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Analysis of Sodium Content and Estimated Daily Intake from Shellfish Consumption: Case Study in Banda Aceh

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Abstract

This study aims to analyze sodium (Na) levels and estimate the daily intake (EDI) from the consumption of three shellfish species: blood mussels (Anadara granosa), kepah (Polymesoda erosa), and nipah (Geloina coaxans) obtained from Al Mahira Market and the Alue Naga area in Banda Aceh. Sodium concentrations were determined using Atomic Absorption Spectrophotometry (AAS). The results showed that sodium levels ranged from 1186 to 4656 mg/kg (wet weight). The highest EDI was found in blood mussels from Al Mahira Market at 0.99 mg/kg body weight/day (3.48% of the recommended daily sodium intake). In comparison, the lowest was observed in nipah clams from the exact location at 0.24 mg/kg body weight/day (0.86%). Overall, sodium intake from shellfish in both locations contributed less than 5% of the daily sodium limit. These findings indicate that shellfish consumption poses a low sodium-related health risk, although frequent or high intake may still contribute to long-term hypertension risk.

Keywords: Banda Aceh; estimated daily intake; health risks; shellfish; sodium

Introduction

Seafood is an essential component of the consumption patterns of coastal communities, including those in Aceh, Indonesia. One of the marine groups widely consumed is shellfish, which is part of Indonesia's biodiversity, with an estimated 8,000 species. Mussels have a strategic role in food security due to their abundant availability, affordable price, and high nutritional content, such as complete protein, essential amino acids, fat-soluble vitamins, and water (Yaghubi et al., 2021; Durazzo et al., 2022; Erniati et al., 2023; Bjerknes et al, 2024). Nevertheless, some species of shellfish also accumulate certain metals, such as sodium (Na), in varying amounts depending on the type, habitat, and location of capture.

Sodium (Na) is an essential mineral that is naturally found in a variety of foods, including seafood. In appropriate amounts, sodium is needed to maintain electrolyte balance, nerve function, and osmotic pressure in the body (Mohamed et al., 2025). However, overconsumption has become a global concern. The WHO recommends a daily intake not exceeding 2000 mg for adults, while the current average consumption reaches 4310 mg/day, more than double that threshold (World Health Organization, 2023). While the human body has mechanisms to regulate sodium levels and maintain them within normal limits, consuming too much sodium can disrupt this balance. Excessive sodium intake is directly associated with higher blood pressure (hypertension) and an increased risk of cardiovascular disease (Bernal et al., 2023; Eryanti & Farapti, 2023).

Numerous studies indicate a positive correlation between high sodium intake and rising blood pressure, changes in cholesterol and triglyceride levels, and anthropometric measurements such as body mass index (BMI), waist circumference, and body fat (Furqonia et al., 2023; Jomova et al., 2022). According to Global Health Metrics, excessive sodium consumption is responsible for approximately 1.89 million deaths worldwide each year (Global Burden of Disease Collaborative Network, 2020).

In addition, several studies have examined the metal content in shellfish, focusing on both essential metals, such as zinc (Zn) and copper (Cu), and toxic metals, such as lead (Pb) and cadmium (Cd). In Southeast Asia, shellfish are commonly used as bioindicators of metal pollution because they accumulate metals from their aquatic environments (Yap & Al-Mutairi, 2023; Puspitasari et al., 2023). However, research specifically investigating sodium (Na) content in shellfish and

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its associated health risks based on estimated daily intake remains limited.

Coastal communities in Aceh consume shellfish regularly and in substantial quantities; however, to date, no empirical study has quantified the contribution of shellfish consumption to daily sodium intake. Existing research in Aceh has primarily focused on heavy metal contamination in seafood, largely overlooking the public health risks associated with excessive sodium intake from foods traditionally regarded as safe and nutritious.

This study seeks to address this research gap by quantifying sodium levels in three commonly consumed shellfish species obtained from two major local markets in Banda Aceh, by conducting a targeted health risk assessment with particular emphasis on hypertension and related cardiometabolic diseases. The findings are expected to provide essential scientific evidence to support dietary recommendations and inform public health interventions tailored to the environmental and nutritional context of coastal communities.

