Occurrence of microplastics in packages of crispy dried crickets

Anchana Kuttiyawong[a], Kamontip Kuttiyawong[b] & Taeng On Prommi[c*]

[a]Division of Chemistry, Faculty of Science and Technology, Rajamangala University of Technology Phra Nakhon, Bangkok, 10800 Thailand
[b]Division of Chemistry, Department of Physical and Material Sciences, Faculty of Liberal Arts and Science, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom, 73140 Thailand
[c]Department of Science and Bioinnovation, Faculty of Liberal Arts and Science, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom, 73140 Thailand

Abstract

Microplastic contamination is a serious problem all around the world. This issue arises because microplastics impact both human health and the environment. In many countries, insects are gaining popularity as a health-promoting and protein-rich dietary alternative. The purpose of this study was to investigate microplastic contamination in five packages of crispy insects, which were separated into 3 sizes: small, medium, and large, each with ten individual insects for a total of 150 crickets. A total of 3,865 microplastic particles were found. Small-sized crispy crickets had a higher level of microplastic contamination (128 items/individual) than medium-sized crispy insects (6 items/individual). The different sizes of crispy dry crickets in each package have no correlation with the quantity of microplastics. The most common type of microplastic (74.57%) was film-shaped, followed by fiber (7.50%), lines (2.69%), and fragments (15.27%). The major plastic polymers, identified using FT-IR, included cellulose acetate and the plasticizers, including glycerol triacetate and methyl acetyl ricinoleate. According to this investigation, crispy cricket products were contaminated with microplastics. The study's findings can be used to assess the risk of microplastic exposure and the level of exposure to microplastics contaminated with other processed insect products that are often ingested.

Keywords: Edible insect, Products, Microplastics, Human health

***Corresponding author**
e-mail: faastop@ku.ac.th

Introduction

The global population is expected to reach 9.7 billion by 2050 and 11.2 billion in 2100 (Giusti et al., 2024). As a result, demand for alternative protein sources has increased dramatically, owing to rising global population, environmental concerns, and the growing popularity of health-conscious diets. Edible insects, particularly crickets, have gained popularity as a sustainable and extremely nutritional protein source. Crickets are commonly farmed for food because of their high protein level, which is comparable to that of pigs, chickens, and mackerel. Crickets also contain a large number of important amino acids for the body. They also offer benefits in terms of lowering greenhouse gas emissions and are free of pesticides, chemicals, heavy metals, and allergens (Frigerio et al., 2020).

The most commonly processed insects include crickets, followed by grasshoppers, caterpillars, silkworm pupae, beetles, ants, and scorpions (Krongdang et al., 2023). The available product formats and distribution channels include individual offerings such as frozen, dried, canned, and seasoned sachets, which are sold domestically as well as for export, including online. Powder products, such as those packaged in retail sachets and sold wholesale both locally and internationally, including online, are used as raw materials in processed foods such as pasta, baking flour components, other processed meals, and beverages. Processed food goods (domestic market), such as rice crackers, crispy bread, rice vermicelli, chili paste ingredients, porridge mixes, and rice sprinkles for protein, are largely offered online and in specialty stores. Processed food products (global market) include sweets, cookies, pasta, chocolate-coated bug nibbles (energy bars/insect bars), and burger buns that are sold to specific customers or restaurants (Melgar-Lalanne et al., 2019). Crickets are dried for a variety of reasons, including preservation against deterioration and spoiling, ease of storage and transportation, a crisp and better sensory profile, greater shelf life, and higher market value. Crickets are typically dried using 1 of 4 methods: boiling, roasting, sun-drying, or freezing. Sun-drying may entail exposing crickets to sunlight for extended periods of time, allowing the deposition of plastic particles carried into them by air. Following processing, dried crickets are stored and transported in plastic containers, polyethylene/cellophane bags, sacks, sachets, and basins (Liang et al., 2024).

Microplastics (MPs) are plastic particles ranging from 0.1 µm to less than 5 mm. Microplastics are produced directly (primary microplastics) or indirectly through the disintegration of large plastics (secondary microplastics). They have been discovered in a wide range of environmental matrices, including bottled drinking water, tap water, various foods, organisms, air, soil, sediment, and surface and groundwater (Jolaosho et al., 2025; Al-Mansoori et al., 2025). More worrying is its finding in human organs, which has the potential to inflict catastrophic harm. Recent observations of microplastic contamination in human blood, placentas, breast milk, and testes suggest a widespread invasion of human bodies. Plastic particles are harmful because of their tendency to gather and transmit poisonous organic chemicals and heavy metals. Humans are exposed to microplastics mostly by ingestion, such as drinking contaminated water or eating foods (Nawab et al., 2024). Edible insects, particularly those swallowed whole, such as crickets, are sources of microplastic ingestion by humans as well as the species that consume them. Therefore, the purpose of this study was to evaluate the number, size, color, and type of plastic particles present in varieties of crispy dry crickets that are marketed commercially in the marketplace. This study's objectives were to use the FT-IR spectrophotometric approach to describe the plastics and ascertain the quantity and presence of microplastics in packages of crispy dried crickets.

Materials and methods

1. Sampling and sample treatment

Sampling occurred from December 1st to 10th, 2024. 5 packages of crispy dried crickets were purchased from the coffee shop located at Kasetsart University's Kamphaeng Saen Campus in Nakhon Pathom Province, Thailand. Because of privacy concerns, the commercial names of the purchased products cannot be disclosed.

Crickets were divided into 3 sizes: small, medium, and large. Then, 10 dried crickets of each size were selected from each bag, resulting in 150 individuals who were part of the microplastic investigation. Each cricket was weighed, and the results were recorded. Small dried insects weigh no more than 0.250 g, medium-sized crickets weigh between 0.25 and 0.350 g, and large-sized crickets weigh 0.350 g or more. The results were presented as a mean ± standard deviation.

