

Preliminary Screening of Microplastic Contamination in Commercial Spotted Babylon (*Babylonia areolata*) and Green Mussels (*Perna viridis*): A Case Study of Muang Lampang District, Lampang Province, Thailand

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Abstract

Microplastics, as plastic fragments less than 5 millimeters (mm), are a global environmental concern that can provide a primary risk related to food contamination. Shellfish are marine organisms that are commonly subjected to microplastic contamination. The objectives of this study were to investigate microplastic contamination in spotted babylon (*Babylonia areolata*) and green mussels (*Perna viridis*) from supermarkets, local markets, and wholesale shops in Lampang province, Thailand. The results showed that spotted babylon and green mussels from the wholesale shop had the highest number of contaminated microplastics, with 1.67 ± 2.89 and 0.67 ± 0.58 particles/g wet weight, respectively. The average number of microplastics in the spotted babylon and green mussels were 0.89 ± 0.69 and 0.44 ± 0.19 particles/g wet weight, respectively. However, the number of microplastics was not significantly different among supermarkets, local markets, and wholesale shops ($p > 0.05$), and there was no significant difference between spotted babylon and green mussels ($p > 0.05$). The average length of microplastic particles found in spotted babylon and green mussels was 0.13 ± 0.14 and 0.12 ± 0.07 mm, respectively. The predominant fragment shape of microplastics found in spotted babylon and green mussels were 100.00% and 66.67%, respectively. The dominant colors of the microplastics found in spotted babylon and green mussels were blue (50.00%) and black (66.67%), respectively. The major microplastics detected were polypropylene (PP) in spotted babylon; PP and polyethylene terephthalate in green mussels. These polymers are commonly used in protective packaging and containers. Therefore, the findings of this study recommended microplastic prevention policies, especially regarding fishing and aquaculture sources. These policies could include monitoring the concentrations of microplastics in both wild and farmed seafood, encouraging circular design for fishing, evaluating the hazards and effects of microplastics on consumers, marking and tracking fishing gear to discourage discarding and facilitating the recovery of missing gear, and requiring the reporting of lost fishing and aquaculture gear to public authorities.

Keywords: Food contamination; Green mussels; Microplastic; Plastic; Spotted babylon

1. Introduction

Microplastics (MPs) are frequently described as plastic debris with a diameter of less than 5 mm (typically 50 to 5000 μm) (Wang *et al.*, 2020). They are categorized into two types based on their origin: primary

microplastics and secondary microplastics. Primary microplastics are plastic resins that are developed from the start to be minuscule in size (less than 5 mm). These plastics are commonly used for scrubbing, polishing,

and cleaning duties and can be found in consumer skin care products such as body cleansing, liquid soap, facial cleanser, and toothpaste (Punyauppa-path & Punyauppa-path, 2020). Secondary microplastics are formed when plastic waste in the environment is reduced in size through physical, biological, and chemical processes (Napper *et al.*, 2015). These degradation processes cause large plastic items (microplastics) to fracture or tear to a microscopic size (less than 5 mm). They also entail removing broken fibers from the textile production process, cleaning garments, and disposing of plastic fibers used in everyday life and fishing gear (Napper *et al.*, 2015). Microplastic contamination is a major global problem as it may have adverse effects on the environment and human health (Anthony, 2011; Wright *et al.*, 2013). According to a recent study, between 4.8 and 12.7 million tons of microplastics are discharged annually into water sources all around the world (UNEP, 2016). Microplastics were identified at all study locations along Thailand's main river, the Chao Phraya, with average abundances ranging from 0.54 ± 0.05 to 1.07 ± 0.28 pieces/L across all provinces (Ounjai *et al.*, 2022). Furthermore, numerous plastic wastes are improperly disposed of in Southeast Asia's waterways. Microplastics were found in urban areas of Chao Phraya (Thailand), Citarum (Indonesia), and Saigon River (Vietnam) at concentrations of 80 ± 60 , 12 ± 6 , and 68 ± 20 items/m³, respectively (Babel *et al.*, 2022). Numerous human activities, such as the consumption of products containing microplastics, serve as sources of microplastic contamination. This causes the introduction of microplastics into aquatic ecosystems and affects wastewater treatment systems. Furthermore, inappropriate plastic waste treatment and the dumping of plastic trash into water sources can result in microplastic contamination in water bodies. Thailand is the world's tenth-largest dumper of plastic garbage into waterways and the environment (Meijer *et al.*, 2021). Additional contributing factors include the natural breakdown of plastics in household activities, beach activities, coastal aquaculture, and fishing (Department of Marine and Coastal Resources, 2018; Khemsawat, 2016).

