Mal J Nutr 32 (2): 205 - 216, 2026

Assessment of sodium labelling compliance and Healthier Choice Logo nutrient criteria alignment in processed and ultra-processed foods in Malaysia

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ABSTRACT

Introduction: Malaysian adults consume an average of 2892 mg of sodium daily, exceeding the recommended <2000 mg/day. In response, Malaysia implemented mandatory sodium labelling in 2022; however, compliance with regulatory limits remains uncertain, as discrepancies between laboratory-analysed and label-declared sodium values have been reported internationally. Given the limited local evidence, this study examined sodium labelling compliance in selected processed and ultra-processed foods. **Methods:** A total of 52 products, including salted packaged nuts, commercially packaged biscuits, and canned fish, of which 8 bore the Healthier Choice Logo (HCL), were analysed. Sodium content was determined using flame atomic absorption spectroscopy, following dry ashing and nitric acid digestion. Compliance was assessed using the <120% regulatory tolerance criterion, primarily applied for enforcement purposes. **Results:** Only three out of the eight products (37.5%) met the regulatory tolerance criterion for sodium labelling compliance: almond (94.8 vs. 103.6 mg/100 g; label-declared vs. laboratory-analysed sodium), raisin biscuit (245.4 vs. 286.8 mg/100 g), and canned mackerel in tomato sauce (337.0 vs. 365.6 mg/100 g). The remaining products (62.5%) had higher laboratory-analysed sodium than declared. Sodium content did not differ significantly across categories. HCL products generally had lower sodium content than non-HCL products across all categories, although differences were not statistically significant for sweet cookies and canned fish. As HCL certification is voluntary, non-HCL products were also assessed against HCL nutrient criteria; none met all criteria. **Conclusion:** These findings highlight the need for more rigorous regulatory enforcement and periodic laboratory verification to ensure sodium labelling compliance in Malaysia.

Keywords: healthier choice logo, processed and ultra-processed foods, sodium labelling compliance

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doi: https://doi.org/10.31246/mjn-2026-0068

INTRODUCTION

Sodium is widely present in foods in various forms, including sodium chloride (table salt) and sodium-containing additives used for preservation and flavour enhancement. Although sodium is vital for bodily functions, such as maintaining plasma volume, acid-base balance, nerve impulse transmission, and normal cellular function, excessive sodium intake is associated with elevated blood pressure, significantly raising the risk of hypertension and related conditions such as heart disease, stroke, kidney disease, stomach cancer, osteoporosis, and obesity (NCCFN, 2021). However, in Malaysia, the National Health and Morbidity Survey (NHMS) 2024 revealed that the average sodium intake among Malaysian adults was 2892 mg/day, exceeding the World Health Organization (WHO) recommendation of <2000 mg/day. Alarmingly, 75.9% of Malaysian adults exceed this recommended limit, placing them at a higher risk of hypertension and cardiovascular complications (IPH, 2025).

Processed and ultra-processed foods, classified under the NOVA food classification system based on the nature, extent, and purpose of industrial processing, are recognised as major dietary sources of sodium. Processed foods are produced by adding salt, sugar, oil, or other culinary ingredients to unprocessed or minimally processed foods such as fruits, vegetables, and meats. Examples include freshly made packaged breads, vegetables preserved in brine, and other ready-to-eat products. In contrast, ultra-processed foods are industrial formulations manufactured predominantly from refined substances and food additives that are not commonly used in home cooking, including flavour enhancers, colourings, sweeteners, thickeners, and emulsifiers, which are added to improve taste, appearance, and shelf life (Monteiro *et al.,* 2019; Monteiro *et al.,* 2017). In Malaysia, commonly consumed processed and ultra-processed foods, such as salted packaged nuts, commercially packaged biscuits, and canned fish, are important contributors to dietary sodium intake, thereby raising public health concerns (Eng *et al.*, 2022; Gan *et al.*, 2022; Mohammad, Ramli & Razinah Sharif, 2023; Setyowati, Andarwulan & Giriwono, 2018).

To address this issue, the Malaysian government implemented sodium reduction strategies, including mandatory sodium labelling on food products. Sodium content, along with other key nutrients, such as energy, carbohydrates, protein, and fats, must be declared on the Nutrition Information Panel (NIP) in accordance with the standard format. However, discrepancies between declared sodium values on the NIP and the actual sodium content from laboratory analysis have raised concerns about the reliability of sodium labelling. Non-compliant labelling may mislead consumers, undermine sodium reduction efforts, and weaken public confidence in nutrition labelling policies. While some studies have shown good agreements between NIP and laboratory values (Ahuja *et al.*, 2019; Calliope & Sammán, 2019; Champeny *et al.*, 2023), others have reported inconsistencies, including both over- and under-declaration of sodium content (Albuquerque *et al.*, 2020; Shirani *et al.*, 2024).