After weighing, each individual was transferred to the 100 mL flask. Then, 20 mL of 30% H_2O_2 was added to the samples to digest organic matter. Each flask was covered with aluminum foil and heated at 60°C in a shaken water bath at 150 rpm for 3 h, or until all organic matter had been digested. The samples were then filtered using pressure filtering equipment with a nylon membrane filter (pore size, 0.45 µm; diameter, 47 mm) (Whatman, UK) The membrane filters were then placed on a clean Petri dish, wrapped in aluminum foil, and dried in a drying chamber at 50°C for 2 d.

The presence and properties of suspected microplastics on filters after sample filtration were determined using a stereomicroscope equipped with a camera and image analysis software (Leica EZ4E, Leica Microsystems, Germany). Microplastic particle size was estimated using the LAS X software, and length was calculated from the longest side. A visual examination was also carried out to identify probable MPs using morphological characteristics such as color and shape (Hidalgo-Ruz et al., 2012). MP particles were characterized according to their shapes, including fiber, sphere, film (a thin and small layer), and fragment (a component of a larger plastic item) (Su et al., 2016, 2018). MPs were classified into four categories based on their largest diameter length (L): first-category ($L \leq 100$ µm), second-category ($100 < L \leq 250$ µm), third-category ($250 < L \leq 500$ µm), and fourth-category ($L > 500$ µm). All samples were photographed with a 35× magnification or higher lens.

2. The polymer type

To determine the polymer types, a representative number of MPs from each morphotype were randomly chosen and evaluated with a PerkinElmer Spectrum-Fourier transform Infrared spectrometer (FT-IR) in attenuated total reflection (ATR) mode. The MPs chosen reflected the most common types of visually inspected particles detected in all samples. A Hyperion 2000 FT-IR microscope with a mercury-cadmium telluride detector (Bruker Daltonik, USA) was used to manually analyze 380 particles from the crickets at wavenumbers ranging from 4000 to 600 cm^{-1}. There were 32 co-added images with a spectrum resolution of 4 cm^{-1}. The Bruker spectrum library was used to compare the functional group characterization and polymer type analyses. Woodall et al. (2014) approved spectra matching with a quality index of ≥0.7.

3. Quality control

To remove the chance of contamination, all laboratory instruments were washed 3 times with distilled water and dried in a fume hood (Lusher et al., 2015). When not in use, they were promptly sealed with aluminum lids. Throughout the laboratory phases, all personnel wore 100% cotton lab coats and nitrile gloves. Before and after each process, all work surfaces and instruments were cleaned with 70% ethanol.

4. Data analysis

Types and numbers of MPs in cricket samples were presented as mean ± SD (MPs/individual and MPs/g of sample). The number, shape, size, and color of MPs were recorded. Non-parametric analyses were utilized since the types and number of MPs did not follow a normal distribution across the 3 sample types. Differences in mean microplastic (MP) abundance among sample types were assessed using the Kruskal–Wallis H test in SPSS version 19 (IBM SPSS Statistics 19, IBM Corp., USA). Differences in the types and quantities of MPs among crickets of different size classes across 5 packages were analyzed using a two-way analysis of variance (ANOVA), with package and cricket size treated as fixed factors. Statistical significance was set at $p<0.05$.

Results and discussion

1. Quantity of MP in crickets

After weighing all 5 packages of dried crickets, which were divided into 3 sizes—small, medium, and large—with 10 crickets in each class per package, or 150 crickets total, it was determined that all 50 small dried crickets were 8.56 g (159.64±114.31 MP/g), all 50 medium dried crickets were 13.47 g (95.97±54.74 MP/g), and all 50 large dried crickets were 19.45 g (71.22±41.05 MP/g) (Table 1).

Table 1 Summary of the weight and number of MPs in each of the 3 cricket sample sizes across 5 packages

Size	n	Total weight (g)	Total MPs (particle)	MP/individual	MP/g
Small	50	8.56	1274 (range 9–128 particle)	25.48±18.51	159.64±114.31
Middle	50	13.47	1226 (range 6–54 particle)	24.52±11.44	95.97±54.74
Large	50	19.45	1365 (range 9–92 particle)	27.30±15.48	71.22±41.05

Fig. 1 shows a bar graph of the total number of MPs projected onto 5 packages of crispy dried cricket. MPs were discovered in all of the samples. The lowest number of microplastics per individual was 6, while the highest was 128. In all, 3,865 items of microplastic were found (Table 1, Fig. 2).

In all 50 replicates of pooled samples, the total number of MP particles was 1274, 1226, and 1356 in small, medium, and large sizes (Table 1, Fig. 1). The mean abundance per individual was 25.48±18.51, 24.52±11.44, and 27.30±15.48 particles in small, medium, and large sizes, respectively.