Consequently, the water supply and oceans have become polluted with microplastics, leading to the ingestion of these particles by aquatic organisms. The primary environmental danger associated with microplastics is their bioavailability within aquatic biota (Li *et al.*, 2015). The bioavailability of microplastics is determined by their size, density, abundance, shape, and color (Wright *et al.*, 2013). Because microplastics are bioavailable to the smallest organisms, they might spread via the food web (Prinz & Korez, 2020). A food web is made up of interconnected food chains. Most ecosystems have many populations of production organisms that are devoured by a variety of consumer populations (USEPA, 2024). Microplastics have been detected at the base of the food web in a large variety of planktonic organisms, such as zooplankton, chaetognaths, larval fish, copepods, and salps. Also, at higher trophic levels, both invertebrates, such as polychaetes, crustaceans, echinoderms, bryozoans, and bivalves, and vertebrates, such as fish, seabirds, and marine mammals, are known to ingest microplastics either directly or via lower trophic levels (von Moos *et al.*, 2012).

Microplastics pollute aquatic food chains at all trophic levels, raising concerns about their potential transmission to higher trophic levels, including human consumption (Li *et al.*, 2015). Shellfish are aquatic animals commonly consumed by Thai people, as they filter their food, allowing microplastics to pass through them and potentially enter the human body when consumed whole (Saelee *et al.*, 2021). Microplastics are currently detected in several shellfish species in various places across the world. There was microplastic contamination in mussels in France, China, New Zealand, Korea, India, Turkey, Argentina, and Thailand (Li *et al.*, 2021; Saelee *et al.*, 2021). Furthermore, clam-contaminated microplastics have been discovered in France, China, Korea, the United States, and India (Li *et al.*, 2021). They have also been discovered in China, Korea, and Thailand, in addition to the oyster (Li *et al.*, 2021; Saelee *et al.*, 2021). However, there is currently no evidence indicating the presence of microplastics in shellfish available in various marketplaces in Thailand, including

local markets, supermarkets, and wholesale shops. As a result, it is crucial to evaluate the microplastic contamination status in shellfish, including spotted babylon (*Babylonia areolate*) and green mussels (*Perna viridis*), in various marketplaces, as this constitutes an important pathway for consumer exposure to microplastics. Because of the restricted number of experiments, spotted babylon was chosen. Green mussels were chosen for this study due to their economic value as a highly sought-after seafood in Thailand. If green mussels are polluted, low pricing and convenience may result in the direct transfer of microplastics. Mussels are filter feeders, so their actions are determined by the environment (water temperature, salinity, and currents) as well as the concentration of food particles in the water. Green mussels are reliable bioindicators of marine pollution due to their propensity to collect a variety of contaminants (Phaksopa et al., 2023). Moreover, spotted babylon and green mussels are a favorite shellfish in Thailand (National Bureau of Agricultural Commodity and Food Standards, 2016).

Consequently, the number, size, shape, color, and type of microplastics in spotted babylon and green mussel samples from supermarkets, local markets, and wholesale shops were studied. This study contributes to the understanding of microplastic contamination in commercial spotted babylon and green mussels, which has the potential to cause major problems for humans. The findings of this study may offer valuable

insights to provide suitable microplastic pollution prevention policies in Thailand.

2. Methodology

2.1 Sample collection

Both spotted babylon (*Babylonia areolate*) and green mussels (*Perna viridis*) were collected from 3 different markets (a supermarket, a local market, and a wholesale shop) during August–November 2022, in Muang Lampang district, Lampang province, Thailand. When investigating the source of spotted babylon and green mussels from local markets and wholesale shops, it was discovered that the distributor also purchased seafood from Mahachai Fresh Market (Samut Sakhon province, Thailand). The supermarket vendor refused to provide any information about the sources of spotted babylon and green mussels. Samples of spotted babylon and green mussels were similar in size, weighing between 245 - 280 g and 125 - 200 g. Twenty spotted babylon individuals from each market and twenty green mussels from each market were collected. Each shellfish was wrapped in aluminum foil, placed in a stainless steel box, and delivered to the laboratory in ice-filled coolers. Sample preparation of the samples were frozen at -20 °C. with control of contamination in the laboratory through the use of equipment and sample caps to prevent airborne contamination, and the water used was de-ionized (DI).