Methods

Materials

Samples of blood clams (Anadara granosa), kepah (Polymesoda erosa), and nipah clams (Geloina coaxans) were collected from two locations in Banda Aceh: the Al Mahira local market and shellfish traders in the Alue Naga area. Analytical-grade reagents, including nitric acid (HNO_3), hydrogen peroxide (H_2O_2), and a 1000 mg/L sodium nitrate ($NaNO_3$) standard solution, were used for sample preparation and analysis. All dilutions and cleaning procedures were performed using deionized water to prevent contamination and ensure measurement accuracy.

Equipment

Sample digestion was performed using a microwave digestion system, with soft tissues homogenized prior to digestion. Digestion was carried out in PTFE vessels, after which the solutions were diluted in volumetric flasks. Sample weights were measured using a high-precision analytical balance. Sodium concentrations in the digested samples were determined using an Atomic Absorption Spectrophotometer (AAS) equipped with an air–acetylene flame, providing accurate and reliable measurements.

Procedure

Sample preparation

Each fresh shellfish sample was separated into soft tissue and shell. A total of 50 g of soft tissue from each mussel was homogenized. Approximately 0.5 g of each homogenized sample was weighed into a PTFE vessel, then 8 mL of nitric acid (65% v/v) and 2 mL of hydrogen peroxide (30% v/v) were added.

Samples were digested using a microwave digestion system under the conditions shown in Table 1. After digestion, the solutions were diluted to 100 mL with deionized water and analyzed for sodium content using Atomic Absorption Spectrophotometry (AAS).

Table 1. Microwave Oven Operation Settings for the Destruction Process

Step	Time (minutes)	Temperature (°C)	Microwave Power (W)
1	5	0-150	500
2	20	150	500
3	10	Cooling	-

Na metal analysis using AAS

Sodium content analysis was carried out using the PerkinElmer PinAAcle 900 T AA Spectrometer with reference to the ASTM D3561-16 method. The instrument's operating conditions are set as follows: wavelength 330.24 nm. Gap width 0.7 nm, acetylene flow rate 2.5 L/min, and oxidant (air) with a flow rate of 10 L/min. Calibration was carried out using five standard sodium solutions of 10-50 mg/L. The method was validated based on the parameters of correlation coefficient (r), accuracy (%R), precision (%RSD), and sensitivity, expressed as detection limits (MDL) and quantification limits (LOQ).

Sodium exposure assessment from food consumption patterns

Estimated daily intake (EDI)

The Estimated Daily Intake of the sodium content in the sample is calculated based on the average concentration of sodium in each type of shellfish sample and the amount of daily consumption (in grams) of the food. The average daily protein consumption for seafood is 14.6 g/ capita per day, which is the Intake Badan Pusat Statistik (2023) Rate (IR). The equations used to calculate EDI are as follows:

$$EDI = \frac{(C \times IR)}{BW}$$

Estimated Daily Intake (EDI) is an estimate of the amount of metal consumed daily based on body weight (in mg per kg of body weight per day)(Chowdhury et al., 2024; Oladeji et al., 2023). In this case, C indicates the level of the metal (Na) in the shellfish (mg/kg), and IR describes the rate of seafood consumption per day (in grams); the IR value should be converted to kilograms per day by dividing it by 1000. Meanwhile, BW refers to body weight, which is 70 kg for adults (Abdullah & Rak, 2025).

Contribution of sodium intake from shellfish consumption

The percentage contribution to the daily sodium intake limit was used to assess potential health risks from seafood, particularly shellfish, based on sodium intake. The calculation was based on comparing the Estimated Daily Intake (EDI) of sodium from shellfish consumption with the

maximum daily intake limit recommended by the World Health Organization (WHO), which is 2,000 mg per day for adults (World Health Organization, 2023).

$$\%Contribution \frac{EDI \text{x BW}}{Daily\ Intake\ Limit\ mg/day} x100$$

Based on the 2019 Indonesian Nutritional Adequacy Figures (AKG), the daily sodium intake limit for adults is also set at less than 2,000 mg per day, in line with WHO guidelines. If the value of 2,000 mg/day is converted based on a standard body weight of 70 kg, the figure is about 28.57 mg/kg of body weight per day (Kementerian Kesehatan Republik Indonesia, 2019).

However, it should be emphasized that the WHO does not recommend sodium intake in units per kg of body weight, as these guidelines are absolute and aimed at the general population. Therefore, the value of 28.57 mg/kg/day is a purely mathematical conversion, not an official recommendation value.