Despite growing global attention to sodium labelling compliance, limited published studies have examined this issue in the Malaysian context. Kok & Mohamed Radzi (2017) studied the compliance of macronutrient labelling in Malaysia, but not sodium content. Their study found discrepancies in the labelling of energy, fat, carbohydrate, and protein, with 34.0% of products failing to comply with the tolerance limits set out under the Malaysian Food Act 1983. Given that discrepancies have been reported in macronutrient labelling, which has been mandatory for many years before the introduction of sodium labelling, it is plausible that similar issues may exist in sodium labelling. Hence, more local studies are needed to assess the compliance of sodium labelling in order to enhance the reliability of nutrition label information provided to consumers.

In addition to back-of-pack nutrition labelling, Malaysia introduced the Healthier Choice Logo (HCL) in April 2017 as a front-of-pack (FOP) labelling initiative to promote healthier food selection and support healthier lifestyles. The HCL is intended to assist consumers in identifying healthier products within the same category based on nutrient criteria established for specific food groups, including those with improved nutrient profiles such as lower sodium content. These criteria also encompass nutrients, such as energy, fat, total sugars, dietary fibre, and omega-3, which are periodically revised in line with current scientific evidence and national nutrition priorities (NCCFN, 2021; Nutrition Division, 2024). Studies conducted in other countries have shown that products carrying FOP labels generally contain lower sodium levels compared with products without such labels (Bablani *et al.,* 2020; Davies *et al.,* 2022; Mhurchu, Eyles & Choi, 2017). Despite this evidence, scarce published studies in Malaysia have examined the reliability of HCL in indicating lower sodium content, highlighting a critical gap in local evidence. As HCL is a voluntary labelling scheme, not all products within the same category carry this label in the market. Limited research has examined the extent to which non-HCL products align with the nutrient criteria established under the HCL scheme, particularly for sodium. Such an evaluation will help assess whether the HCL truly differentiates lower-sodium products in the market.

Taken together, these issues highlight a broader concern regarding the reliability of sodium-related information provided to consumers through back-of-pack nutrition labelling, in the form of sodium declaration in the NIP, and FOP labelling systems such as the HCL. Therefore, this study aimed to evaluate sodium labelling compliance in selected processed and ultra-processed foods in Malaysia, compare sodium content according to product category and HCL status, and assess the extent to which non-HCL products meet the HCL sodium-related nutrient criteria.

METHODOLOGY

Market survey, product classification and sample selection

A market survey was conducted in March 2025 to assess the sodium content declared on the NIP of selected food products, including salted packaged nuts, commercially packaged biscuits, and canned fish. Product selection was guided by the NOVA food classification system, which was used to identify and categorise foods according to the nature, extent, and purpose of industrial processing. Only products classified as processed or ultra-processed foods under the NOVA system were included in this study, as these food groups are recognised as important contributors to dietary sodium intake. The selected product categories were chosen based on their widespread commercial availability in Malaysia and their relevance as commonly consumed sodium-containing processed foods. Products were further selected based on the availability of sodium declaration on the NIP.

Both products with and without the HCL were included. Products bearing the HCL were identified and verified using the official government database to ensure accurate classification, whereas all available non-HCL products identified on supermarket shelves within the selected categories were included. Photographs of the front packaging, NIP, and HCL label were taken for documentation purposes. Nutritional information, including sodium content per 100 g, was extracted from the NIP of all selected products, and the presence or absence of the HCL was recorded. Based on this information, a subset of HCL-labelled products with relatively lower declared sodium content within each category was selected for laboratory verification. These products were purposively chosen because they represent items perceived as healthier options that are more likely to be selected by health-conscious consumers, thereby enabling the assessment of labelling accuracy in products intended to support lower sodium intake.

Alignment with HCL nutrient criteria

Using the extracted label data, nutrients declared on the NIP of products without the HCL were evaluated against the updated HCL nutrient criteria (December 2025) to assess potential eligibility. Each nutrient value per 100 g was compared with the corresponding threshold for its respective food category.

