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Chewing Gum as a Source of Oral Microplastic Intake: An Investigational Study

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Abstract

Recent evidence suggests that chewing gum might be a source of microplastic (MP) exposure in humans. In this study, MPs are determined in five brands of chewing gum, sourced in Iran, following solvent-assisted digestion of the gum matrix. MPs were detected in all samples at concentrations ranging from 20 to 50 per g. MPs were dominated by fibres and fragments below 50 μm in size (with a detection limit of about 20 μm), with white the most common colour and polyethylene and polypropylene the main polymers. The origin of MPs in chewing gum is not clear but possible sources include the gum matrix, contaminated ingredients, manufacturing processes or plastic-based packaging. With concentrations of MPs greater than in many other foods and beverages, chewing gum could represent a significant means of exposure for individuals who regularly consume the product. As such, further research is warranted into a wider range of products and (smaller) particle sizes, and comparisons between new and chewed products and resulting saliva.

Highlights

• Microplastics detected in five brands of commercial chewing gum sold in Iran.

• A total of 242 particles were identified, mainly fibres and fragments < 50 μm.

• Polyethylene and polypropylene were the predominant polymers.

• Findings indicate preliminary evidence of contamination; broader studies are needed.

1. Introduction

Microplastics (MPs) are plastic particles smaller than 5 mm but larger than 1 micrometre. In some sectors, MP beads and pellets are manufactured within this size range, and these are known as primary MPs[1]. However, degradation causes plastics more generally to break down into smaller pieces known as secondary MPs[2].

MPs enter natural ecosystems from sources like cosmetics, clothing, agriculture, water treatment and industrial processes, in addition to being generated by weathering of larger debris like soft drinks bottles, fishing gear, plastic bags, and food packaging [3–7]. Because of their small size and low density, MPs disperse throughout the environment and are commonly detected in the atmosphere, soil, freshwater and marine sediments, surface waters and the deep ocean [8–12].

Due to their persistence and small size, MPs can be ingested by and accumulate in the tissues of organisms [13]. Recent research has also raised concerns that MPs can enter human organs through skin contact, inhalation and ingestion [14–17], potentially resulting in harmful inflammation or the release of chemicals [18]. Significant regarding ingestion, many studies have revealed high concentrations of MPs in various food products, including sea salt, bottled water, tea brewed from plastic tea bags and seafood [19].

Chewing gum is a widely enjoyed activity that can reduce stress, substitute for smoking or caffeine, and improve oral health [20–23]. Its potential as an innovative way to deliver drugs has also garnered attention, thanks to its convenience, ease of use, and ability to release active ingredients in a controlled manner [24–26]. Modern gum contains synthetic, non-biodegradable polymers, like butadiene-styrene rubber, isobutylene-isoprene copolymer (butyl rubber) and polyvinyl acetate, along with artificial sweeteners, colourings, and flavours [27]. As well as acting as a source of exposure to monomers [28], chewing gum for extended periods may also act as a source of exposure to MPs. These might be derived from the production or breakdown of the constituent polymers or through contamination during the manufacturing process.

Recently, [29] reported a correlation between the concentration of MPs in the endometrium of twenty women from Shanghai and chewing gum habits, while Pant et al. (2025) detected MPs in saliva arising from chewing gum over different periods of time. To the best of our knowledge, however, MPs have not been directly determined in chewing gum itself. Our study, therefore, aims to investigate the presence of MPs in popular chewing gum brands available in Iran, where cultural, and social norms and product availability contribute to its popularity and growing use. Following solvent digestion of the gum matrix, we identify, quantify and characterise microplastics by standard microscopic and spectroscopic techniques.

2. Material and Methods

2.1. Sample collection

Five brands of mint-flavoured chewing gum, containing six or more pieces each, were purchased from different supermarkets in Ahvaz, Iran. To maintain privacy and for ethical issues, the brand names are coded as A, B, C, D, and E, but details of packaging and stated ingredients are shown in Table 1.

Table 1: Details of the chewing gum samples used in the study.