Results and Discussion

Validation of the Na analysis method on shellfish

Method validation has been conducted to ensure the reliability of the quantitative analysis of sodium levels in samples. The parameters tested included correlation coefficients, accuracy, precision, sensitivity, and evaluations based on the Horwitz approach (**Table 2**).

Table 2. Validation of the Na test method on shellfish

No	Parameters	Requirement	Results
1	Correlation coefficient	r ≥ 0.995	0.999
2	Accuracy	%R: 95-105%	99.23
3	Accuracy	%RSD < 2/3 CV Horwitz	0.869
4	CV Horwitz	-	11.30
5	2/3 CV Horwitz	-	7.533
6	MDL (mg/L)	-	0.275
7	LOQ (mg/L)	-	0.876

The calibration curve (**Figure 1**) yields a regression equation y = 0.0063x + 0.0056 and a correlation coefficient (r) of 0.999, indicating an excellent linear relationship. Accuracy and precision were 99.23% and 0.869%, respectively, well within the limits set by the Horwitz approach and international standards (McGeehan et al., 2020).

The method showed high sensitivity, with a method detection limit (MDL) of 0.275 mg/L and a limit of quantification (LOQ) of 0.876 mg/L, suitable for detecting sodium at low concentrations. Overall, all validation parameters met AOAC and ICH Q2(R1) criteria (Bhukya & Beda, 2024).

Sodium (Na) levels in shellfish

The results of the analysis of sodium (Na) levels in three types of shellfish collected from two locations in Banda Aceh, namely Al-Mahira Market and traders in Alue Naga, showed significant variation between shellfish species and sampling locations (**Figure 2**). The ANOVA two-way test confirmed that shellfish type ($p < 0.001$), location ($p < 0.001$), and their interaction ($p < 0.001$) had a strong effect on sodium levels. Further tests were carried out. The Tukey post hoc test showed that each combination of shellfish type and location differed significantly ($p < 0.05$).

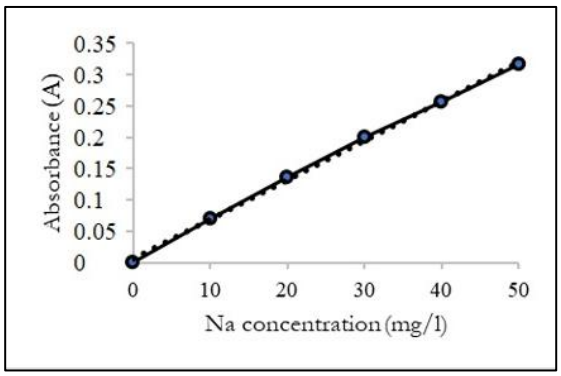


Figure 1. Calibration curve

At Al-Mahira Market, clams had the highest sodium content (4779 mg/kg), followed by blood clams (4645 mg/kg), and nipah clams (1186 mg/kg). In Alue Naga, blood clams had the highest sodium (3582 mg/kg), followed by clams (3371 mg/kg), and nipah clams (1436 mg/kg).

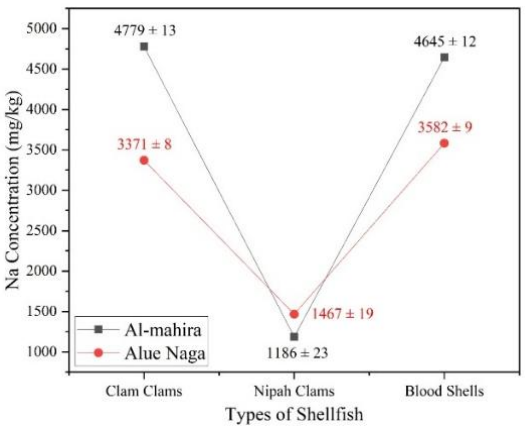


Figure 2. The interaction of shellfish type and location on sodium levels

In addition, biological and environmental factors. Biologically, shellfish differ in their sodium accumulation depending on species, age, size, and metabolic activity, with larger or older individuals typically accumulating more minerals (Agristiyani et al., 2022). The larger or older the individual shellfish is, the more it can absorb particles, including metals or minerals, from its environment. This also explains the variation between species observed in this study (Rodrigues et al., 2021).

Previous studies have reported similar variability across regions and species. For instance, sodium content in clams ranged from 27.2–152.7 mg/kg in Southeast Asia (Moniruzzaman et al.,

2021), whereas certain bivalves, such as razor clams in Indonesia, reached 2640–3394 mg/kg.