Sample preparation and extraction

Selected HCL-labelled samples for laboratory verification were prepared following AOAC Official Methods (Latimer, 2023), with minor modifications based on Norhayati *et al.* (2015). Solid samples were ground and homogenised to fine powder, while canned fish products were blended based on label specifications. For sample extraction, 5 g of each sample underwent dry ashing in a muffle furnace at 550 °C overnight, followed by nitric acid digestion and further dilution to 100 mL using distilled water, based on the Malaysian Food Composition Database protocol (National Technical Working Group of Malaysian Food Composition Database, 2011).

Determination of sodium content and sodium labelling compliance

Sodium content was determined using a flame atomic absorption spectrophotometer (Model PinAAcle 900T, PerkinElmer, Waltham, MA, USA) at a wavelength of 589.0 nm and a slit width of 0.2 nm, using acetylene gas. Calibration was performed using sodium standard solutions of 1, 5, and 10 mg/L, and all samples were analysed in duplicate. Results were converted to mg/100 g using the formula for comparison with label-declared values.

$$\frac{ppm \ \text{x} \ \left(\frac{1}{1000}\right) \ \text{x} \ 100 \ \text{x}100}{sample \ \ weight} \text{x} \ \ dilution \ \ factor$$

Sodium labelling compliance was assessed by comparing laboratory-determined sodium values with label-declared values on the NIP. The laboratory-to-label sodium ratio (%) was calculated, and compliance was defined as values less than 120% of the declared sodium content, in accordance with the Food Safety and Quality Division (FSQD, 2023).

Quality assurance and quality control

Quality control procedures were performed using a PerkinElmer flame atomic absorption spectrophotometer to ensure the accuracy and precision of sodium analysis. Sodium standard solutions with known concentrations of 1, 5, and 10 mg/L were analysed in replicates. Method performance was evaluated based on recovery and relative standard deviation (%RSD).

Data analysis

Data were analysed using IBM SPSS Statistics (Version 30.0, IBM Corp., Armonk, NY, USA). Analyses included: (i) comparison of declared sodium content between HCL and non-HCL products based on NIP; (ii) assessment of non-HCL products against HCL nutrient criteria based on NIP; and (iii) evaluation of laboratory-determined sodium in selected HCL products for labelling compliance. Descriptive statistics were presented as mean±standard deviation (*SD*) or median (interquartile range) for salted packaged nut samples, due to a small sample size. An independent *t*-test or Mann-Whitney *U* test was used to compare sodium content between HCL and non-HCL products. Welch's test was conducted to compare sodium content across product categories, as the variance homogeneity assumptions were violated. Statistical significance was set at $p<0.05$.

RESULTS

Sodium content declared on NIP by product categories and HCL status

The sodium content declared on the NIP for all processed and ultra-processed food products ($n=52$) is presented in Table 1, categorised by product categories and HCL status. Overall, products with HCL contained significantly lower sodium content than those without HCL ($t=2.34$, $p=0.024$). A significant difference was also observed in salted packaged nuts ($U=1.00$, $p=0.041$). However, no significant difference was found for sweet cookies and canned fish. Comparison across product categories using Welch's ANOVA showed no statistically significant difference in sodium content among salted packaged nuts, sweet cookies, savoury crackers, and canned fish ($F=1.01$, $p=0.417$).

Alignment with HCL nutrient criteria

Table 2 shows the alignment of nutrient content declared on the NIP with HCL criteria among non-HCL products. Based on label values, none of the non-HCL products met all HCL nutrient criteria. Alignment with sodium criteria varied across product categories: 81.8% of canned sardine or mackerel, 66.7% of canned tuna, 50.0% of sweet cookies and savoury crackers, and 15.4% of salted packaged nuts met the criterion. Among HCL-bearing products, all met the sodium criterion based on NIP values. However, some products did not meet other nutrient criteria or had incomplete nutrient declarations, for example, sugar and fibre, when assessed using label information.

Compliance of sodium labelling

Table 3 presents the compliance of sodium labelling by comparing the mean laboratory-to-label sodium ratio (%) with the sodium compliance criterion. All HCL products met the sodium criteria for HCL eligibility, but only three out of eight products (37.5%), namely almond, raisin biscuit, and canned mackerel in tomato sauce, met the regulatory tolerance criterion for sodium labelling compliance (<120%). Most products had higher laboratory-analysed sodium than declared on the NIP, especially sugar-free biscuit and tuna flakes in water, where values were approximately twice the declared amounts.