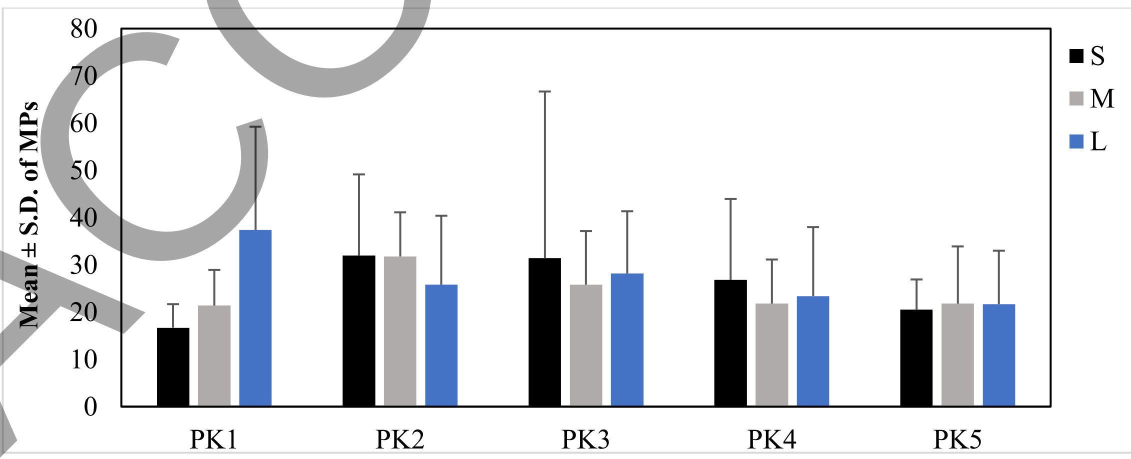

Fig. 1 The average amount of microplastics found in various sizes of crispy dried crickets. (S = small, M = medium, L = large; PK1 = package 1, PK2 = package 2, PK3 = package 3, PK4 = package 4, and PK5 = package 5)

A two-way analysis of variance revealed that the quantity of microplastic contamination measured in crispy dried crickets of different sizes was not significantly different ($p>0.05$) (Table 2). A simple linear regression study of the number of microplastics and crispy dry crickets in each size indicated no correlation (p>0.05).

Table 2 Two-way ANOVA test for MP abundance based on the influence of package and size of crispy dry crickets across all samples

Source of variation	Sum of squares	*df*	Mean square	F	Sig.
Package	1417.067	4	354.267	1.552	.191
Size	199.373	2	99.687	.437	.647
Package*size	2702.893	8	337.862	1.480	.170
Error	30821.500	135	228.307		
Total	134729.000	150			

Fig. 2 An example of a photograph of the microplastic type, size, and color found in the crispy dried cricket. Scale bar = 500 µm. Photos numbered 1–8 as fibers; numbers 18, 20, and 21 as lines; numbers 172–185 as fragments; and number 163 as film.

MPs in edible insects have been addressed (Maneechan & Prommi, 2022). A dragonfly larva, *Pantala* sp. (Odonata: Libellulidae), was found to be contaminated with microplastics. The microplastics content was 121 in the entire body, 95 in the gastrointestinal tract, and 66 in the body without the gastrointestinal tract, with an average abundance of 1.34±1.11, 1.06±0.77, and 0.73±0.51/individual, respectively (Maneechan & Prommi, 2022). Microplastic contamination was found in 261 longhorned beetles collected from 4 Chinese cities: Hangzhou (4.0 items/ind.), Wuhan (2.9 items/ind.), Kunming (2.5 items/ind.), and Chengdu (2.3 items/ind.). This demonstrates that when processed meals are produced in greater quantities—insects being one of the most popular processed foods today—microplastic contamination in the environment is growing and may affect humans through the food chain (Zhu et al., 2023). Although the MP contamination rate varies between regions, direct comparisons are not possible. One possible explanation for this variation is the employment of various analytical procedures. Furthermore, variations in the manufacturing techniques of crispy dry crickets may add to these discrepancies.

2. Shape of MPs

The morphology of the 3,865 suspected microplastic items detected varies and can be classified into 4 shapes: fragments, fibers, lines, and films. The most likely microplastics were detected in the form of film (2,882 items, or 74.57%), followed by fragmented items (590 items, 15.27%), fibers (290 items, 7.50%), and lines (104 items, 2.69%) (Figs. 2–3). Other studies (Maneechan & Prommi, 2022) have found that the primary forms of MPs are fragments and fibers, which is consistent with our findings. According to Maneechan & Prommi (2023), fragments and fibers were the most common types of polymers identified in odonate larvae (Aeshnidae: *Anax* sp.) in rice fields, whereas spheres and film accounted for less than 7%.

The shape differences between the suspected microplastic items were compared using a non-parametric test (Kruskal-Wallis H test). The fibers and films of small dried crickets differed significantly ($X^2 = 11.834$, $df = 4$, $p = 0.019$; $X^2 = 11.513$, $df = 4$, $p = 0.021$). There was no statistically significant difference between the fragment and line ($X^2 = 6.278$, df = 4, $p = 0.179$; $X^2 = 5.123$, $df = 4$, $p = 0.275$). In medium-sized crispy dried crickets, it was discovered that the fragment, fiber, line, and film were not statistically significantly different ($X^2 = 2.991$, $df = 4$, $p = 0.559$; $X^2 = 0.907$, $df = 4$, $p = 0.924$; $X^2 = 2.088$, $df = 4$, $p = 0.720$; $X^2 = 8.604$, $df = 4$, $p = 0.072$). The film considerably differed in large crispy dried crickets ($X^2 = 9.571$, $df = 4$, $p = 0.048$). There was no statistically significant difference between fragments, fibers, and lines ($X^2 = 2.061$, $df = 4$, $p = 0.725$; $X^2 = 3.685$, $df = 4$, $p = 0.450$; $X^2 = 8.939$, $df = 4$, $p = 0.063$).

