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Public Perception and Consumption Rate of Water Spinach (*Ipomoea aquatica*) among Malaysian Adult Population: Basis for Future Human Health Risk Assessment

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Abstract

Understanding the consumption rates of water spinach is vital for accurately assessing its impact on health and nutrition among various demographic groups in Malaysia. This research provides an updated exploration of water spinach consumption patterns and public attitudes across the country. The study was conducted using a self-administered online questionnaire distributed to Malaysian adults (aged 18 and above), resulting in 191 complete responses collected between May 2023 and March 2024. Consumption rate data, initially derived from the monthly frequency and serving size reported by participants, was converted into weight-based measurements (where 84g is the standard weight of a vegetable serve) and subsequently weighted by ethnicity to improve demographic representativeness. A recent public survey revealed that the average daily intake of water spinach stands at 69.26 grams overall, with distinct gender differences: males consume an average of 80.52 grams, while females consume 36.90 grams. These variations highlight how dietary habits may differ between men and women, possibly influenced by factors such as cultural preferences or lifestyle choices. Consumption rates also differ significantly across ethnic groups. The Malay ethnic group reported an average consumption of 74.44 grams (males at 93.20 grams and females at 38.67 grams), showing a notable gender gap. In contrast, the Chinese community exhibited lower and more uniform rates, with overall consumption at 25.76 grams (males at 25.35 grams, and females at 26.12 grams), suggesting minimal gender disparity. The Indian community, however, reported the highest rates, with an overall average of 156.56 grams (males at 136.60 grams, and females at 43.04 grams), indicating significant variation within the group. The survey further revealed that while Malaysians possess a general awareness of water spinach—commonly valued for its affordability and versatility in local cuisine—this understanding lacks depth. Many may not fully grasp its nutritional benefits, such as its rich iron and vitamin content, or the best preparation methods to preserve these qualities. To address this knowledge gap, educational initiatives are recommended. These could include public health campaigns, community workshops, and school programs, designed to enhance awareness of water spinach's health benefits, safe handling practices, and optimal cooking techniques, ensuring consumers are well-informed about this staple vegetable.

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Keyword

Public health, Consumption rate, water spinach, Malaysian demographic, Central Peninsular Malaysia.

Introduction

Ipomoea aquatica, often referred to as water spinach, is a perennial or annual plant species that grows in aquatic or semi-aquatic ecosystems (Austin, 2007; Liu et al., 2023; Wong et al., 2021; Yap et al., 2019, 2020). It is indigenous to the tropical regions of Asia and Africa, is widely grown and consumed in various areas including Southern China (Chen et al., 2010; Shen et al., 2017), Taiwan(Chen et al., 2010; Hseu et al., 2013), India (Chen et al., 2010), Thailand (Göthberg et al., 2004) and Malaysia (Wong et al., 2021). Therefore, it is widely cultured as an edible green leafy vegetable in Asian countries. Its leaves contain adequate quantities of vitamins, minerals, plant fibre, amino acids and antioxidant components. It has also been used as a traditional medicine for treating swelling, food poisoning and antioxidant-related disorders (Khwankaew et al., 2018).

Human Health Risk Assessment (HHRA) estimates the likelihood of adverse health effects from exposure to contaminants in environmental media, now or in the future (Bizjak et al., 2022). A critical step, the Exposure Assessment, evaluates the duration, frequency, extent, pathways, and routes of exposure, including human activities that lead to it. When exposure involves ingesting contaminated food or water, assessing consumption rates is key to estimating the intake of hazardous substances. Previous HHRAs on I. aquatica in Malaysia relied on generalised consumption rates (Wong et al., 2021; Yap et al., 2019, 2020), which may not reflect actual dietary habits, as typical consumers eat a variety of vegetables rather than a single type daily. Updating consumption rates and determining the frequency of water spinach (WS) consumption among Malaysians is essential for a more accurate assessment.

The present study aimed to assess the consumption habits of Malaysian consumers regarding *Ipomoea aquatica* to aid future human health risk assessment for this species.

Materials and Methods

Public Survey

A public survey was conducted to assess the consumption patterns and perceptions of water spinach (*Ipomoea aquatica*, WS) among Malaysian adults aged 18 and above. Data collection was facilitated through a self-administered online questionnaire (Appendix 1), which offered advantages such as broad accessibility, cost-effectiveness, and ease of administration, potentially improving response reliability. The survey was administered from 12th May 2023 to 23rd March 2024, utilising various social media and communication platforms for distribution. This convenience sampling method was selected to minimise respondent pressure and enhance data reliability (Andrade, 2020). A total of 191 complete responses were collected.