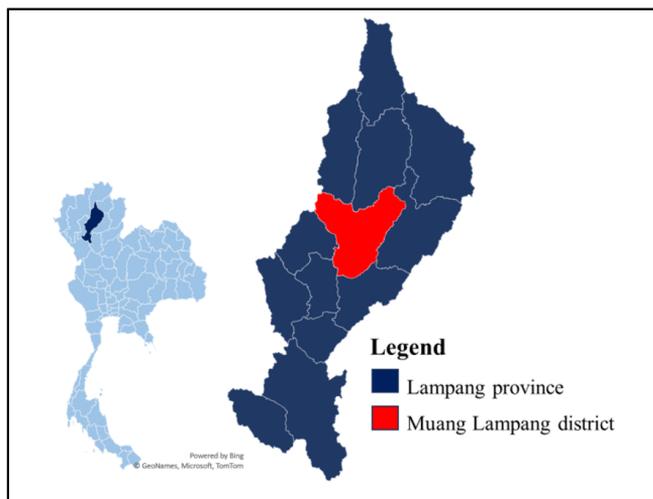


Figure 1. Study area; Muang Lampang district, Lampang province, Thailand

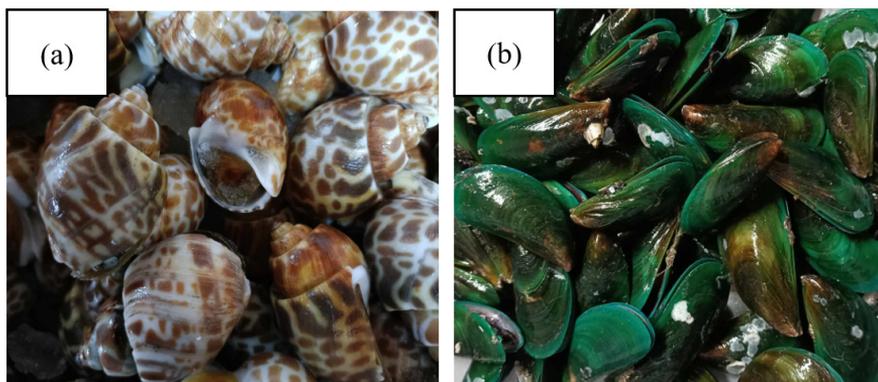


Figure 2. (a) Spotted babylon (*Babylonia areolate*) and (b) Green mussels (*Perna viridis*)

2.2 Sample preparation

The extraction of microplastics and the separation method was modified from Saelee *et al.* (2021). The frozen samples were thawed at room temperature and then weighed and measured for size, width, length, and thickness. The samples were sliced or separated into parts. Their shellfish meat was removed from the shell, and then the meat of both shellfish was separated and ground to a homogeneous texture by chopping with a knife and crushing with a mortar and pestle. It was rinsed with DI water, and approximately 1 g wet weight of the ground tissue sample was taken at random. Then, 1 g wet weight of ground sample and 200 mL of 10% potassium hydroxide (KOH) solution were added to the beaker containing the sample and heated at 60 – 65 °C until the tissue of the sample decayed. Then, 100 mL of sodium chloride (NaCl) solution (250 g/L) was added to the heated sample in the beaker and stirred for 2 min with a magnetic stirrer. The sample was poured into a 100 - mL graduated cylinder and left for 24 h to separate the organic matter and sediment from the floating microplastics according to the density of the NaCl solution. Three replications were performed on each shellfish sample from each shop. The solution was then slowly poured through a 1.2 µm GF/C filter with a filter set connected to a vacuum pump. The GF/C filter was dried in a hot air oven at 50 °C for 4 h, put in a stainless-steel box, and then stored in a desiccator.

2.3 Sample analysis

Cooled filter papers were placed on a Fourier-transform infrared spectroscopy (FT-IR) microscope (Bruker LUMOS II) to determine the number, length, shape, and type of microplastics. This microscope is capable of measuring small samples of microplastics using infrared wavelengths. Each chemical can be identified by its unique spectrum. Microplastic types were identified through attenuated total reflection (ATR) measurements, and their spectra were compared with the polymer database (IR Library). Spectra with a match quality below 70% were excluded from our dataset.

2.4 Statistical analysis

This study analyzed the differences in the number and amount of microplastics found in spotted babylon and green mussels in different markets using the SPSS program version 18 for Windows (SPSS Inc., Chicago, IL) and conducted an ANOVA test at significance level (P) of ≤ 0.05 .

3. Results and Discussion

3.1 General information on spotted babylon and green mussels

The average length, width, and thickness of spotted babylon from supermarkets were the highest, measuring approximately 48.65 ± 1.27 , 32.94 ± 1.26 , and 29.62 ± 0.59 mm, respectively, with a wet weight per shellfish

of about 10.00 ± 0.55 g. The average length, width, and thickness of green mussels from the local market measure approximately 74.65 ± 6.29 , 33.05 ± 1.13 , and 21.39 ± 1.08 mm, respectively, with a wet weight per shellfish of about 5.10 ± 0.36 g (Table 1). The ANOVA test found significant differences in average wet weight of each shellfish without shell, length, and thickness between spotted babylon and green mussels ($p < 0.05$).

3.2 Abundance of microplastics and frequency occurrences in length, shape, and color

The number and lengths of microplastic contamination in spotted babylon and green mussels from three sources (supermarket, local market, and wholesale shop) are shown in Table 2. The spotted babylon from the wholesale shop had the highest number of contaminated microplastics with 1.67 ± 2.89 particles/g wet weight (16.30 ± 28.24 particles/individual), and the average number of microplastics from the three sources was 0.89 ± 0.69 particles/g wet weight (8.29 ± 12.85 particles/individual), which was less than that of a previous study by Saelee (2020). Saelee (2020) found that the number of microplastics in spotted babylon from Fishery Wharf Market, Chonburi Province (Thailand), was 6.5 ± 3.20 particles/g (35.93 ± 13.40 particles/individual) (Saelee, 2020). The green mussels from the wholesale shop green mussel exhibited the highest number of microplastics contaminated at 0.67 ± 0.58 particles/g wet weight (2.04 ± 1.77 particles/individual),

