0.97)	0.38 (0.15-2.79)	<0.001*

†Significant level for KruskalWallis test *$p<0.05$

‡*n* indicates the number of foods in each sugar level group (low, moderate, high, very high)

dough-based confectionery, and fresh fruit. These foods have a moderate energy density, contributing less sugar than levels 3 and 4 but more than level 1, reflecting their position between nutrient-dense foods and processed options high in sugar. In contrast, levels 3 and 4 foods have higher sugar content, particularly from added sugars and processed foods. BiPlot visualisations confirmed that foods with higher sugar levels generally contained fewer essential macronutrients, emphasising the need for clear dietary guidance.

Table 3 highlighted significant differences in sugar and nutrient contents across the four levels. This analysis showed that foods with higher sugar content tended to have lower protein and fat levels, raising concerns about their overall nutritional value. Level 4 foods have the highest sugar and carbohydrate contents, with daily sugar intakes ranging from 15.72% to 69.38% and sugar content ranging from 5.30 g/100 g to 21.98 g/100 g. Level 3 foods, although slightly lower in sugar content, have the highest energy density, contributing significantly to both sugar and energy intakes. Level 2 foods have moderate sugar content and energy density, reflecting a mix of processed and natural sugar sources. In contrast, level 1 foods contribute the least sugar and are nutrient-dense, with high protein and fat contents, emphasising their roles in a balanced diet. Overall, the results indicated that foods with higher sugar content and daily sugar intake limits tend to have lower protein and fat levels, whereas nutrient-dense foods, such as those in level 1, contributed less sugar to the diet. These findings emphasised the need for targeted interventions to reduce the consumption of high-sugar, nutrient-poor foods in levels 3 and 4 while promoting the inclusion of healthier options from levels 1 and 2.

DISCUSSION

The socio-demographic characteristics of the study population, including age, gender, parental education, and economic status, were compared with the Indonesian Census 2020 to assess representativeness. The proportion of children aged 5-9 years (8.2%) and gender ratio (male: 54.8%, female: 45.2%) in this study agreed well with the national data and showed similar distributions. Parental education and economic status in the study also reflected national trends, with most parents having completed primary or secondary education, and a range of socioeconomic levels represented. This suggests that the sample is broadly representative of Indonesian school-age children.

This study did not examine how sugar intake varied across socio-demographic groups, such as income level, education, or urban/rural differences. Previous studies suggested that children from higher-income households tended to consume more ultra-processed foods and sugary beverages, while those from lower-income backgrounds relied more on traditional sweetened foods (Fayet-Moore *et al.*, 2022; Nguyen *et al.*, 2023). These disparities highlight the importance of targeted interventions that take socioeconomic contexts into account. For example, sugar reduction education campaigns may be less effective in low-income communities if affordable, healthier alternatives are not readily available.

Nevertheless, the findings provided valuable insights into the dietary habits of Indonesian children aged 5-9 years. Future research should further investigate these socio-demographic factors to better inform public health strategies. Such analysis could reveal differences in dietary patterns, such as whether children from different socioeconomic backgrounds rely more on traditional sweetened foods or commercially processed snacks and beverages. Understanding these differences could help develop targeted interventions that address specific socio-demographic challenges, such as improving access to healthy foods or regulating the marketing of processed foods.

Building on the representativeness of the sample, this study classified foods into four levels based on their contribution to daily sugar intake, namely level 1 (green), level 2 (yellow), level 3 (orange), and level 4 (red). This provided insight into the role of different food groups in shaping sugar consumption. The higher the food level, the higher the contribution of the food group to the daily sugar intake of school-aged children in Indonesia. Level 1 (green) is the food group with the lowest contribution to daily sugar intake, generally high in energy, protein, and fat per 100 g of food. Level 2 (yellow) is a food group that contributes moderately to the subject's daily sugar intake, but foods in this group have the second highest food energy density (kcal/g) among the levels. Meanwhile, foods in the level 3 (orange) group contribute to high daily sugar intake in subjects and have the highest food energy density (kcal/g). Level 4 is a food group that contributes the highest daily sugar intake and has the second highest carbohydrate and energy contents (per 100 g) in subjects compared to other levels, but is poor in protein and fat contents per 100 g of food.