Sampling and Potential Biases

The target demographic for the survey was Malaysian adults aged 18 and above. However, analysis of the respondent demographics revealed a socio-economic disparity compared to the 2023 Malaysian Population Consensus (DOSM, 2023). This is a potential bias inherent in

online data collection, which may result in the over- or under-representation of specific demographic groups.

Consent approval

The public survey has been conducted with a clear disclose of its research methodology, potential adverse effects, and complications. Participants are informed of their right to withdraw from the research at any time without the need to provide justification. Furthermore, the study ensures confidentiality, guaranteeing that all personal information related to participants' identities will be kept private and secure. The public survey has been conducted and received approval from Ethics Committee for Research involving Human Subjects, Universiti Putra Malaysia (Reference no: JKEUPM-2023-688).

Quantification of Water spinach consumption

Given that humans do not typically retain precise recollections of the quantity of food they have consumed, simpler variables were investigated instead. These variables include the frequency of consuming a specific food item in a month and the number of servings of vegetables consumed per meal. The findings from these investigations were then converted into weight-based measurements using Eq. 1. 84g is the standard definition of weight of a vegetable serve.

$$Rate_{consumption}^{weight-based} = Rate_{consumption}^{serve-based} \times 84g \times (\frac{Freq_{monthly}}{30\ days}) \quad \text{(Eq. 1)}$$

To address the sampling bias and improve the representativeness of the WS consumption rates across the Malaysian population, a weighting by ethnicity statistical method was applied to the responses. This adjustment, following principles outlined by Johannesson & Perjons, (2021), allowed the final calculated consumption rates for the overall Malaysian group to be adjusted according to the national demographic proportions. The data for Malaysian consumers were calculated from each ethnicity's figures, adjusted to reflect the national demographic.

Results and Discussions

Respondents' Demographics

Among the total of 190 participants, 63 are male, accounting for 33.16% of the total, while 127 are female, constituting a larger proportion of 66.84%. In terms of ethnicity, 72 respondents identify as Malay and Bumiputera, 85 as Chinese, and 33 as Indian. These groups represent 37.89%, 44.74%, and 17.37% of the total respondents, respectively. Regarding age distribution, 90% of the respondents (177 individuals) fall within the age range of 19 to 59 years, while the remaining 10% (19 individuals) are over 60 years old. Most respondents come from metropolitan or urban areas, accounting for 93.16% of the total, with the remaining 6.84% residing in rural areas. In terms of academic background, 53.68% of the respondents have a science-related educational background, while 33.16% come from non-science fields, and 13.16% have irrelevant academic backgrounds. When considering the highest level of education attained, 32.63% of the respondents have completed postgraduate education, 50% have tertiary education, 13.68% have secondary education, and 3.68% have either primary education or no formal education. Lastly, in terms of socioeconomic status (SES), 57.89% of the respondents come from the B40 category, 31.05% from the M40 category, and 11.05% from the T20 category.

Consumption of Water Spinach

An analysis of respondent demographics revealed a socio-economic disparity compared to the 2023 Malaysian Population Consensus (DOSM, 2023), potentially skewing consumption rate assessments due to over- or under-representation of demographic groups. To improve representativeness of WS consumption rates among Malaysian ethnicities, responses were weighted by ethnicity (Johannesson & Perjons, 2021). Table 1 shows adjusted consumption rates: overall Malaysian consumers averaged 69.26 g/day (80.52 g/day for males, 36.90 g/day for females). Ethnic Malays and Bumiputra consumed 74.44 g/day (93.20 g/day males, 38.67 g/day females), Chinese 25.76 g/day (25.35 g/day males, 26.12 g/day females), and Indians 156.56 g/day (136.60 g/day males, 43.04 g/day females).

Demographic factors like age and gender influence vegetable consumption, affecting heavy metal exposure. Younger adults, particularly students, consume fewer vegetables, increasing health risks from heavy metals (Mello Rodrigues et al., 2019). These habits may persist in adulthood, necessitating increased vegetable intake promotion. Older adults often prefer healthier foods, potentially reducing consumption of heavy metal-contaminated vegetables. Women consume approximately 30% more vegetables than men, who prefer meat and processed foods, reducing women's heavy metal exposure (Li et al., 2024). Men face higher risks of heavy metal-related health issues, such as cardiovascular diseases, due to dietary and biological differences (Idowu et al., 2023). Thus, age and gender significantly shape vegetable consumption patterns and associated heavy metal exposure risks.