Fig. 2 shows stereomicroscope images of MPs with various shapes, sizes, and colors. Accordingly, the real color and type of particles may be examined using a stereomicroscope. As seen in Fig. 2, fragments and fibers are clearly apparent. Microplastic contamination from food packaging has arisen as a major public health concern due to its ability to migrate into food products and cause chronic human exposure. However, incidents of contamination in edible insect packaging are still low when compared to conventional food packaging (Chinglenthoiba et al., 2025). While specific studies on microplastics in packages of crispy dried crickets are lacking, research shows that microplastic contamination in packaged food is a widespread concern. Edible insects, including crickets, can accumulate microplastics from various sources. Crickets are predominantly contaminated with microplastics (MPs) via their surroundings and food supply, rather than from the final packing. Crickets ingest microplastics from contaminated soil, water, and feed, which are frequent sources in terrestrial environments (Fudlosid et al., 2022). Although research on microplastic contamination in packaged cricket crisps is still scarce, previous research on packaged salt found that some particles extracted from salt samples were similar in composition to the packaging itself (Karami et al., 2017). These findings indicate that salt products may become contaminated as a result of packaging material degradation. The method of producing table salt, which includes salt rock milling from a mine, centrifugation, and packing, may explain why there are more pieces than fibers in current MPs. Some unit mechanisms in sugar can alter fragment size and abundance. These include washing, preparing beet slices or shredding sugarcane, and drying the pulp using pressing, centrifugation, and packaging. Rubbing the beet slices together improves washing because it breaks the MPs into fragment particles (Karami et al., 2017).

The shape of MPs is important because of their fate and negative effects on human health. For example, consider the migration of fragment particles into cells. Stock et al. (2020) discovered that the physicochemical properties of MPs, such as shape and size, can influence the movement of MP particles into the gastrointestinal tract. Gray & Weinstein (2017) found that the form of MPs has a significant effect on polymer uptake in grass shrimp. They also discovered that fragments accumulate more than spheres and fiber particles in shrimp guts. Makhdoumi et al. (2021a) found that MPs accumulate in fish muscle. They found that fragment particles were composed of approximately 96% of the particles, with fiber accounting for roughly 4% (Makhdoumi et al., 2021b). According to Qiao et al. (2019), shape influences the impact of MPs and should not be ignored when evaluating their health risks. They also discovered that MP buildup can lead to a variety of toxic effects in the zebrafish intestine, including mucosal injury, inflammation, and metabolic disturbance, with fibers being more harmful than fragments or beads (Qiao et al., 2019).

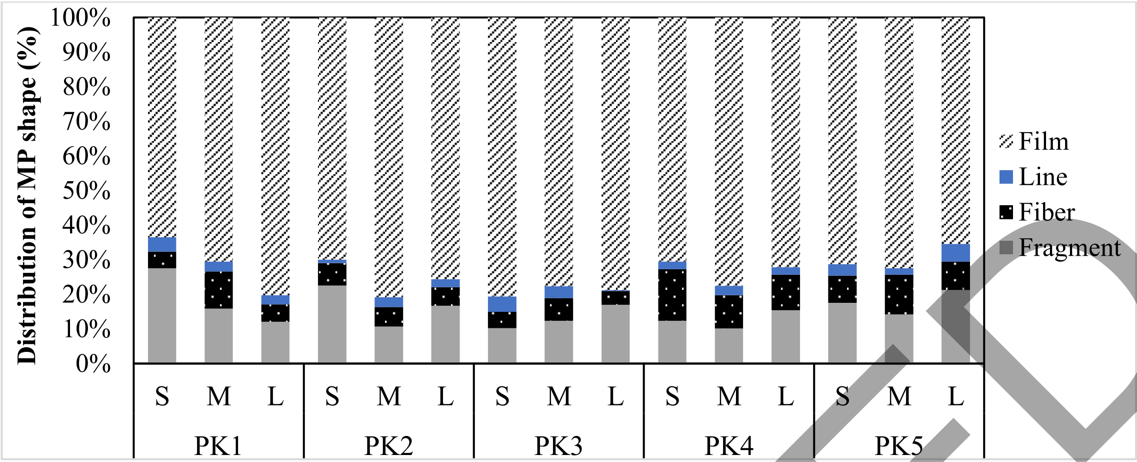

Fig. 3 The percentage of MP shapes in crispy dry crickets. (S = small, M = medium, L = large; PK1 = package 1, PK2 = package 2, PK3 = package 3, PK4 = package 4, and PK5 = package 5)

3. Size distribution of MPs

Dried crickets contained microplastics ranging in size from less than 100 µm to more than 500 µm. Microplastics smaller than 100 µm were the most common, accounting for 2,528 items (65.41%), followed by those between 100–250 µm (1,002 items, 25.92%), > 500 µm (175 items, 4.53%), and 250–500 µm (160 items, 4.14%) (Fig. 4).

There was a significant difference in the microplastics in small dried crickets that were less than 100 µm and those that were between 100–250 µm in size ($X^2 = 9.754$, *df* = 4, p = 0.045; $X^2 = 11.063$, *df* = 4, p = 0.026). There was no significant difference in the sizes of 250–500 µm and >500 µm. The microplastic content of medium-sized dried crickets varied significantly between those that were 100–250 µm in size and those that were less than 100 µm ($X^2 = 12.476$, *df* = 4, p = 0.045). 0.014; X2 = 9.825, *df* = 4, p = 0.043. There was no statistically significant difference between the sizes of 250–500 µm and >500 µm. There was no statistically significant difference in the <100 µm, 100–250 µm, 250–500 µm, and >500 µm sizes in large dried crickets ($X^2 = 8.970$, *df* = 4, p = 0.062; $X^2 = 5.974$, *df* = 4, p = 0.201; $X^2 = 5.687$, *df* = 4, p = 0.224; $X^2 = 4.081$, *df* = 4, p = 0.395).