Table 1. Sodium content on NIP by product categories and HCL status (N=52)

Product category	*n (%)*	*Sodium content on NIP (mg/ 100 g) (mean±SD)*	*HCL status comparison*		*Product categories comparison*	
			t value/ *U* value	*p* value	*F* value	*p* value
All products [a]	52 (100.0)	346.42±261.71				
With HCL	12 (23.1)	223.58±105.85	2.34 [h]	0.024 *	-	-
Without HCL	40 (76.9)	383.28±228.51				
Salted packaged nuts [b]	15 (28.8)	357.00 (107.00–422.20) [f]				
With HCL	2 (13.3)	99.65 (94.80–104.50) [g]	1.00 [i]	0.041 *		
Without HCL	13 (86.7)	400.00 (177.85–448.60) [f]				
Sweet cookies [c]	8 (15.4)	311.45±139.19				
With HCL	4 (50.0)	237.65±96.96	1.69 [h]	0.143		
Without HCL	4 (50.0)	385.25±145.87				
					1.01 [k]	0.417
Savoury crackers [d]	6 (11.5)	408.90±137.89				
With HCL	0 (0.0)	N/A	N/A [j]	*N/A* [j]		
Without HCL	6 (100.0)	408.90±137.89				
Canned fish [e]	23 (44.2)	310.71±104.21				
With HCL	6 (26.1)	255.50±107.11	1.56 [h]	0.134		
Without HCL	17 (73.9)	330.20±98.99				

HCL: Healthier Choice Logo; NIP: Nutrition Information Panel; N/A: Not Applicable
*Significant at p<0.050.
[a] All products included all salted packaged nuts, commercially packaged biscuits (sweet cookies and savoury crackers), and canned fish.
[b] Salted packaged nuts included almonds, cashew nuts, macadamias, peanuts, pistachios, broad beans, sunflower seeds, and mixed nuts that have added salt.
[c] Sweet cookies included digestive biscuits, Marie biscuits, chocolate chip cookies, chocolate sandwich cookies, and oat cookies.
[d] Savoury crackers included sandwich crackers and cream crackers.
[e] Canned fish included canned sardine in tomato sauce, canned mackerel in tomato sauce, canned sardines in spring water, canned tuna in mayonnaise, oils (olive or sunflower), and water.
[f] Reported as median (25^{th}–75^{th} percentile).
[g] Reported as median (minimum–maximum) due to small sample size (n=2).
[h] Independent t-test, with reported t value.
[i] Mann-Whitney U test, with reported U value.
[j] Unable to run statistical test due to absence of data for savoury crackers with HCL.
[k] Welch's test, with reported F value, as Levene's test for homogeneity of variance was violated (p=0.022).

Table 2. Alignment with HCL nutrient criteria among products without the HCL (n=40) [a]

Product category	n (%)	Energy n (%)	Fat n (%)	Sodium n (%)	Total sugar n (%)	Dietary fibre n (%)	Omega-3 n (%)	Additional criteria n (%)	All criteria n (%)
Salted packaged nuts	13 (32.5)	N/A	4 (30.8)	2 (15.4)	4 (30.8)	12 (92.3) [b]	N/A	N/A	0 (0.0)
Commercially packaged biscuits	10 (25.0)	5 (50.0)	1 (10.0)	5 (50.0)	4 (40.0)	5 (50.0)	N/A	9 (90.0)	0 (0.0)
Sweet cookies	4 (40.0)	4 (100.0)	1 (25.0)	2 (50.0)	0 (0.0)	3 (75.0)	N/A	3 (75.0)	0 (0.0)
Savoury crackers	6 (60.0)	1 (16.7)	0 (0.0)	3 (50.0)	4 (66.7)	2 (33.3)	N/A	6 (100.0)	0 (0.0)
Canned fish	17 (42.5)	-	-	-	-	-	-	-	-
Canned sardine/mackerel	11 (64.7)	N/A	9 (81.8)	9 (81.8)	8 (72.7)	N/A	5 (45.5) [c]	1 (9.1) [d]	0 (0.0)
Canned tuna	6 (35.3)	N/A	4 (66.7)	4 (66.7)	3 (50.0)	N/A	1 (16.7) [e]	0 (0.0) [f]	0 (0.0)

HCL: Healthier Choice Logo; NIP: Nutrition Information Panel; N/A: Not Applicable
[a] Based on the HCL nutrient criteria updated in December 2025. Detailed nutrient criteria for each food category are shown in Appendix B (Nutrition Division, 2024).
[b] One salted packaged nuts product did not report dietary fibre content on the NIP.
[c] Five canned sardine/mackerel products did not report omega-3 on the NIP.
[d] Nine canned sardine/mackerel products did not report additional criteria on the NIP.
[e] Five canned tuna products did not report omega-3 on the NIP.
[f] Six canned tuna products did not report additional criteria on the NIP.