Brand	Type and packaging	Specified ingredients
A	Small cubes, foil-wrapped	Sugar, gum base, glucose, natural and artificial flavourings, permitted food colourings
B	Small dragees, unwrapped in cardboard box	Sugar, gum base, glucose, natural and artificial flavourings, permitted food colourings
C	Small dragees, unwrapped in cardboard box	Gum base, sugar-free sweeteners such as xylitol, natural and artificial flavourings, permitted food colourings
D	Small dragees, unwrapped in cardboard box	Sorbitol, gum base, maltitol, mannitol, xylitol, glycerin, lecithin, citric acid, malic acid, sucralose, acesulfame potassium, permitted food colouring, gum arabic, carnauba wax
E	Small dragees, unwrapped in cardboard box	Sorbitol, isomalt, xylitol, maltitol syrup, sucralose, acesulfame potassium, gum base

2.2. Sample preparation and MP extraction

A stainless-steel scalpel cut 1.5 g of gum (from one or more pieces for a brand) from a packaging, placed in covered 100-mm borosilicate glass Petri dishes and dried at room temperature (24°C). The dried gum sample was ground together in a pre-cleaned glass mortar and pestle. Samples were placed in 100 mL glass beakers and digested with 30 mL 30% hydrogen peroxide (H_2O_2, analytical grade, Merck) for 24 hours at a temperature of 60 °C. The digestion method was adapted from protocols used for microplastic isolation from complex food matrices. The digestion solution was stirred intermittently to

facilitate digestion. After digestion vacuum filtration through 2.5 µm pore size glass fibre filters (Whatman GF/C) was performed. The filters were then placed in sterile Petri plates and dried for subsequent characterization studies at 24°C in a dust-free environment.

2.3. Visual Identification, Characterisation, and Validation of MPs

Dried filters were mounted on clean glass slides and examined under a trinocular optical microscope (SAIRAN ZSM1001-3E) at magnifications between 40x and 100x. With the aid of a camera (iPhone 13 Pro Max) and ImageJ software, particles suspected of being MPs (according to colour, morphology and lustre) were counted, sized (with a minimum size detection limit of about 20 mm), and categorised by colour and shape (fibres, fragments, films, or spherules/pellets).

Micro-Raman spectrometry was used to identify the polymers in a selection of suspected MPs (n = 10, and n = 2 from each brand). Specifically, MPs were transferred from their filters to double-sided adhesive tape using a metal needle and were analysed using a Horiba Lab Ram HR spectrometer. The instrument was operated at an excitation wavelength of 785 nm and over a Raman shift range of 400 – 1800 cm^{-1}, with resulting Raman spectra matched to spectra from various reference libraries.

2.4. Quality Assurance and Quality Control

To minimise MP contamination, all equipment was pre-cleaned with ethanol and rinsed with ultrapure water. Sample processing and analyses were conducted in a clean laboratory environment and workspaces were thoroughly cleaned using ethanol and lint-free cloths before and after each session. Only cleanroom-grade air filters were used and analysts wore nitrile gloves, cotton laboratory coats, and face masks that were replaced regularly. Procedural blanks (five empty filter membranes) were analysed alongside the samples to evaluate any contamination introduced during the experimental process. As no MPs were detected in the blank samples, we have confirmation that no external MPs were inadvertently introduced throughout the process. The mortar and pestle used for grinding were not tested separately for microplastic contamination; therefore, there remains a possibility of cross-contamination between samples. This is acknowledged as a limitation. Furthermore, the study was exploratory in nature and did not include technical or biological replicates, which limits statistical confidence in the reported values.

2.5. Statistical analysis

In SPSS (*v*28), the chi-squared test of independence was performed on MP size data to determine whether there were significant differences across the five brands. An a-value for significance of 0.05.

3. Results

A selection of MPs identified in the chewing gum samples is shown in Fig. 2. In most cases, MPs were distinctive entities on the filters, but occasionally MPs, and especially fibres, were embedded in or adhered to insoluble residues of the gum itself.

The numbers and physical characteristics of the MPs identified in the five brands of chewing gum are summarised in Table 2. A total of 242 MPs were found and contamination was evident in all brands, with numbers ranging from 30 to 75 per 1.5 g (mean ± standard deviation = 48.4 ± 18.0). MPs were dominated by fibres and fragments in each brand (overall, ~ 65% and ~ 24%, respectively); 11 films were identified and were present in each sample, but only four pellets were identified and were absent from three brands.