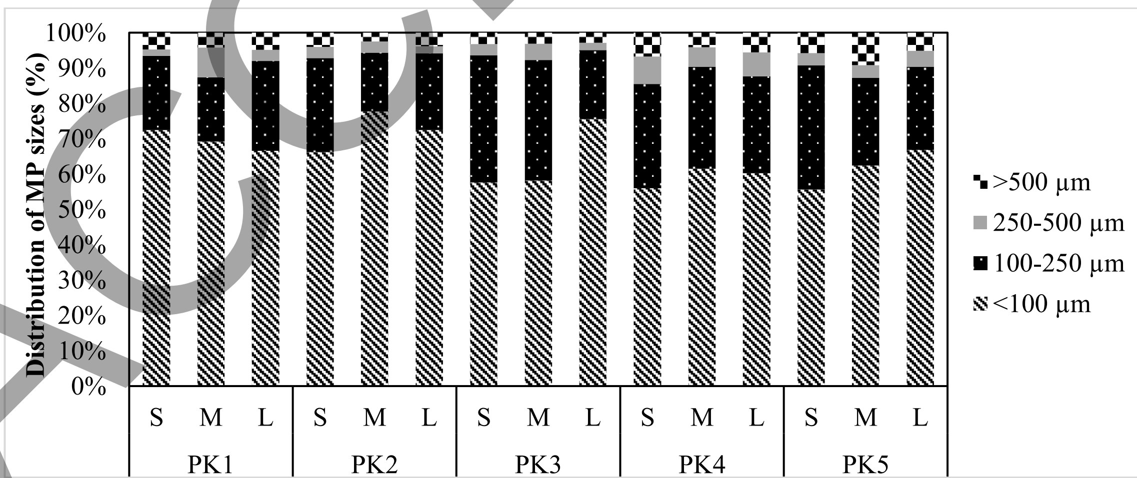

Fig. 4 The percentage of MP sizes in crispy dry crickets. (S = small, M = medium, L = large; PK1 = package 1, PK2 = package 2, PK3 = package 3, PK4 = package 4, and PK5 = package 5)

The dried cricket had the highest number of MPs < 100 µm (65.41%), followed by 25.92%, 4.14%, and 4.53% in the 100–250 µm, 250–500 µm, and > 500 µm size categories, respectively (Fig. 4). In the study of Maneechan & Prommi (2022, 2023), the size of most of the MP particles in all odonate larvae (Libellulidae: *Pantala* sp. and Aeshnidae: *Anax* sp.) was less than 100 µm. According to Stock et al. (2019), larger MPs (0.1–5 mm) may provide an environmental risk, whereas smaller particles (less than

150 µm) may raise concerns due to their bioavailability to humans. Additionally, MPs smaller than 4 µm can be absorbed by intestinal cells (Stock et al., 2019).

4. Color of MPs

The colors of 3,865 suspected microplastics were classified into 11 colors: black, dark blue, brown, light blue, multicolor, green, yellow, orange, red, violet, and pink. The most suspected blue microplastics were found in 2,002 items (51.8%), followed by brown (448 items, 11.59%), green (337 items, 8.72%), multicolor (330 items, 8.54%), red (225 items, 5.82%), black (221 items, 5.72%), orange (144 items, 3.73%), yellow (95 items, 2.46%), violet (37 items, 0.96%), and pink (26 items, 0.67%) (Fig. 5). The findings show that the greatest release of microplastics (MPs) came from the blue portions of the packages. Additionally, the colors blue, brown, and green were identified in both the insect feed and the insect rearing cages (Schiano et al., 2024).

The color difference of microplastics in 5 packages of dried cricket crisps was tested; it was discovered that green and red microplastics in small dried cricket crisps were statistically substantially different ($X^2 = 12.997$, $df = 4$, $p = 0.011$; $X^2 = 12.071$, $df = 4$, $p = 0.017$). There was no statistically significant distinction between black, blue, brown, light blue, multicolored, yellow, orange, purple, and pink. The presence of brown, green, and red microplastics in medium-dried cricket crisps was substantially different ($X^2 = 13.129$, $df = 4$, $p = 0.011$; $X^2 = 18.229$, $df = 4$, $p = 0.001$; $X^2 = 18.876$, $df = 4$, $p = 0.001$). There were no statistically significant differences among the colors black, blue, multicolored, yellow, orange, violet, and pink. Yellow microplastics in large dried crickets were found to be substantially different ($X^2 = 11.234$, $df = 4$, $p = 0.024$), whereas black, blue, brown, blue, multicolored, green, orange, red, purple, and pink were not.

The containers may contribute to the color of MPs, depending on the type of crispy dry cricket packing used in Thailand. The most common packaging colors were blue, white, brown, red, and black. The samples' wide range of colors suggests that the particles came from several sources (Lee et al., 2019).

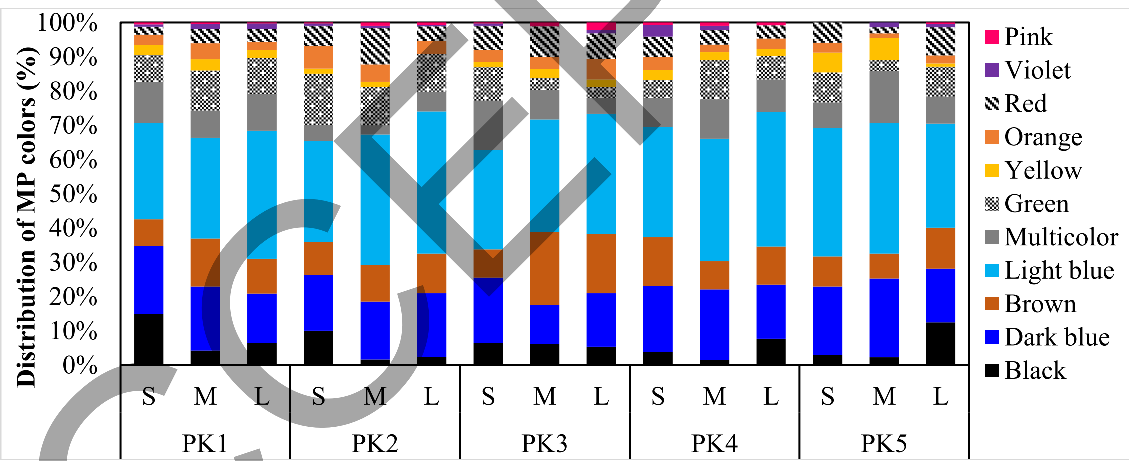

Fig. 5 The percentage of MP colors in crispy dry crickets. (S = small, M = medium, L = large; PK1 = package 1, PK2 = package 2, PK3 = package 3, PK4 = package 4, and PK5 = package 5)