and the average number of microplastics from the three sources was 0.44 ± 0.19 particles/g wet weight (1.75 ± 2.44 particles/individual), which is a higher number than previous reports of Bandon Bay and Sri Racha Bay (Thailand) (Ruairuen et al., 2022; Phaksopa et al., 2023). Microplastics were found in blue mussels in the amounts of 0.50 ± 0.06 particles/individual and 0.22 ± 0.57 particles/g, respectively. However, the amount of microplastics found in the green mussels was found to be lower than that of previous studies (Oanh et al., 2021; Cherdsukjai et al., 2022; Srikrajang & Prommi, 2021). It was found that the amounts of green mussels in Vietnam, Phuket (Thailand), and Nakhon Pathom fresh market (Thailand) were 1.0 ± 0.1 to 1.7 ± 0.6 particles/g, $2.7 - 5.8$ particles/individual, and 0.51 ± 0.22 particles/g, respectively (Oanh et al., 2021; Cherdsukjai et al., 2022; Srikrajang & Prommi, 2021). Compared with microplastic contamination in blue mussels, the average number of microplastics in this study were of a higher number than previous reports in Germany and South Korea (Cauwenberghe & Janssen, 2014; Cho et al., 2019). Microplastics were found in blue mussels in the amounts of 0.36 ± 0.07 particles/g and 0.12 ± 0.11 particles/g, respectively (Cauwenberghe & Janssen, 2014; Cho et al., 2019). The amount of microplastics found in the green mussels was found to be lower than that of a previous study (Saelee et al., 2021). It was found that in blue mussels from the fish market in Chonburi province, Thailand, there were

Table 1. General information about spotted babylon and green mussels

Information	Average \pm Standard deviation							
	Spotted babylon				Green mussels			
	S ¹	L ²	W ³	Ave ⁴	S ¹	L ²	W ³	Ave ⁴
Wet weight of each shellfish without shell (g/shellfish)	10.00 ± 0.55	7.86 ± 0.57	9.78 ± 0.47	$9.21 \pm 1.18^*$	4.52 ± 0.28	5.10 ± 0.36	3.06 ± 0.13	$4.23 \pm 1.05^*$
Length (mm)	48.65 ± 1.27	46.85 ± 2.47	47.07 ± 2.54	$47.53 \pm 0.98^*$	73.03 ± 2.67	74.65 ± 6.29	56.59 ± 6.69	$68.09 \pm 9.99^*$
Width (mm)	32.94 ± 1.26	31.82 ± 0.66	31.11 ± 1.71	31.96 ± 0.92	30.91 ± 1.16	33.05 ± 1.13	26.63 ± 2.97	30.20 ± 3.27
Thickness (mm)	29.62 ± 0.59	28.58 ± 0.97	27.68 ± 2.16	$28.63 \pm 0.97^*$	20.97 ± 1.54	21.39 ± 1.08	17.13 ± 1.57	$19.83 \pm 2.35^*$

¹S = Supermarket, ²L = Local market, ³W = Wholesale shop, ⁴Ave = average of spotted Babylon and green mussels from supermarket, local market, and wholesale shop

* The ANOVA analysis revealed notable distinctions in the average wet weight, length, and thickness of shellfish without shells between spotted babylon and green mussels ($p < 0.05$)

9 ± 3.55 particles/g (Saelee et al., 2021). The ANOVA test revealed that the number of microplastics was not significantly different among supermarkets, local markets, and wholesale shops (p > 0.05), and there was no significant difference between spotted babylon and green mussels (p > 0.05). However, this result indicates the presence of microplastic contamination in many spotted babylon and green mussels available in various Thai markets.

The spotted babylon discovered in the wholesale shop had microplastic particles with the longest length of 0.29 ± 0.17 mm. The average length of spotted babylon from the three sources was 0.13 ± 0.14 mm. According to an earlier study, the microplastic particles in spotted babylon were 0.24 ± 0.35 mm long (Saelee, 2020). Furthermore, Saelee (2020) found that the length of microplastics found in spotted babylon was the shortest compared to the length of microplastics found in mussels, oysters, and cockles. Green mussels from the local market had the longest microplastic particles on average, measuring 0.16 ± 0.29 mm, whereas the average length of microplastic particles found in green mussels from three sources was 0.12 ± 0.07 mm. This length is shorter than that reported in a previous research study, where microplastic particles found in green mussels from Nakhon Pathom fresh market, Thailand, measured 0.25 - 0.05 mm (Srikrajang & Prommi, 2021). However, this length is

shorter than that reported in previous research, where microplastic particles in blue mussels measured 0.64 ± 0.36 mm (Saelee, 2020).

The proportions of microplastics detected in spotted babylon and green mussels are depicted in Figure 3. The largest shape of microplastics found in spotted babylon was irregular fragments, with an average of 100.00%. Similar to other research studies, there were irregular microplastic fragments and fiber shapes (Saelee, 2020). An average of 66.67% of the microplastic particles in green mussels from three sources were fragments, followed by fibers (33.33%). In contrast to earlier investigations, this study found that green mussels in various locations in Thailand, including Bandon Bay, Phuket, Sri Racha Bay, and Nakhon Pathom fresh markets, contained the highest concentration of fibrous microplastics (Ruairuen et al., 2022; Cherdasukjai et al., 2022; Phaksopa et al., 2022; Srikrajang & Prommi, 2021). Furthermore, the sources of fragmented microplastics included littering, runoff, wind deposition, and the decomposition of large plastic waste packaging material. Fiber shape is derived from monofilament fragmentation (single fiber) of fishing nets, ropes, synthetic textiles, or textiles used for clothing. Microplastics of the pellet shape are primarily created by manufacturers as raw materials to produce plastic goods (Browne et al., 2011; Cole et al., 2011; Brahney et al., 2020).