More recent findings, however, indicate that certain bivalves may serve as significant dietary sources of sodium. Bruno et al. (2024) reported that a single serving of Mytilus galloprovincialis can provide up to 36% of the recommended dietary allowance (RDA) for sodium (Kingwascharapong et al., 2024). Collectively, these studies highlight that sodium content in shellfish varies widely across species and geographic regions, with some concentrations reaching levels of nutritional and clinical relevance.

Evaluation of EDI and contribution to the daily sodium intake limit from shellfish consumption

The estimated daily intake (EDI) of sodium from three types of shellfish collected from two local markets in Aceh is presented in **Table 3**. The calculation of the EDI value was carried out based on the sodium content in the shellfish meat (mg/kg) and daily consumption patterns, then normalized to the standard body weight of adults (70 kg), so that it was expressed in units of mg/kg of body weight/day (Anderson & Ali, 2025).

Table 3. Evaluation results of EDI and impact on daily sodium intake limits for shellfish

Types of Shellfish	Al-Mahira		Alue Naga	
	EDI	%Contributions	EDI	%Contributions
Blood Shells	0.969	3.391	0.747	2.615
Clam Clams	0.997	3.489	0.703	2.461
Nipah Clams	0.247	0.866	0.305	1.067

The highest sodium intake was recorded in Al Mahira clams, with an EDI of 0.997 mg/kg body weight/day, followed by Blood Clams from the exact location (0.969 mg/kg BW/day). Meanwhile, the lowest intake was observed from Nipah Shellfish consumption from Al Mahira (0.247 mg/kg BW/day). These values show variations in sodium content across shellfish types and locations, which are influenced by environmental factors such as salinity, habitat, and post-harvest processing methods.

The EDI value is used to assess the contribution of daily sodium intake for adults, with the WHO (World Health Organization, 2020) recommending a value of 2000 mg/day. The EDI value is measured per kilogram of body weight. This value is then converted into a total daily intake (in mg/day) by multiplying the EDI by a standard body weight of 70 kg. This total can then be compared to the established threshold for sodium intake.

Based on calculations, the highest contribution comes from Al Mahira clams at 3.489%, and the lowest from Al Mahira nipah shells at 0.866%. Meanwhile, the American Heart Association (AHA) sets a daily sodium intake limit of 2,300 mg (Cheng et al., 2025; Tian et al., 2025), so the percentage of contribution will be slightly lower, but will remain within the same range.

Overall, all shellfish types from the two local markets in Aceh contributed less than 5% of the daily sodium intake limit, indicating minimal risk of excess sodium for the general adult population. In coastal communities with frequent seafood consumption, repeated intake of large portions of shellfish or shellfish combined with high-sodium foods can significantly increase total sodium intake. Sodium exposure assessments should consider dietary patterns, portion sizes, and consumption frequency to assess the potential risk of excessive sodium intake accurately.

Conclusions

The sodium levels in three types of shellfish from two local markets in Banda Aceh, blood clams (Anadara granosa), kepah (Polymesoda erosa), and nipah clams (Geloina coaxans), varied depending on species and location, ranging from 1186 to 4645 mg/kg, with the highest levels observed in clams from Al-Mahira Market. The estimated daily intake (EDI) of sodium from shellfish contributed only 0.87–3.49% of the World Health Organization's (WHO) recommended daily limit of 2,000 mg/day, indicating a low immediate health risk. However, frequent or high consumption, particularly in coastal communities where shellfish are a dietary staple, may increase cumulative sodium intake over time. Therefore, it is important to consider consumption patterns and the combination of shellfish with other dietary sodium sources to prevent long-term health risks such as hypertension.

Conflict of Interest

Regarding this study, the authors declare that they have no financial or commercial conflicts of interest.

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References

Abdullah, N. N., & Rak, A. E. (2025). Assessment of the potential health risks associated with the plumbum, cadmium, zinc, and nickel content in fish tissue collected from retention pond. *Jurnal Kesehatan Lingkungan, 17*(1), 77–84. https://doi.org/10.20473/jkl.v17i1.2025.77-84

Agristiyani, N., Suprijanto, J., & Ario, R. (2022). Asupan aman konsumsi logam Cu pada kerang darah dari tempat pelelangan ikan tambak lorok, Semarang. *Buletin Oseanografi Marina,*

11(1), 71–76. https://doi.org/10.14710/buloma.v11i1.37143

Andthony, O. O., Rashid R. J., & Ali, M. Y. (2025). Assessment of toxic elements accumulation in seagrasses and commonly edible fishes from chwaka bay, zanzibar: A threat to marine and human health. *Journal of Marine Biology and Environmental Sciences, 7*(1), 1–10. https://doi.org/10.36266/JMBES/140

Badan Pusat Statistik. (2023). *Rata-rata konsumsi protein per kapita sehari menurut kelompok komoditas dan kelompok pengeluaran di Kota Banda Aceh.* Banda Aceh: Badan Pusat Statistik.