5. The type of MPs

A total of 310 suspected microplastics (representing 8.02% of 3,865 microplastics) were randomly chosen to confirm the type of microplastic polymer using a Fourier Transform Infrared Spectrometer (FT-IR). There were 37 polymers discovered in microplastics, with cellulose acetate being the most common (Table 3, Fig. 6). It is mostly produced as packaging materials and apparel; therefore, film- and fiber-shaped microplastics are common. The next most common types of microplastics/plasticizers were cellulose propionate, poly (1,4-cyclohexanedimethyne terephthalate), polycaprolactone, poly (1,4-butylene terephthalate), methyl acetyl ricinoleate, triethyl citrate, polyvinyl alcohol, poly (hexadecyl methacrylate), glycerol triacetate) poly (vinyl propionate), polyvinyl acetate, respectively.

Table 3 Distribution of polymer types and plasticizers in crispy dry crickets

Polymer/plasticizer types	Number	Percentage
Particles measured	310	100
Acetyl triethyl citrate (ATEC)	1	0.32
ACN/Butadiene	1	0.32
Alpha-cellulose	1	0.32
Alkyl aryl siloxane copolymer GE SF	2	0.65
Cellulose acetate	166	53.55
Cellulose propionate	9	2.90
Cellulose ecteola modified	2	0.65
Cellulose triacetate	1	0.32
Cellulose	1	0.32
Dimethyl azelate	1	0.32
Dimethyl sebacate	1	0.32
Glycerol monooleate	2	0.65
Glycerol triacetate	24	7.74
Methyl acetyl ricinoleate (MAR)	24	7.74
Methyl vinyl ether maleic anhydride (MVE/MA)	18	5.81
N-butyl acetyl ricinoleate	2	0.65
N-vinylpyrrolidone/Styrene	1	0.32
Poly (1,4-butylene terephthalate) (PBAT)	1	0.32
Poly (1,4-cyclohexane dimethylene terephthalate) (PCT)	3	0.97
Poly (1,4-cyclohexane-dimethylene Succ)	1	0.32
Polycaprolactone (PCL)	1	0.32
Polyethylene (PE)	1	0.32
Polyvinyl acetate (PVA)	8	2.58
Polyvinyl alcohol (PVA)	5	1.61
Poly (vinyl formal) (PVF)	1	0.32
Poly (hexadecyl methacrylate) (PHDMA)	1	0.32
Poly (norbornene)	1	0.32
Poly (octadecyl methacrylate) (POMA)	1	0.32
Poly (vinyl propionate) (PVPr)	11	3.55
Poly (vinyl pyrrolidone) (PVP)	1	0.32
Propylene glycol ricinoleate	1	0.32
Styrene/Allyl alcohol copolymer	1	0.32
Styrene/Maleic anhydride (SMA)	2	0.65
Tricapryl trimellitate	1	0.32
Triethyl citrate	10	3.23
Vinyl acetate	1	0.32
Vinyl chloride acetate	1	0.32

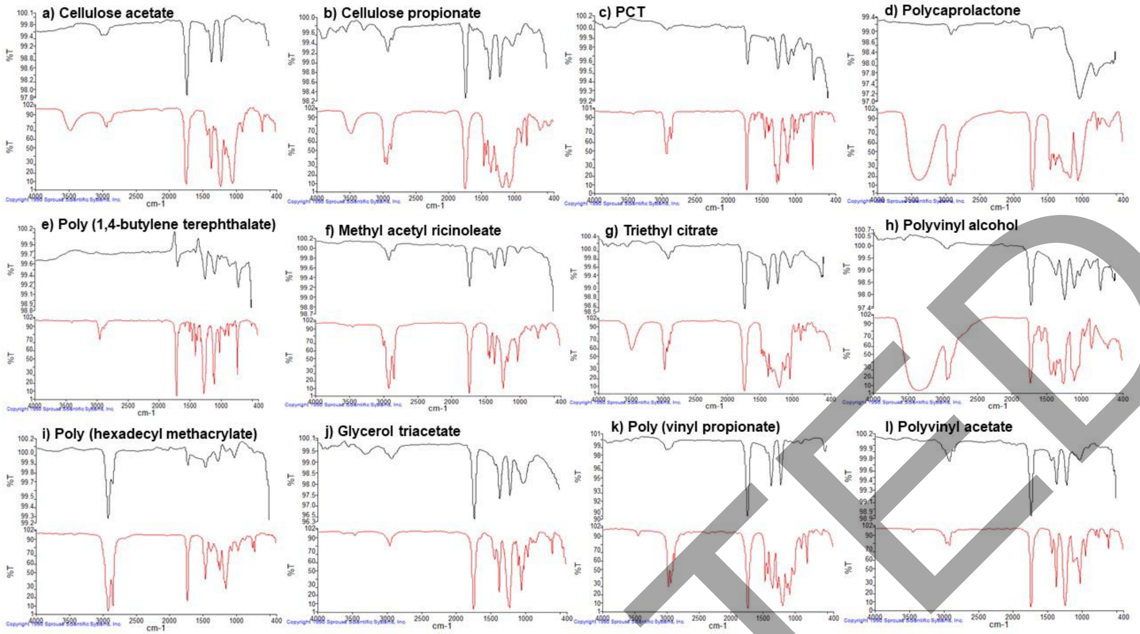

Fig. 6 FT-IR spectra of microplastics/plasticizers from crispy dry crickets under an FT-IR microscope. The red spectrum is the result of the FT-IR measurement, while the black spectrum is the reference spectrum from the Bruker spectrum library.