While it is well known that snacks, processed foods, and sugar-sweetened beverages (SSBs) contribute significantly to children's sugar intake, this study provided a nuanced understanding of the specific food items and their relative contributions within these categories. For example, clustering analysis revealed that certain snack items, such as chocolate confectionery and sweetened dairy products, have a disproportionate impact on daily sugar intake despite being consumed less frequently. The high sugar content in foods commonly perceived as healthy, such as flavoured yoghurts and fruit drinks, highlights the urgent need for stricter food labelling policies. Furthermore, 'free sugars' include all monosaccharides and disaccharides added to foods or beverages by manufacturers or consumers, as well as naturally occurring sugars in honey, syrups, fruit juices, and fruit juice concentrates. Consumption of foods with free sugars may increase overnutrition, dental caries risk, reduced dietary diversity, and other health problems such as type 2 diabetes mellitus and cardiovascular risk (Lara-Castor *et al.*, 2025).

The policy implications of these findings are particularly relevant to the implementation of traffic light labelling as a public health intervention. The traffic light system, which clearly labels foods based on sugar, fat, and salt contents, has been shown to influence consumer behaviour and promote healthier choices (Ma & Zhang, 2023). However, such a system has yet to be widely adopted in Indonesia. Studies have demonstrated that front-of-pack labelling can be effective in reducing the purchase of high-sugar foods, particularly when consumers have a clear understanding of the labelling system (Guan, Lin, & Jin, 2024). Given the high sugar consumption observed in levels 3 and 4 foods, traffic light labelling could serve as a crucial tool for guiding consumer choices and reducing sugar intake among school-aged children. Policymakers should prioritise its implementation alongside public education efforts to improve label comprehension.

Although instant noodles and pasta are level 1 foods, they were generally consumed 3 times/week in reasonably large quantities of 124.65 (±80.19) g (about two serving sizes). A recent study in Indonesia found that a regular instant noodle soup contains an average sodium content of 1,627.65 mg per 100 grams, exceeding 109% of the recommended daily salt intake. In contrast, "healthier choice" instant noodles contain 697.84 mg per 100 grams, accounting for 47% of the recommended daily intake (Wibowo, Andarwulan & Indrasti, 2024). Additionally, a study in South Korea using Mendelian randomisation found a positive causal relationship between noodle consumption and metabolic syndrome, suggesting that higher noodle intake may increase the risk of abdominal obesity and hyperglycaemia (Park & Liu, 2023). This highlights a key limitation of sugar-based classification systems: foods low in sugar may still pose health risks due to other nutritional factors. To address this, a multi-nutrient classification approach should be considered, incorporating sodium, saturated fat, and total calorie contents to provide a more balanced assessment of food quality.

While tea/coffee/cocoa drinks and chocolate biscuits/wafers (dough-based sweets) are in level 2, they were consumed 3-4 times a week. Soft/fruit drinks (powder/liquid), chocolate-based sweets, ready-to-drink (RTD) cereals, and fermented milk in level 3 were consumed quite rarely by school-age children, on average 1-2 times per week; however, some of these foods were consumed by subjects on average equal to or more than 1 serving size per day. Children who frequently consume sweet snack foods can overconsume nutrients such as added sugars (Fayet-Moore *et al.*, 2022). Prior evidence confirmed that SSB consumption promotes higher body mass index and body weight in both children and adults (Nguyen *et al.*, 2023). Other systematic reviews have also shown that high SSB consumption is associated with a higher risk of type 2 diabetes mellitus in Asian populations (Neelakantan *et al.*, 2022).

Meanwhile, sweetened milk (condensed, powdered, flavoured ultra-high-temperature (UHT in level 4 is generally consumed 2 times per week, contributing to a daily sugar intake close to the upper limit (~20-23 g/day). In addition, added sugars (level 4) were consumed almost daily (6 times per week), with daily consumption also touching the maximum sugar recommendation limit for school-aged children according to ESPGHAN. This finding is consistent with another study that found flavoured skim milk to be one of the most common sources of added sugars in children's lunches (Fox, Gearan & Schwartz, 2021). A study found that flavoured milk encourages higher milk consumption among children, helping them meet essential nutrients like calcium and vitamin D. However, this type of milk raises concerns about added sugars, suggesting that while flavoured milk can support a balanced diet, its sugar content should be carefully managed (Ricklefs-Johnson & Pikosky, 2023). Indonesians prefer sweetened milk (condensed, powdered, UHT) compared to fresh milk because of its affordable price and ease of storage (Juffrie *et al.*, 2020). Given this preference, policymakers should consider regulating sugar levels in sweetened milk products, similar to policies enacted in other countries to limit added sugars in dairy products targeted at children (Mahato *et al.*, 2020).