MPs were most frequently encountered in the finest (< 50 μm) size fraction in each sample (overall, ~ 40%) and were least abundant (and absent in two brands) in the 100 to 200 μm size fraction. Results of the chi-squared test (chi-squared statistics = 10.48, $p > 0.05$) revealed no statistical difference in particle size between the different brands. Regarding colours, white-transparent was the most common in all samples, with black and each remaining colour contributing between 25 and 36 MPs in total. Overall, the most abundant type of MP was white-transparent fibres < 50 μm in size ($n = 25$).

Results of the μ-Raman analysis of ten microplastics are shown in Table 3. Nine fibres and fragments were constructed of the polyolefins, polyethylene and polypropylene, while one pellet was identified as polyurethane.

Table 2
Physical characteristics of the MPs identified in 1.5 g portions of the five different brands of chewing gum. *L* is size of length in µm.

Total	**A**	**B**	**C**	**D**	**E**	**Total**
	30	**41**	**58**	**38**	**75**	**242**
Shape						
Fibres	20	27	33	27	51	158
Pellets	0	0	1	0	3	4
Fragments	9	13	10	10	17	59
Films	1	1	4	1	4	11
Size						
< 50	15	14	21	18	27	95
50 ≤ *L* < 100	9	13	10	8	21	61
100 ≤ *L* < 200	0	3	8	0	10	21
≥ 200	6	11	9	12	17	55
Colour						
White	17	19	24	18	30	108
Black	2	6	8	4	16	36
Other	11	16	26	16	29	98

Table 3: Polymers identified by m-Raman spectroscopy in ten MP samples.

Brand	Characteristics	Polymer
A	White fragment, 50 ≤ *L* < 100	Polyethylene
	Black fibre, ≥ 200	Polyethylene
B	Black fibre, 50 ≤ *L* < 200	Polyethylene
	White fragment, ≥ 200	Polypropylene
C	Blue fibre, < 50	Polypropylene
	Red pellet, < 50	Polyurethane
D	White fragment, < 50	Polyethylene
	White fibre, 100 ≤ *L* < 200	Polypropylene
E	White fragment, < 50	Polyethylene
	White fibre, 100 ≤ *L* < 200	Polypropylene

It should be noted that no technical replicates were performed in this study, and analytical precision (e.g., intra-sample variability or repeatability of counts) was not formally assessed. This represents a limitation and should be addressed in future investigations.

4. Discussion

4.1. Comparison with other studies of foodstuffs

MPs, and mainly fibres and fragments, have been reported in a variety of beverages and foods but as far as we are aware, this is the first published study to directly determine MPs in samples of chewing gum. Concentrations range from 20,000 to 50,000 per kg and are significantly higher than concentrations reported for sea salt and well salt (about 10 to 700 per kg; [30]), tap water and bottled water (up to about 630 and 5000 per L, respectively; [3]), bivalves-crustaceans and fish (up to about 3000 and 6000 per kg, respectively; [31].

That said, we note that the release of MPs from chewing gum into saliva has recently been reported. Thus, Pant et al. (2025) determined MPs and nanoplastics (NPs, < 1 μm) in saliva arising from chewing a single brand of gum over different periods of time up to 60 minutes by surface-enhanced Raman spectroscopy. Based on counts of a small subsample, tens of thousands of MPs were estimated to be released from whole gum samples. MPs were mainly in the 20 to 150 μm size range, but colours, shapes or polymer types were not reported. NPs were confirmed in saliva but were not quantified or classified by morphology, and their composition matched the plastics used in the gum base (polyethylene and polyvinyl acetate). In addition, results of a study into MP release from chewing gum that were presented at a symposium gained significant media coverage (ACS, 2025). Here, an average of 100 particles per g, of > 20 μm in size and that were mainly polyolefins (of unspecified shape), were reported.

The quantities of MPs released in these studies are at least an order of magnitude greater than the total concentration in our study. Differences could reflect a broad range in abundance among different brands, types and flavours of chewing gum studied. Discrepancies could also be related to differences in the precise means of isolating and identifying MPs. For instance, the incomplete digestion of the gum matrix or partial or complete solubilisation of certain polymers by a solvent may have led to an underestimation of MPs in the present study. It is also possible that MPs in the gum are broken down into a greater number of smaller particles during mastication.

However, the size distributions reported by Pant et al. (2025) are similar to those reported herein, and mechanical grinding of foodstuffs containing MPs does not appear to affect their abundance [30]. More likely, chewing generates and releases microscopic fragments of the gum matrix itself that would not be determined by direct analysis of the unchewed product.