According to the literature, all types of polymers have been found in insect samples, such as polymethyl methacrylate (PMMA), polyethylene terephthalate (PET), polypropylene (PP), polyethylene (PE), polyamide (PA), polyvinyl acetate (PVA), cellulose acetate (CA), cellulose propionate (CP), polyvinyl propionate (PVPr), polyvinylpyrrolidone (PVP), and cellulose (Maneechan & Prommi, 2022; 2023; Vitheepradit et al., 2024; Maneechan et al., 2022). PE is a typical raw material used in the production of plastic bags and many other items. The type of polymer used can influence its toxicity, bioavailability, and ability to absorb contaminants such as organic debris, heavy metals, and infections. Hwang et al. (2019) discovered that PP particles can cause cytotoxicity, disrupt the immune system, and increase potential hypersensitivity. Furthermore, PE can cause a variety of issues, including changes in the lipid profile, changes in the gut flora, disruptions in metabolism, and liver damage. CA is commonly used in cigarette filters and packaging films; however, due to its acetylation, it is difficult to decompose in the natural environment, making pollution a severe issue (Yadav & Hakkarainen, 2021; Bouftou et al., 2024).

If a person consumes 150 crispy dry crickets, they are likely to consume 3865 microplastics. Crispy dry crickets are typically consumed whole, without the gastrointestinal tract and exoskeletal parts removed; MPs discovered in crispy dry crickets may be passed to humans through the food chain. The presence of MPs in crispy dry crickets suggests that future research into MPs' effects in edible insects should include a broader range of species, habitats, rearing methods, and manufacturers.

Conclusion

The current study examined the presence, quantity, quality, and human exposure to MP contamination in crispy dry crickets for the first time. The results revealed that MPs polluted all of the product samples, with the majority of fractions consisting of film, fragment, and fiber structures. The majority of MPs observed in all products were related to film, fragment, and fiber particles with sizes smaller than 100 μm. MPs in the crispy dry cricket samples were primarily blue, followed by brown and green. Cellulose acetate (CA), glycerol triacetate, and methyl acetyl ricinoleate were found as the most probable polymers/plasticizers. A person who consumes 150 crispy dry crickets is predicted to receive 3,865 microplastics into their body. This investigation revealed that microplastic contamination came mostly from crickets rather than packing, as evidenced by the type of polymer/plasticizer discovered.

Acknowledgment

This research was supported by the Faculty of Liberal Arts and Science, Kamphaeng Saen Campus, Kasetsart University, and Rajamangala University of Technology Phra Nakhon.

Conflicts of interest

The authors declare that they have no conflict of interest.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the author(s) utilized QuillBot's grammar-checking features to review the grammatical accuracy of the sentences.

References

Al-Mansoori, M., Harrad, S., & Abdallah, M.A.E. (2025). MPs in drinking water and beverages: Concentrations, characteristics and implications for human exposure. *Emerging Contaminants*, *11*(4), 100552.

Bouftou, A., Aghmih, K., Lakhdar, F., Abidi, N., Gmouh, S., & Majid, S. (2024). Enhancing cellulose acetate film with green plasticizers for improved performance, biodegradability, and migration study into a food simulant. *Measurement: Food*, *15*, 100180.

Chinglenthoiba, C., Lani, M.N., Anuar, S.T., Amesho, K.T., KL, P., & Santos, J.H. (2025). Microplastics in food packaging: Analytical methods, health risks, and sustainable alternatives. *Journal of Hazardous Materials Advances*, *18*, 100746.

Frigerio, J., Agostinetto, G., Galimberti, A., De Mattia, F., Labra, M., & Bruno, A. (2020). Tasting the differences: Microbiota analysis of different insect-based novel food. *Food Research International*, *137*, 109426.

Fudlosid, S., Ritchie, M.W., Muzzatti, M.J., Allison, J.E., Provencher, J., & MacMillan, H.A. (2022). Ingestion of microplastic fibres, but not microplastic beads, impacts growth rates in the tropical house cricket *Gryllodes sigillatus*. *Frontiers in Physiology*, *13*, 871149.

Giusti, A., Spatola, G., Mancini, S., Nuvoloni, R., & Armani, A. (2024). Novel foods, old issues: Metabarcoding revealed mislabeling in insect-based products sold by e-commerce on the EU market. *Food Research International*, *184*, 114268.

Gray, A.D., & Weinstein, J.E. (2017). Size-and shape-dependent effects of microplastic particles on adult daggerblade grass shrimp (*Palaemonetes pugio*). *Environmental Toxicology and Chemistry*, *36*(11), 3074–3080.

Hidalgo-Ruz, V., Gutow, L., Thompson, R.C., & Thiel, M. (2012). Microplastics in the marine environment: A review of the methods used for identification and quantification. *Environmental Science & Technology*, *46*, 3060–3075.

Hwang, J., Choi, D., Han, S., Choi, J., & Hong, J. (2019). An assessment of the toxicity of polypropylene microplastics in human derived cells. *Science of the Total Environment*, *684*, 657–669.

Jolaosho, T.L., Rasaq, M.F., Omotoye, E.V., Araomo, O.V., Adekoya, O.S., Abolaji, O.Y., & Hungbo, J.J. (2025). Microplastics in freshwater and marine ecosystems: Occurrence, characterization, sources, distribution dynamics, fate, transport processes, potential mitigation strategies, and policy interventions. *Ecotoxicology and Environmental Safety*, *294*, 118036.