Table 1. Ethnic variation in WS consumption rate and bodyweight by Malaysian consumers

		$Consumption_{serve}$	±	SE	$Freq_{monthly}$	±	SE	Body weight (kg)	±	SE	$Consumption_{weight-based}$
Malaysian[1]	Overall	1.50	±	1.13	16.45	±	7.17	74.88	±	5.37	69.26
	Female	1.47	±	0.63	19.53	±	7.16	73.33	±	42.79	80.52
	Male	1.09	±	0.38	12.04	±	4.72	71.55	±	10.88	36.90
Malay and Bumiputera	Overall	1.33	±	0.47	19.99	±	7.20	78.33	±	56.40	74.44
	Female	1.38	±	0.49	24.12	±	7.48	79.38	±	50.80	93.20
	Male	1.00	±	0.26	13.81	±	3.47	70.00	±	5.60	38.67
Chinese	Overall	1.44	±	0.80	6.39	±	7.09	64.20	±	54.57	25.76
	Female	1.47	±	0.83	6.16	±	6.32	58.36	±	29.18	25.35
	Male	1.39	±	0.77	6.71	±	8.04	72.54	±	25.39	26.12
Indian	Overall	3.73	±	9.38	14.99	±	7.86	82.73	±	27.30	156.56
	Female	2.62	±	1.44	18.62	±	7.43	68.15	±	8.86	136.60
	Male	1.20	±	0.41	12.81	±	7.08	92.20	±	18.44	43.04

[1] The data for Malaysian consumers were calculated from each ethnicity adjusted according to Malaysian demographic.

The consumption rate of vegetables among Malaysian communities was previously analysed to evaluate the human health risk associated with different types of vegetables (Wong et al., 2021). The data on vegetable consumption used in the Human Health Risk Assessment was obtained from a previous study that focused on the overall fruit and vegetable intake among Malaysian consumers (Nurul Izzah et al., 2012). HHRA based on a generalised consuming figure has an intrinsic shortcoming. The assessment was made based upon an assumption that the public would consume identical food constantly. Therefore, a more realistic and accurate consumption data would be necessary for an accurate HHRA.

In current survey, Malaysians were found to have a bodyweight ranging from 58.36-82.73kg. This weight range is consistent with a previous study conducted in 2008-2009, which reported average bodyweights of 62.0kg for Overall Malaysians, 62.0kg for Malays, 60.5kg for Chinese, and 63.9kg for Indians (Ahmad et al., 2016). These findings suggest that there has been minimal change in the bodyweight of Malaysians since the 2008-2009 study period. This

assessment is also in conjunction with finding by a survey in 2013 surveyed for >18-year-old Malaysian bodyweight at 67.2-71.4kg (Ibrahim et al., 2013).

Knowledge and Perceptions of Respondents Regarding Water Spinach

Malaysian perception to WS was assessed via 5-point Likert scale via 15 questions. Each question represented a common conception in regards of WS (Table 2). The Key findings of this public survey were summarised in Table 3.

Malaysian consumers demonstrated strong awareness of WS's ecological significance. The survey revealed high recognition of its native status and adaptability to aquatic and terrestrial environments, reflecting its prevalence in local agriculture and cuisine. Significant acknowledgment existed regarding its capacity to absorb heavy metal pollutants and its potential for bioremediation. However, awareness of its invasiveness in non-native regions was moderate. Widespread agreement confirmed its suitability for subtropical and tropical climates. These findings highlighted a positive perception of WS's ecological contributions.

WS's nutritional value and diverse applications were well-recognised. The survey indicated strong awareness of its richness in protein, carbohydrates, minerals, and vitamins, reinforcing its status as a valuable food source. Its role in livestock nutrition and aquaculture was also well-acknowledged. There was a consensus, with some reservations, about its potential protective effect against diabetes. However, recognition of its potential to combat high cholesterol was more mixed, suggesting a need for further education.

Malaysian consumers exhibited a robust understanding of WS's propagation methods. The survey highlighted strong recognition that it could be grown from seeds and cuttings, reflecting practical knowledge likely tied to local agricultural traditions, underscoring its accessibility and ease of cultivation.

This survey showed that Malaysian consumers generally held WS in high regard across ecological, nutritional, and cultivation dimensions. The perceptions of health benefits and risks revealed areas where further education could address knowledge gaps. Strong awareness of safety practices alongside contamination concerns highlighted a conscientious consumer base. These insights offered a foundation for public health campaigns and environmental initiatives to reinforce WS's positive attributes while addressing lingering doubts.