Table 2. Number and lengths of microplastic contaminants in spotted babylon and green mussels

Shellfish /Source	Average ± Standard deviation		
	Number of microplastic (particles/g wet weight)	Number of microplastic (particles/individual)	Length of microplastic (mm)
Spotted babylon			
Supermarket (n = 3)	0.33 ± 0.58	3.33 ± 5.77	0.02 ± 0.04
Local market (n = 3)	0.67 ± 0.58	5.24 ± 4.54	0.08 ± 0.12
Wholesale shop (n = 3)	1.67 ± 2.89	16.30 ± 28.24	0.29 ± 0.17
Average	0.89 ± 0.69	8.29 ± 12.85	0.13 ± 0.14
Green mussels			
Supermarket (n = 3)	0.33 ± 0.58	1.51 ± 2.61	0.05 ± 0.08
Local market (n = 3)	0.33 ± 0.58	1.70 ± 2.94	0.16 ± 0.29
Wholesale shop (n = 3)	0.67 ± 0.58	2.04 ± 1.77	0.16 ± 0.14
Average	0.44 ± 0.19	1.75 ± 2.44	0.12 ± 0.07

The microplastics examined in this investigation were identified as being black, blue, and brown (Figure 4). Microplastics were detected in spotted babylon from three different sources, with an average of 50.00% being blue, 33.33% being brown, and 16.67% being black. Other studies of microplastics have shown only white and transparent color contamination on spotted babylon (Saelee, 2020). Black microplastics were detected in green mussels from local markets and wholesale shops, whereas blue microplastics were found in green mussels from supermarkets. In the mussels from three sources, an average of 66.67% was found in black, followed by 33.33% in blue, which is different from a previous study (Ruairuen et al., 2022). Microplastics in green mussels in Bandon Bay, Suratthani Province, Thailand,

were blue, white, and black, amounting to 41%, 22%, and 20%, respectively (Ruairuen et al., 2022). However, the majority of black microplastics in spotted babylon and mussels might have been caused by either the original color of the particles or the color of deterioration induced by the elimination of the original color by photochemical processes or other environmental processes (Ruairuen et al., 2022). Furthermore, the color of microplastics may be connected to several sources and environmental conditions throughout the transmission process, making the corresponding polymer a different color (Gallagher et al., 2016; Wang et al., 2021). The shape of microplastics is anticipated to impact particle color variety to some extent (Ruairuen et al., 2022).

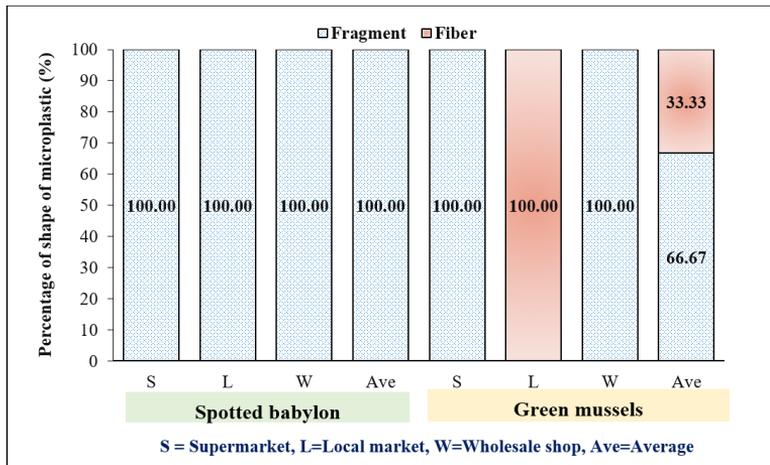


Figure 3. Percentages of the shapes of microplastic contamination in spotted babylon and green mussels

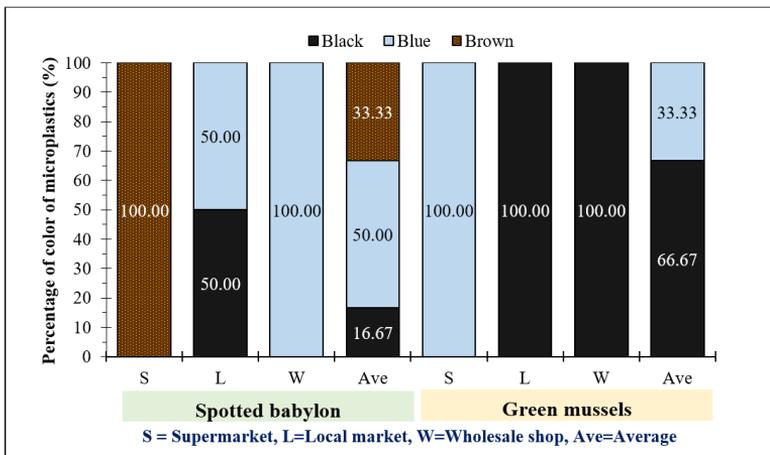


Figure 4. Percentage of colored microplastic contamination in spotted babylon and green mussels