Bernal, A., Zafra, M. A., Simón, M. J., & Mahía, J. (2023). Sodium homeostasis, a balance necessary for life. *Nutrients, 15*(2), 395. https://doi.org/10.3390/nu15020395

Bhukya, V. N., & Beda, D. P. (2024). Implementation of green analytical principles to develop and validate the HPLC method for the separation and identification of degradation products of Panobinostat, and its characterization by using LC-QTOF-MS/MS and its in-silico toxicity prediction using ADMET software. *Green Analytical Chemistry, 8*(12), 1–15. https://doi.org/10.1016/j.greeac.2023.100090

Bjerknes, H., Elvevoll, E. O., Alterskjær Sundset, M., Langdal, A., & Eilertsen, K. E. (2024). Farmed blue mussels (Mytilus edulis)—a nutrient-dense resource retaining nutritional value through processing. *Frontiers in Nutrition, 11*(November), 1-13. https://doi.org/10.3389/fnut.2024.1443229

Bruno, F., Nava, V., Zappalà, S., Costa, G. L., Fazio, F., Parrino, V., & Licata, P. (2024). Mineral composition in mussel mytilus galloprovincialis and clam tapes decussatus from faro lake of messina: Risk assessment for human health. *Frontiers in Toxicology, 6*(12), 1-9. https://doi.org/10.3389/ftox.2024.1494977

Cheng, J., Thorndike, A. N., & Yi, S. (2025). Racial and ethnic differences in sodium sources and sodium reduction behaviors among us adults: NHANES 2017 to 2020 prepandemic. *Journal of the American Heart Association, 14*(11), 1-14. https://doi.org/10.1161/JAHA.124.037997

Chowdhury, A. I., Shill, L. C., Raihan, M. M., Rashid, R., Bhuiyan, M. N. H., Reza, S., & Alam, M. R. (2024). Human health risk assessment of heavy metals in vegetables of Bangladesh. *Scientific Reports, 14*(1), 1-10. https://doi.org/10.1038/s41598-024-65734-6

Durazzo, A., Lena, G. D., Gabrielli, P., Santini, A., Lombardi-Boccia, G., & Lucarini, M. (2022). Nutrients and bioactive compounds in seafood: quantitative literature research analysis. *Fishes, 7*(3), 1-14. https://doi.org/10.3390/fishes7030132

Erniati., Andika, Y., Imanullah., Imamshadiqin., Salmarika., 'Akla, C. M. N., Yulistia, E. D., Maulana, S., & Lazuardy, R. (2023). Proximate composition of shell (bivalves) in north aceh district, aceh province based on differences in species and environmental characteristics. *International Journal of Engineering, Science and Information Technology, 3*(1), 57–62. https://doi.org/10.52088/ijesty.v1i4.424

Eryanti, F., & Farapti. (2023). Gambaran kandungan natrium pada bumbu instan varian rawon di surabaya : Survei pasar. *Jurnal Kesehatan Tambusai, 4*(4), 6487–6494. https://doi.org/10.31004/jkt.v4i4.20384

Furqonia, A. W., Farapti., & Notobroto, H. B. (2023). Is excess sodium intake a risk factor for overweight? A systematic review. *Amerta Nutrition, 7*(3), 459–467. https://doi.org/10.20473/amnt.v7i3.2023.459-467

Global Burden of Disease Collaborative Network. (2020). *Global burden of disease study 2019 (GBD 2019) disease and injury burden 1990–2019.* London: The Lancet.

Jomova, K., Makova, M., Alomar, S. Y., Alwasel, S. H., Nepovimova, E., Kuca, K., Rhodes, C. J., & Valko, M. (2022). Essential metals in health and disease. chemico-biological interactions. *Chemico-biological interactions*, *367*(September), 1-28. https://doi.org/10.1016/j.cbi.2022.110173

Kementerian Kesehatan Republik Indonesia. (2019). *Angka kecukupan gizi (AKG) Indonesia tahun 2019*. Jakarta: Kementerian Kesehatan Republik Indonesia.