Limitation of Study

A notable limitation of this study lies in the restricted sample size, with only 191 complete responses collected during the survey period. An analysis of the respondent demographics indicated a socio-economic disparity when compared to the 2023 Malaysian Population Consensus (DOSM, 2023), which could potentially skew the consumption rate assessments due to the over- or under-representation of specific demographic groups. For instance, the sample was heavily skewed towards metropolitan or urban residents, who accounted for 93.16% of the total participants, while only 6.84% resided in rural areas. While the study attempted to improve the representativeness of water spinach consumption rates by weighting responses according to ethnicity, the limited and demographically imbalanced initial sample size remains a constraint in fully generalising these findings to the broader Malaysian adult population.

Table 2. Comparison of Malaysia consumers' attitudes toward water spinach in Malaysia.

			Likert Scale					Average
			1	**2**	**3**	**4**	**5**	
1	Water spinach (Kangkung) is a native (local or endemic) species for Malaysian ecosystem.	n[1]	11	1	48	48	82	**3.99**
		%[2]	**5.8**	**0.5**	**25.3**	**25.3**	**43.2**	
2	Water spinach (Kangkung) can be grown on aquatic (watery) as well as terrestrial (land) environment.	n[1]	5	5	46	34	100	**4.15**
		%[2]	**2.6**	**2.6**	**24.2**	**17.9**	**52.6**	
3	Water spinach (Kangkung) is considered as invasive pest for certain countries that it is not native for it, for example, United States.	n[1]	21	22	83	14	50	**3.26**
		%[2]	**11**	**12**	**43.7**	**7.37**	**26.3**	
4	Besides being consumed by humans, water spinach (Kangkung) is also a main ingredient in feed for livestocks, such as chickens, pigs, rabbit, cattle, and goats.	n[1]	4	5	38	43	100	**4.21**
		%[2]	**2.1**	**2.6**	**20**	**22.6**	**52.6**	
5	Water spinach (Kangkung) are rich sources of protein, carbohydrate minerals and vitamins	n[1]	3	11	60	45	71	**3.89**
		%[2]	**1.6**	**5.8**	**31.6**	**23.7**	**37.4**	
6	Water spinach (Kangkung) can also be used as a major ingredient in the food source for commercially cultured fishes such as Tilapia.	n[1]	7	23	59	41	60	**3.65**
		%[2]	**3.7**	**12**	**31.1**	**21.6**	**31.6**	
7	Water spinach (Kangkung) has the potential to absorb heavy metal pollutants, such as cadmium, lead and mercury, in its habitat, hence cleaning its surrounding environment.	n[1]	5	9	80	33	63	**3.74**
		%[2]	**2.6**	**4.7**	**42.1**	**17.4**	**33.2**	
8	Water spinach (Kangkung) has been proposed as a potential bioremediation agent against eutrophic water.	n[1]	3	5	87	42	53	**3.72**
		%[2]	**1.6**	**2.6**	**45.8**	**22.1**	**27.9**	
9	Consuming water spinach (kangkung) during confinement period after giving birth could cause weak joint in the mothers' body.	n[1]	21	11	83	25	50	**3.38**
		%[2]	**11**	**5.8**	**43.7**	**13.2**	**26.3**	
10	Consuming water spinach (Kangkung) could potentially provide consumers with diabetes.	n[1]	16	24	86	35	29	**3.19**
		%[2]	**8.4**	**13**	**45.3**	**18.4**	**15.3**	
11	In addition to propagating by seeds, water spinach can also be propagated by cuttings.	n[1]	9	19	59	47	56	**3.64**
		%[2]	**4.7**	**10**	**31.1**	**24.7**	**29.5**	
12	Water spinach (Kangkung) could be contaminated with bacteria when grown in wastewater-fed systems, causing infections to human consumers.	n[1]	9	6	36	60	79	**4.02**
		%[2]	**4.7**	**3.2**	**18.9**	**31.6**	**41.6**	
13	Consuming water spinach (Kangkung) could potentially provide consumers against high cholesterol (Hyperlipidaemia).	n[1]	8	37	80	37	28	**3.21**
		%[2]	**4.2**	**19**	**42.1**	**19.5**	**14.7**	
14	Water spinach (Kangkung) thrives in subtropical and tropical climates.	n[1]	4	4	53	31	98	**4.13**
		%[2]	**2.1**	**2.1**	**27.9**	**16.3**	**51.6**	
15	Removal of stems and bottom of water spinach (Kangkung) could reduce heavy metal intake risk.	n[1]	7	18	62	37	66	**3.72**
		%[2]	**3.7**	**9.5**	**32.6**	**19.5**	**34.7**	

[1] n=respondent count; [2] %=respondent percentage.

Table 3. Summarisation of key findings of public survey on Malaysia consumers' perception toward water spinach.