3.3 Types of microplastics

The microplastics sampled in this study were identified as consisting of various types of plastic (Figure 5). Figure 6 shows the percentage transmission plot for the identification of microplastics. This study found that the microplastics found in spotted babylon from local markets and wholesale shops were polypropylene (PP) and accounted for 50.00% and 100.00%, respectively. Microplastics found in spotted babylon from supermarkets were polyethylene (PE), which accounted for 100.00%. However, the PP, PE, and polyacrylamide (PARA) types of microplastics were found in equal proportions in spotted babylon from three sources, each accounting for approximately 50.00%, 33.33%, and 16.67%, respectively. The study's findings differed from those of a previous study (Saelee, 2020). Polyetherimide (PEI) and polyethylene terephthalate (PET) were discovered to be the most common types of microplastics identified in spotted babylon (Saelee, 2020). This study discovered that PP accounted for 100.00% and 50.00% of the microplastics identified in green mussels from supermarkets and wholesale shops, respectively. PET were the microplastics found in the green mussels from the local market and wholesale shop, accounting for 100.00% and 50.00%, respectively. However, PP and PET microplastics were equally abundant in mussels from three sources, each accounting for 50.00% of the total. The results of the study differed from those of previous research (Saelee, 2020). It was found that the microplastic types found in blue mussel included PE (33.33%), styrene acrylonitrile (SAN, 22.22%), polytetrafluoroethylene (PTFE, 22.22%), and polystyrene (PS, 11.11%) (Saelee, 2020). PP is used in food packaging, sweet and snack wrappers, microwave containers, pipelines, and other applications. PP and PE are most likely byproducts of the weathering of larger plastic debris. Furthermore, in aquaculture farms, farmed mussels were typically tied to PP plastic lines (Feng *et al.*, 2018). Studies worldwide have discovered substantial quantities of PP and PE microplastics in marine water, sediment, and biota samples

(Cho *et al.*, 2019). The lower specific densities of PP (0.90 – 0.91 g/cm³) and PE (0.92 - 0.97 g/cm³) compared to seawater (1.02 g/cm³) enhance their transportability at sea, making them readily available to biota (Cho *et al.*, 2019). Furthermore, mussels are often grown in Thailand on the top layer of seawater columns. On the sea surface water, less dense PP and PE polymers were frequently observed (Berglund *et al.*, 2019). However, this study found that the higher specific densities of PET (1.38 g/cm³) compared to seawater (1.02 g/cm³) also has the potential to accumulate in mussels. PET, which is used to make water bottles, soft drink bottles, juice bottles, textiles, and other containers and fibers, accounted for 7.9% of European sales in 2019 (Gedik & Eryaşar, 2020). PET, utilized in water and soft drink bottles, degrades in seawater, becoming accessible to mussels (Imasha & Babel, 2021). In addition, Weis (2020) discovered that organisms living in surface waters are more likely to encounter microplastics with a density lower than that of seawater, such as PS, PP, and PE, whereas benthic organisms living at the lowest level of a water body (such as a lake or ocean) are more likely to encounter denser PET or polyvinylchloride (PVC) that settles to the bottom (Weis, 2020).

The analysis revealed that the microplastics in spotted babylon and green mussels from supermarkets were also irregularly shaped. Microplastics were found in various colors and shapes. The microplastic colors of spotted babylon and green mussels from the local market were found to be the same; however, the shape and type of microplastics differed. Microplastics discovered in spotted babylon and green mussels from wholesalers were also irregularly fragmented. Microplastics were detected in a variety of hues and shapes. Table 3 shows a comparison of microplastics in shellfish from different sources. While investigating the sources of spotted babylon and green mussels from local markets and wholesale shops, it was discovered that the distributor also purchased products from Mahachai Fresh Market (Samut Sakhon province, Thailand). However, the results of this study revealed differences in colors, shapes, and types of microplastics found in spotted babylon and green mussels

from local markets and wholesalers. The sellers in Mahachai Fresh Market (Samut Sakhon Province, Thailand) may sell seafood from farms that offer a variety of cultures. Nevertheless, the supermarket vendor refused to provide information on their sources of spotted babylon and green mussels. Based on the findings of this study, it is proposed that shellfish producers mark and track fishing gear to discourage discarding, assist in the recovery of missing gear, and require the reporting of lost fishing and aquacultural gear to public authorities. Sellers and consumers should be able to find out the original sources of these edible shellfish, which are also readily available.