Karami, A., Golieskardi, A., Keong Choo, C., Larat, V., Galloway, T.S., & Salamatinia, B. (2017). The presence of microplastics in commercial salts from different countries. *Scientific Reports*, *7*, 46173.

Krongdang, S., Phokasem, P., Venkatachalam, K., & Charoenphun, N. (2023). Edible insects in Thailand: An overview of status, properties, processing, and utilization in the food industry. *Foods*, *12*(11), 2162.

Lee, H., Kunz, A., Shim, W.J., & Walther, B.A. (2019). Microplastic contamination of table salts from Taiwan, including a global review. *Scientific Reports*, *9*(1), 10145.

Liang, Z., Zhu, Y., Leonard, W., & Fang, Z. (2024). Recent advances in edible insect processing technologies. *Food Research International*, *182*, 114137.

Lusher, A.L., Tirelli, V., O'Connor, I., & Officer, R. (2015). Microplastics in Arctic polar waters: The first reported values of particles in surface and sub-surface samples. *Scientific Reports*, *5*, 14947.

Makhdoumi, P., Amin, A.A., Karimi, H., Pirsaheb, M., Kim, H., & Hossini, H. (2021a). Occurrence of microplastic particles in the most popular Iranian bottled mineral water brands and an assessment of human exposure. *Journal of Water Process Engineering*, *39*, 101708.

Makhdoumi, P., Hossini, H., Nazmara, Z., Mansouri, K., & Pirsaheb, M. (2021b). Occurrence and exposure analysis of microplastic in the gut and muscle tissue of riverine fish in Kermanshah province of Iran. *Marine Pollution Bulletin*, *173*, 112915.

Maneechan, W., & Prommi, T.O. (2022). Occurrence of microplastics in edible aquatic insect *Pantala* sp. (Odonata: Libellulidae) from rice fields. *PeerJ*, *10*, e12902.

Maneechan, W., & Prommi, T.O. (2023). Proximate composition, fatty acid profile, and microplastic contamination of edible odonate larvae (Aeshnidae: *Anax* sp.) in rice fields. *Jordan Journal of Biological Science*, *16*(4), 649–654.

Maneechan, W., Vitheepradit, A., & Prommi, T.O. (2022). Nutritional compositions of aquatic insects living in rice fields, with a particular focus on odonate larvae. *Insects*, *13*(12), 1131.

Melgar-Lalanne, G., Hernández-Álvarez, A.J., & Salinas-Castro, A. (2019). Edible insects processing: Traditional and innovative technologies. *Comprehensive Reviews in Food Science and Food Safety*, *18*(4), 1166–1191.

Nawab, A., Ahmad, M., Khan, M.T., Nafees, M., Khan, I., & Ihsanullah, I. (2024). Human exposure to microplastics: A review on exposure routes and public health impacts. *Journal of Hazardous Materials Advances*, *16*, 100487.

Qiao, R., Deng, Y., Zhang, S., Wolosker, M.B., Zhu, Q., Ren, H., & Zhang, Y. (2019). Accumulation of different shapes of microplastics initiates intestinal injury and gut microbiota dysbiosis in the gut of zebrafish. *Chemosphere*, *236*, 124334.

Schiano, M.E., D'Auria, L.J., D’Auria, R., Seccia, S., Rofrano, G., Signorelli, D., ... Cocca, M. (2024). Microplastic contamination in the agri-food chain: The case of honeybees and beehive products. *Science of the Total Environment*, *948*, 174698.

Stock, V., Böhmert, L., Lisicki, E., Block, R., Cara-Carmona, J., Pack, L.K., ... Lampen, A. (2019). Uptake and effects of orally ingested polystyrene microplastic particles in vitro and in vivo. *Archives of Toxicology*, *93*(7), 1817–1833.

Stock, V., Fahrenson, C., Thuenemann, A., Dönmez, M.H., Voss, L., Böhmert, L., ... Sieg, H. (2020). Impact of artificial digestion on the sizes and shapes of microplastic particles. *Food and Chemical Toxicology*, *135*, 111010.

Su, L., Cai, H., Kolandhasamy, P., Wu, C., Rochman, C.M., & Shi, H. (2018). Using the Asian clam as an indicator of microplastic pollution in freshwater ecosystems. *Environmental Pollution*, *234*, 347–355.

Su, L., Xue, Y., Li, L., Yang, D., Kolandhasamy, P., Li, D., & Shi, H. (2016). Microplastics in taihu lake, China. *Environmental Pollution*, *216*, 711–719.

Vitheepradit, A., Mitpuangchon, N., & Prommi, T. (2024). Aquatic insect biodiversity, water quality variables, and microplastics in the living weir freshwater ecosystem. *Ecologica Montenegrina*, *79*, 41–63.

Woodall, L.C., Sanchez-Vidal, A., Canals, M., Paterson, G.L., Coppock, R., Sleight, V., ... Thompson, R.C. (2014). The deep sea is a major sink for microplastic debris. *Royal Society Open Science*, *1*(4), 140317.

Yadav, N., & Hakkarainen, M. (2021). Degradable or not? Cellulose acetate as a model for complicated interplay between structure, environment and degradation. *Chemosphere*, *265*, 128731.

Zhu, J., Wu, P., Zhao, N., Jiang, S., Zhu, H., & Jin, H. (2023). Microplastics in terrestrial insects, long-horned beetles (Coleoptera: Cerambycidae), from China. *Science of The Total Environment*, *888*, 164197.

Article info

Kuttiyawong et al.

Received : 25 August 2025
Revised : 13 December 2025
Accepted : 29 December 2025