Table 3. Comparison of mean laboratory-to-label sodium ratio (%) with compliance criterion for sodium among selected products with HCL (*n*=8) [a]

Product category	*Sodium on NIP* (*mg/ 100 g*)	*Laboratory-analysed sodium* (*mg/ 100 g*) (*mean±SD*)	*Mean laboratory-to-label sodium ratio (%)*
Salted packaged nuts			
Almond	94.8	103.55±6.19	109.2 [b]
Cashew nut	104.5	140.77±1.88	134.7
Commercially packaged biscuits			
Raisin biscuit	245.4	286.81±8.36	116.9 [b]
Wholemeal biscuit	166.5	254.99±18.14	152.5
Sugar free biscuit	166.7	372.71±26.96	223.6
Canned fish			
Mackerel in tomato sauce	337.0	365.57±15.17	108.5 [b]
Tuna flakes in water	95.0	205.75±13.65	216.6
Tuna flakes in sunflower oil	294.0	364.60±9.78	124.0

HCL: Healthier Choice Logo; NIP: Nutrition Information Panel
N/A: Not Applicable
[a] Compliance criterion: <120.0% of the declared sodium value on the NIP.
[b] Compliant sodium labelling; achieved compliance criterion for sodium.

Quality control performance of sodium analysis

Table 4 presents the recovery and precision of the sodium analytical method. Quality control analysis demonstrated satisfactory analytical performance. Sodium recovery ranged from 99.5% to 100.8%, and relative standard deviation (%RSD) ranged from 1.6% to 5.2%. All analytes passed the quality control criteria, indicating good accuracy and precision of the analytical method, thus supporting the reliability of the laboratory-measured sodium data.

Table 4. Recovery and precision of sodium quality control analysis

Data Analysis	*%RSD*	*Recovery (%)*
1	5.2	100.8
2	1.6	99.5
3	3.0	100.1

DISCUSSION

Products bearing the HCL had lower declared sodium content than those without the logo, consistent with previous evidence that FOP labelling is associated with improved nutrient profiles (Bablani *et al.*, 2020; Davies *et al.*, 2022; Mhurchu *et al.*, 2017). However, significant differences were observed only among salted packaged nuts, not among canned fish and sweet cookies. The small sample size for sweet cookies (*n*=8) likely limited statistical power, while many non-HCL canned fish products met sodium criteria but failed other HCL nutrient requirements, explaining the absence of significant differences. Across product categories, no significant differences in sodium content were observed, likely due to wide within-category variation. Sodium levels varied markedly within salted packaged nuts and canned fish, reflecting differences in manufacturing practices, product reformulation, and other contextual factors (WHO, 2024). This variability highlights the potential for further sodium reduction within these categories.

In evaluating non-HCL products against HCL criteria, none of the products met the required standards. Several barriers may limit manufacturers' participation in HCL certification or product reformulation. Although the HCL application is free, manufacturers bear costs related to laboratory nutrient analysis, artwork development, and reformulation, which may pose challenges, particularly for small and medium enterprises (Nutrition Division, 2024). Reformulation may also require additional financial investment for research and technological adjustments to modify nutrient content. This is supported by a study on HCL acceptance among Malaysian food industries, which identified financial constraints, limited technical expertise, and consumer acceptability as key challenges (Sulong *et al.*, 2023). Reformulation was reported to be more likely when financial or fiscal incentives are provided (Ministry of Health, 2023).

Assessment of HCL nutrient criteria among HCL products using label information revealed discrepancies, such as missing nutrient data and sugar values not meeting HCL standards. As these evaluations rely solely on label declarations, they may not reflect actual nutrient content or compliance. Further research using accredited laboratory analysis is warranted to verify these discrepancies. Nevertheless, the findings underscore the importance of clear and complete labelling to support transparency and informed consumer decisions.

Additionally, all salted packaged nut and commercially packaged biscuit products identified as HCL-certified through the official government HCL database did not display the logo on their food packaging. The absence of the HCL on products may reflect practical constraints, such as packaging redesign costs (Nutrition Division, 2024) or the continued use of existing packaging stock, particularly among small and medium enterprises. As HCL is a voluntary initiative, manufacturers may also have flexibility regarding the timing and extent of logo implementation. However, this lack of HCL display may reduce its effectiveness in guiding healthier food choices, as consumers may be unaware that these products meet improved nutrient criteria.