The results also showed a consistent pattern across food levels: as sugar content increases, protein and fat content decreases. Foods high in added sugars, such as confectionery and sugary beverages, generally lack other essential nutrients, contributing to poor dietary quality (Morales-Suarez-Varela *et al.,* 2020). In contrast, level 1 foods, which are low in sugar, tend to have higher protein and fat contents due to the inclusion of animal products and vegetable oils. This supports findings from previous research indicating that energy-dense foods with high sugar content often have lower nutritional quality (Fayet-Moore *et al.*, 2022).

The food classification system developed in this study provided a practical framework for understanding sugar intake patterns among school-aged children. By categorising foods based on their sugar content, this system could serve as a valuable tool for public health interventions and policy development. Moreover, the observed differences in nutrient composition among food groups highlighted the importance of comprehensive nutrition labelling, such as the traffic light system, in guiding consumer choices, just like how ront-of-pack labelling has been shown to effectively reduce sugar consumption and encourage healthier eating habits (Ma & Zhang, 2023).

However, the classification system has limitations. For instance, instant noodles (level 1) are low in sugar but high in sodium and unhealthy fats, which could mislead consumers into perceiving them as healthy options. Instant noodles are commonly consumed by Indonesian school-aged children and are often considered a popular staple food due to their low sugar content. It is important to note that although foods in the level 1 food group are low in sugar, they are often high in other components, particularly sodium, which poses potential health risks if consumed in excess. This highlights a limitation of the sugar-based classification, as it may inadvertently classify certain unhealthy foods as healthy simply because of their low sugar content. This underscores the need for a multi-nutrient classification approach that accounts for sodium, saturated fat, and overall calorie contents. A more holistic system could help prevent misclassification and ensure that foods promoted as "healthy" meet broader nutritional criteria.

A key strength of this study is its detailed classification of foods based on sugar content and their contribution to daily sugar intake among Indonesian school-aged children, highlighting levels of food that have a significant impact on sugar consumption. By using advanced methods such as cluster analysis and PCA, the study provided a holistic understanding of dietary patterns. This will help provide a framework for targeted nutrition interventions and support more effective food labelling policies. Public health strategies should prioritise stricter food labelling, educational campaigns, and improved access to healthier alternatives to reduce the long-term health risks of excessive sugar intake in children.

CONCLUSION

This study provided a novel classification of foods into four levels of sugar intake - low (green), moderate (yellow), high (orange), and very high (red), and highlighted the contribution of specific food groups to the daily sugar intake of Indonesian schoolchildren. These findings highlighted the disproportionate impact of certain foods, such as sweetened dairy products and sugary drinks, on excessive sugar consumption and underscored the urgent need for targeted public health interventions.

The classification system offers practical applications for the development of effective nutrition policies, in particular the implementation of traffic light labelling to clearly communicate sugar content and guide healthier consumer choices. In addition, this framework can support educational initiatives aimed at improving children's diets by promoting the reduction of foods high in sugar. Future efforts should focus on adopting these strategies to reduce the risk of diet-related health problems in children and promote a healthier population.

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Authors' contributions

Humayrah W, principal investigator, conceptualised and designed the study, prepared the draft of the manuscript, conducted data analysis and interpretation, assisted in drafting of the manuscript, and reviewed the manuscript; Stefani M, member investigator, conceptualised and designed the study, prepared the draft of the manuscript for introduction; Fadlina A, member investigator, reviewed the manuscript format, conducted the study, assisted in drafting of the manuscript (results).

Conflict of interest

The authors declare that there is no conflict of interest concerning the publication of this study. We certify that we have no financial, personal, or professional relationships or affiliations that could be perceived to affect the objectivity, integrity, or impartiality of the research reported in this manuscript. The authors are committed to maintaining the highest standards of transparency and ethical conduct in the dissemination of our research.

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