	Question	Key Findings
1	Water spinach (Kangkung) is a **native (local or endemic) species** for Malaysian ecosystem.	**High level of awareness** or appreciation of its local significance.
2	Water spinach (Kangkung) can be **grown on aquatic (watery) as well as terrestrial (land) environment**.	**Broad understanding** of its adaptability.
3	Water spinach (Kangkung) is considered as **invasive pest** for certain countries that it is not native for it, for example, United States.	**Moderate understanding** of its invasive potential abroad.
4	Besides being consumed by humans, water spinach (Kangkung) is also a **main ingredient in feed for live stocks,** such as chickens, pigs, rabbits, cattle, and goats.	**High recognition** of its role in livestock nutrition.
5	Water spinach (Kangkung) are **rich sources** of protein, carbohydrate minerals and vitamins	**High recognition** of its nutritional value.
6	Water spinach (Kangkung) can also be used as a **major** ingredient in the **food source for commercially cultured fishes** such as Tilapia.	**High awareness** of its role in fish nutrition.
7	Water spinach (Kangkung) has the **potential to absorb heavy metal pollutants**, such as cadmium, lead and mercury, in its habitat, hence cleaning its surrounding environment.	**Significant recognition** of its potential use in environmental cleanup.
8	Water spinach (Kangkung) has been proposed as a potential **bioremediation agent** against eutrophic water.	**Strong belief** in its application in improving water quality.
9	**Consuming** water spinach (kangkung) during **confinement (postpartum) period** after giving birth could cause weak joints in the mother's body.	**Mixed response** with moderate concern about its impact on postpartum health.
10	Consuming water spinach (Kangkung) could potentially **provide consumers with diabetes**.	Consensus leans towards **recognising its benefits** with some reservations.
11	In addition to propagating by seeds, water spinach can also be **propagated by cuttings**.	**Strong understanding** of its propagation methods.
12	Water spinach (Kangkung) could be **contaminated with bacteria** when grown in wastewater-fed systems, causing infections to human consumers.	**High awareness** of potential health risks.
13	Consuming water spinach (Kangkung) could potentially provide consumers **against high cholesterol (Hyperlipidemia)**.	**Mixed recognition** of its benefits with a need for further education.
14	Water spinach (Kangkung) **thrives in subtropical and tropical climates.**	**Widespread agreement** on its suitability for these climates.
15	Removal of stems and bottom of water spinach (Kangkung) could **reduce heavy metal intake risk**.	**Strong recognition** of effective pre-cooking techniques for food safety.

Despite the fore-mentioned limitations, the findings of this study still contribute on knowledge in future human health risk assessment on this species by adjustment to the relevant national demographic proportion (Johannesson & Perjons, 2021). Public perceptions of risk and benefit associated with food crops are often influenced by regulatory policies. If there is widespread concern about heavy metal contamination, this could prompt government agencies to prioritise research on soil and water quality management practices (Alengebawy et al., 2021). Regulations may evolve to include more rigorous testing protocols for heavy metals in agricultural produce, particularly those grown in areas that are prone to industrial pollution or improper disposal practices.

Additionally, public perception can drive policy decisions regarding agricultural practices. Consumers expressed a strong preference for organic or sustainably grown vegetables free from chemical pollutants, policymakers may incentivise farmers to adopt safer farming practices through subsidies or grants (Kato-Nitta et al., 2023). This shift not only aligns agricultural practices with consumer preferences but also promotes environmental sustainability. Public perceptions regarding food crops such as water spinach contribute to the shaping of consumer education and regulatory policies. Increased awareness of issues such as heavy metal contamination can lead to changes in consumer behaviour, resulting in demands for safer food production practices and stricter regulations. As such, fostering informed public discourse on food safety is essential for both consumer protection and the development of sustainable agricultural policies.

Conclusion

This study provides updated insights into the consumption patterns and public perceptions of water spinach (*Ipomoea aquatica*) among Malaysian adults, supporting future human health risk assessments. The public survey, conducted between May 2023 and March 2024, determined an average daily consumption of 69.26 grams, with males consuming 80.52 grams and females 36.90 grams. Ethnic differences were pronounced: Malay and Bumiputera consumers averaged 74.44 grams (males: 93.20 grams, females: 38.67 grams), Chinese consumers 25.76 grams (males: 25.35 grams, females: 26.12 grams), and Indian consumers 156.56 grams (males: 136.60 grams, females: 43.04 grams). These variations underscore the role of demographic factors in shaping dietary preferences. The findings enhance the accuracy of exposure assessments for water spinach, facilitating more reliable evaluations of its nutritional contributions and potential health risks in the Malaysian population.

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