In terms of sodium labelling compliance among selected HCL products, 62.5% showed higher laboratory-analysed sodium levels than those declared on the NIP, indicating frequent underreporting. More broadly, this suggests that some HCL-labelled products may not have fully met all HCL nutrient criteria in practice, despite their front-of-pack health positioning. This finding highlights a potential gap between intended HCL standards and real-world product formulation and labelling compliance. These findings differ from studies reporting that most products comply with the 120% tolerance threshold (Ahuja *et al.*, 2019; Calliope & Sammán, 2019; Champeny *et al.*, 2023) but are consistent with studies reporting frequent discrepancies (Albuquerque *et al.*, 2020; Shirani *et al.*, 2024). Discrepancies may result from batch-to-batch variations, natural differences in raw ingredients (nuts, fish, and flour), seasonality, sourcing, or inconsistencies in processing and ingredient proportions. Minor differences are expected due to natural nutrient variation and analytical variability and are generally accounted for within the 20% tolerance limit (Ahuja *et al.*, 2019; Albuquerque *et al.*, 2020). Nevertheless, underreporting in HCL products perceived as healthier could mislead consumers and undermine public health efforts to reduce sodium intake, particularly among individuals managing hypertension who rely on nutrition labels to manage their dietary intake (Ahuja *et al.*, 2019; Albuquerque *et al.*, 2020; Shirani *et al.*, 2024).

This study provides laboratory-verified evidence on sodium labelling compliance among processed and ultra-processed foods, including those with HCL, thereby contributing to limited local data in this area. However, the relatively small sample size, single-batch analysis, and non-accredited laboratory testing limit generalisability and may not fully capture batch-to-batch variability. Future research should include multiple production batches, a broader range of high-sodium food categories (e.g., gravy and sauce, soup, and cheese) and analyses conducted in accredited laboratories to better characterise sodium labelling compliance across the food supply (Haron *et al.*, 2022).

CONCLUSION

This study revealed that products carrying the HCL generally had lower sodium levels than non-HCL products, although certain categories, such as sweet cookies and canned fish, showed no significant differences. Notably, none of the non-HCL products met all HCL nutrient criteria, which may reflect challenges faced by enterprises in fully adopting current HCL initiatives. Only a minority of HCL products (37.5%) had compliant sodium labelling, highlighting the need for strengthened regulatory monitoring and periodic laboratory verification.

Government support for product reformulation may help encourage greater participation by enterprises in HCL initiatives, thereby supporting healthier food choices among consumers. Improved monitoring could also promote further compliance with national sodium reduction strategies and ensure that consumers have access to accurate and reliable nutrition information.

From a public health perspective, the general population is encouraged to make effective use of nutrition information on food labels, in line with Key Message 14 of the Malaysian Dietary Guidelines 2020, which promotes informed food selection through label reading. The findings of this study suggest that HCL products generally contained lower sodium levels, indicating that the HCL may serve as a practical front-of-pack tool to support healthier purchasing decisions, particularly in time-constrained situations. In line with Key Messages 4 and 10 of the Malaysian Dietary Guidelines 2020, the public is encouraged to prioritise home-cooked meals and reduce consumption of processed and ultra-processed foods, including ready-to-eat, frozen, and fast foods, which are major contributors to dietary sodium intake. Instead, greater emphasis should be placed on minimally processed foods such as fresh fruits, vegetables, and lean meats, which provide essential nutrients and natural flavours while reducing reliance on added salt, sauces, and flavour enhancers, thereby directly reducing overall sodium intake. Such dietary practices may support healthier eating patterns and contribute to national sodium reduction efforts.

Acknowledgement

We would like to thank the Faculty of Medicine and Health Sciences, Universiti Putra Malaysia (UPM), vote 14001 for funding this research and for providing access to laboratory and library facilities, which were essential for the successful completion of this study. We also express our sincere appreciation to Pn. Fatimah Sulong, Deputy Director, Ministry of Health Malaysia, for her preliminary review of the manuscript prior to submission.

Authors' contributions

Ng QY, conceptualised and designed the study, conducted the study, performed data analysis and interpretation, drafted the manuscript, and reviewed the manuscript; Azlan A, supervised the study, provided guidance on data analysis and interpretation, and reviewed the manuscript; Khoo LY, assisted in data analysis and interpretation, drafted the manuscript, and reviewed the manuscript.

Conflict of interest

The authors declare that there is no conflict of interest.

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