Kingwascharapong, P., Janthueng, J., Kongsorn, P., Sanprasert, S., Pansawat, N., Wannawisan, N., Hunsakul, K., Ali, A. M. M., Grossman, L., Sai-ut, S., Pongsetkul, J., Phongthai, S., Zhang, W., & Rawdkuen, S. (2024). Development of seasoned green mussel (perna viridis) with sodium reduction using stealth reduction approaches. *Future Foods, 10*(August), 1-10. https://doi.org/10.1016/j.fufo.2024.100441

McGeehan, S., Baszler, T., Gaskill, C., Johnson, J., Smith, L., Raisbeck, M., Schrier, N., Harris, H., & Talcott, P. (2020). Interlaboratory comparison of heavy metal testing in animal diagnostic specimens and feed using inductively coupled plasma–mass spectrometry. *Journal of Veterinary Diagnostic Investigation, 32*(2), 291–300. https://doi.org/10.1177/1040638720903115

Mohamed, E. T., Mahmood, F. N., Merie, G. M. S., & Saadi, A. M. (2025). the medical importance of sodium and potassium. *International Journal of Pharma Growth Research Review, 2*(2), 1–10. https://doi.org/10.54660/ijpgrr.2025.2.2.01-10

Moniruzzaman, M., Sku, S., Chowdhury, P., Tanu, M. B., Yeasmine, S., Hossen, M. N., Min, T., Bai, S. C., & Mahmud, Y. (2021). Nutritional evaluation of some economically important

marine and freshwater mollusc species of Bangladesh. *Heliyon, 7*(5), 1-9. https://doi.org/10.1016/j.heliyon.2021.e07088

Oladeji, O. M., Aasa, O. A., Adelusi, O. A., & Mugivhisa, L. L. (2023). Assessment of heavy metals and their human health risks in selected spices from South Africa. *Toxicology Reports, 11*(12), 216–220. https://doi.org/10.1016/j.toxrep.2023.09.008

Puspitasari, R., Takarina, N. D., Soesilo, T. E. B., & Agustina, H. (2023). Potential risks of heavy metals in green mussels (perna viridis) harvested from cilincing and kamal muara, Jakarta Bay, Indonesia to human health. *Marine Pollution Bulletin, 189*(3), 1-8. https://doi.org/10.1016/j.marpolbul.2023.114754

Rodrigues, R. J., Nasnodkar, M. R., Nayak, G. N., & Tiwari, A. K. (2021). Bioaccumulation of metals by edible bivalve Saccostrea cucullata and its application as a bioindicator of metal pollution, tropical (zuari) estuary, Goa, India. *Arabian Journal of Geosciences, 14*(12), 1–12. https://doi.org/10.1007/s12517-021-07545-x

Tian, Y., Lin, C., Zhong, H., Wu, C., Wu, Y., Chen, B., Zhang, X., Bai, X., Yang, Y., Wang, Y., Hou, L., Cui, J., Xu, W., Song, L., Yang, H., He, W., Zhang, Y., Zhang, H., Zhang, H., Li, X., Hu, S. (2025). Associations and mediators of estimated sodium intake with cardiovascular mortality: data based on a national population cohort. *BMC Medicine, 23*(1), 1-11. https://doi.org/10.1186/s12916-025-04206-8

World Health Organization. (2023). *World health organization global report on sodium intake reduction*. Swiss: World Health Organization.

World Health Organization. (2020). *Guideline: Sodium intake for adults and children*. Swiss: World Health Organization.

Yaghubi, E., Carboni, S., Snipe, R. M. J., Shaw, C. S., Fyfe, J. J., Smith, C. M., Kaur, G., Tan, S-Z., & Hamilton, D. L. (2021). Farmed mussels: A nutritive protein source, rich in omega-3 fatty acids, with a low environmental footprint. *Nutrients, 13*(4), 1-12. https://doi.org/10.3390/nu13041124

Yap, C. K., & Al-Mutairi, K. A. (2023). Biomonitoring–health risk nexus of potentially toxic metals on cerithidea obtusa: A biomonitoring study from peninsular Malaysia. *Foods, 12*(8), 1-23. https://doi.org/10.3390/foods12081575