Microplastics in the spotted babylon and green mussels mainly accumulate in tissues, the circulatory system, and the gastrointestinal tract. The accumulation of microplastics depends on their size. Smaller microplastics (approximately 3 µm) had a higher accumulation rate and duration in shellfish than larger ones (Cauwenberghe & Janssen, 2014; Mathalon & Hill, 2014). Small microplastics can impact the immune system, and cause mortality in the mollusks due to their more efficient food filtration system compared to larger microplastics. As a result, microplastics are regarded as a significant source of economic and industrial losses in the global aquaculture sector (Détrée & Gallardo-Escárate, 2018; Walkinshaw et al., 2020; Thomas et al., 2020; Provenza et al., 2020). Although the study's

results showed microplastics in both shellfish species within a size range of 0.02 to 0.29 mm, which is classified as large microplastics, such contamination can affect human health. A recent study suggests that consumers can reduce the quantity of microplastic contamination in shellfish. Birmstiel et al. (2019) advised soaking shellfish in water for at least 93 h prior to ingestion or cooking to remove pollutants or microplastics. Based on the findings of this study, we provide recommendations for monitoring microplastic contamination in seafood that may impact consumers. The recommendations are as follows: (i) manage plastic waste in important water sources, such as the wastewater treatment system and aquaculture facilities; (ii) promote the use of natural or biomaterials in fishing equipment among fisheries enterprises, and fishermen; (iii) conduct studies on microplastic contamination in water resources, sludge, and seafood species and fisheries; (iv) assess the hazards and fate of microplastics affecting consumers, and provide corresponding recommendations; and (v) develop an analytical method for detecting microplastics in water bodies, sludge, and seafood. Table 4 shows the microplastic pollution prevention policies. However, this study has certain limitations since shellfish samples from each source were only collected once. Therefore, further research should be conducted, involving the collection and monitoring of microplastics in shellfish samples multiple times.

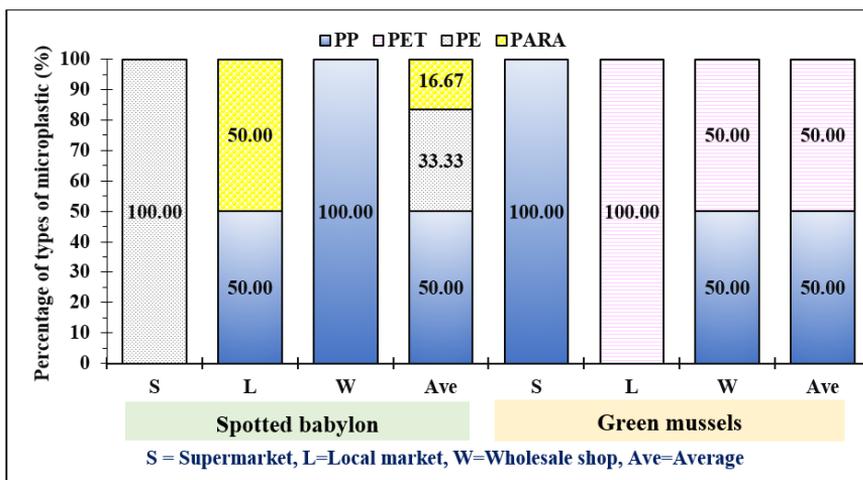


Figure 5. Percentage of microplastic-type contamination in spotted babylon and green mussels

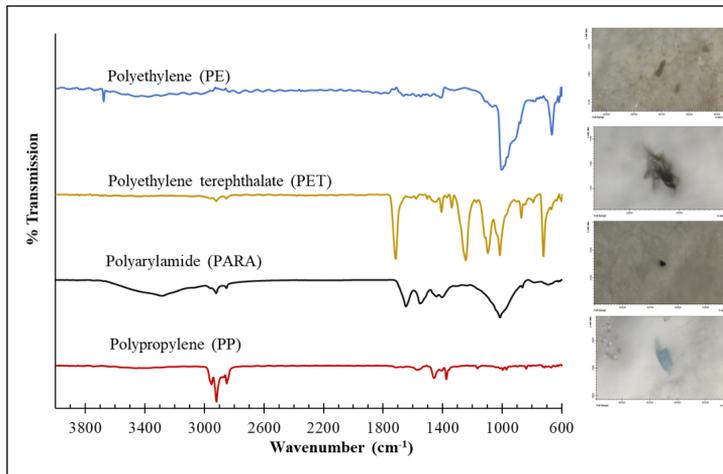


Figure 6. Percentage transmission plot for identification of microplastics by FT-IR microscope

Table 3. Comparison of microplastics in shellfish from different sources

Shellfish/ Source	Number of microplastics	Shape	Color	Type of microplastics	References
Spotted babylon (<i>Babylonia areolata</i>)					
Chonburi, Thailand	6.5 ± 3.20 particles/g	fragment, fiber	transparent, white	PET, PEI	Saelee, 2020
Lampang, Thailand - Supermarket	0.33 ± 0.58 particles/g	fragment	brown	PE	This study
- Local market	0.67 ± 0.58 particles/g	fragment	blue, black	PP, PARA	This study
- Wholesale shop	1.67 ± 2.89 particles/g	fragment	blue	PP	This study
Green mussels (<i>Perna viridis</i>)					
Vietnam	1.0 ± 0.1 to 1.7 ± 0.6 particles/g	fragment, fiber	Purple, green, black, white, blue	PS, PVC, PET, PP, HDPE	Oanh <i>et al.</i> , 2021
Bandon Bay, Thailand	0.50 ± 0.06 particles/indivi dual	fiber, film, pellet, fragment	blue, white, black, red, purple	-	Ruairuen <i>et al.</i> , 2022
Phuket, Thailand	2.7 - 5.8 particles/indivi dual	filament, fragment, sheet	blue, black, transparent, red, green	Polyester, PET, UF, PA	Cherdsukjai <i>et al.</i> , 2022
Sri Racha Bay, Thailand	0.22 ± 0.57 particles/indivi dual	fiber, sheet	black, white, red	PET, PP, nylon	Phaksopa <i>et al.</i> , 2023
Nahkon Pathom fresh market, Thailand	0.51 ± 0.22 particles/g	fiber, fragment	blue, violet	PET, PVA, PGM	Srikrajang & Prommi, 2021
Lampang, Thailand - Supermarket	0.33 ± 0.58 particles/g	fragment	blue	PP	This study
- Local market	0.33 ± 0.58 particles/g	fiber	black	PET	This study
- Wholesale shop	0.67 ± 0.58 particles/g	fragment	black	PET	This study
Blue mussels (<i>Mytilus edulis</i>)					
Chonburi, Thailand	9.00 ± 3.55 particles/g	fragment	black, white	SAN, PS, PE, PTFE	Saelee <i>et al.</i> , 2021
Germany	0.36 ± 0.07 particles/g	fragment, sphere	red, green	-	Cauwenberghe & Janssen, 2014
South Korea	0.36 ± 0.07 particles/g	fiber, fragment, film	white	PE, PP, PS	Cho <i>et al.</i> , 2019

Note: polyetherimide (PEI), urea-formaldehyde (UF), polyamide (PA), polyvinyl alcohol (PVA) and polypropylene glycol methacrylate (PGM), high-density polyethylene (HDPE)

Table 4. Microplastic pollution prevention policy (adapted from European Environmental Bureau, 2022)

Policy solution	
Horizontal recommendation	<ol style="list-style-type: none"> 1. Address all sources of microplastics that were unintentionally added in a comprehensive manner 2. Set ambitious goals for reducing plastic usage and rethinking its use. 3. Incorporate the environmental costs of plastic pollution into the product pricing. 4. Prevent microplastic contamination and eliminate single-use plastics. 5. Remove purposefully added microplastics from consumer products as promptly as possible, as well as unsustainable microplastic applications. 6. Scaling up, reusing, and repairing equipment and goods is more cost-effective and technically efficient than recycling. 7. Increase extended producer responsibility. 8. Mandatory monitoring of microplastic pollution using indicators including sediment, biota, water, and soil. 9. Prohibit the use of plastic granules, flakes, or pellets outside. 10. Regulate microplastic spills and leaks into the environment. 11. Fund, promote, and expand citizen science. Monitor initiatives for trash, plastic, and microplastic pollution. 12. Increase awareness of the harmful effects of plastic and microplastic contamination on both humans and the environment.
Specific source recommendation - Fishing and aquaculture	<ol style="list-style-type: none"> 1. Monitor the concentrations of microplastics in both wild and farmed seafood. 2. Encourage circular design for fishing gear, incorporating low-impact and long-lasting materials like natural fibers or ceramics for fishing gear, traps, and containers. 3. Evaluate the hazards and effects of microplastics on consumers and provide appropriate recommendations. 4. Mark and track fishing gear to discourage discarding and facilitate the recovery of missing gear. 5. Require the reporting of lost fishing and aquaculture gear to public authorities.

4. Conclusion

This study investigated microplastic contamination in spotted babylon and green mussels in Mueang Lampang district, Lampang province (Thailand). The occurrence of microplastics was observed in both spotted babylon and green mussels at a supermarket, a local market, and a wholesale shop, and no significant difference in microplastic accumulation at the difference sources was found. The average length of microplastic particles found in spotted babylon and green mussels was 0.13 ± 0.14 and 0.12 ± 0.07 mm, respectively. The largest shape of microplastic found spotted babylon was irregular fragments. The predominant shapes of microplastics found in green mussels were irregular

fragments and fibers. The predominant colors of microplastics found in spotted babylon and green mussels were blue and black, respectively. The major microplastics were PP in spotted babylon, and PP and PET in green mussels. These polymers are commonly used polymer types in protective packaging and containers. The ranges of polymer length, shape, color, and type suggest a variety of potential sources. These microplastics were contaminants in spotted babylon and green mussels; therefore, soaking them in water prior to ingestion or cooking is an important step to avoid the transfer of microplastics to the human body from seafood consumption. A further study is required to examine a larger proportion of shellfish and to collect samples multiple times. The relatively

limited quantity of shellfish and frequency of collection of samples in this study hindered a more comprehensive analysis. Additionally, further studies should investigate microplastic contamination in water resources, sludge, and various seafood species and fisheries. They should also assess the hazards and fate of microplastics affecting consumers and provide appropriate recommendations.

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