4.2. Possible sources of MPs in chewing gum

including polyethylene and polyvinyl acetate, which are commonly used as base polymers in gum. However, breakdown of these constituents during manufacture is more likely to produce irregular fragments or rounded entities than thin fibres, and should be limited to particles that have the same (white-grey) colour as the matrix.

Secondly, MPs may be introduced externally during manufacturing or through the use of contaminated ingredients. The production process involves mechanical and thermal techniques and if equipment has plastic components, MPs may be shed as a result of wear, pressure and heat. Other plastic components of non-operational equipment could introduce more general contamination into the manufacturing environment. For example, [32]suggested that indoor air may be contaminated by MPs derived from the wear and abrasion of plastic air vents. Textile fibres from clothing, gloves, aprons and hair restraints are also likely to be abundant in the indoor atmosphere, and although this source could account for the variety of coloured fibres detected in chewing gum, it is not necessarily consistent with their polymeric makeup (mainly polyolefins).

Thirdly, it is possible that MPs are derived from packaging that is constructed of or coated with plastic, and effect that could be exacerbated during transportation as units abrade against each other or storage if exposed to high temperatures. MPs in foodstuffs have often been attributed to the packaging [33, 34] but MPs should represent the characteristics of the material used (colour and polymer) and are not likely to be fibrous.

4.3. Other particulate contaminants in chewing gum

MPs and NPs are not the only synthetic particles in chewing gum that are resistant to solvent extraction. Titanium dioxide nanoparticles in the size range 30 to 300 nm are present as an additive at concentrations that greatly exceed those in many other food products [35, 36]. Specifically, TiO_2 is added for whitening, brightening, opacity and resisting discoloration, and is usually more concentrated in the hard chewing gum coating. Although food-grade TiO_2 nanoparticles are high purity and relatively inert, adverse effects have been observed in rodents after ingestion [37, 38] and the material is classified as a possible carcinogen after inhalation in humans [39]. As a consequence, the European Union banned TiO_2 as a food additive in 2022 [40]. The concentrations of TiO_2 nanoparticles employed in toxicity testing are substantially higher than exposures arising from the typical diet, but an added concern is that nanoparticles and other chemicals and materials may act synergistically. For example, there is evidence that TiO_2 nanoparticles compromise epithelial integrity and enhance the translocation and antigenicity of proteins [41]. There is evidence in the literature for the translocation of MPs from exposed organs to secondary organs although the mechanisms involved are still unclear [42].

4.4. Concluding comments

In summary, this study appears to be the first to document the presence of MPs in chewing gum. Concentrations determined after gum base digestion were between 20 and 50 per g and are higher than those in most other beverages and foods reported in the literature. MPs were dominated by fibres and fragments below 50 µm in size and that were white in colour and constructed of polyolefins, and no statistical differences in numbers or characteristics were evident among different brands. Further studies should target a broader range sample types, employ techniques with a smaller size detection, and determine the availability or release of MPs from gum when chewed. Regarding the latter, it would be informative to establish whether release is dependent on particle size or shape or is augmented by

fragments generated by mastication of the matrix - this could be accomplished by analysing both the new and chewed product as well as saliva. A more general requirement is a better understanding of the exposure, translocation and impacts of MPs in humans, including any synergistic effects arising from the presence of co-contaminants.

This was a preliminary study with several limitations. Only five brands were analysed, all sourced from a single country, without technical or biological replicates. The extraction method used, while practical, was not standardised for gum matrices. Moreover, the gum was not subjected to chewing simulation, which limits the relevance of results to actual human exposure. These limitations highlight the need for follow-up studies with a more comprehensive design.

Declarations

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Contributions

Jahedi Faezeh: study conception and design, data collection, analysis, interpretation of results, and draft manuscript preparation.
Jaafarzadeh Haghighi Fard Neamatollah: conceived of the presented idea; interpretation of results, draft manuscript.

Hassan Dehdari Rad: Editing and Reviewing.

Andrew Turner: Editing and Reviewing.
All authors reviewed the results and approved the final version of the manuscript.

Ethics Declarations

Ethics approval and consent to participate

Not Applicable

Consent for publication

Not applicable

Data Availability Statement

All data generated or analysed during this study are included in this published article

Clinical Trial Number

Not Applicable

Competing interests

The authors declare no competing interests

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Figures

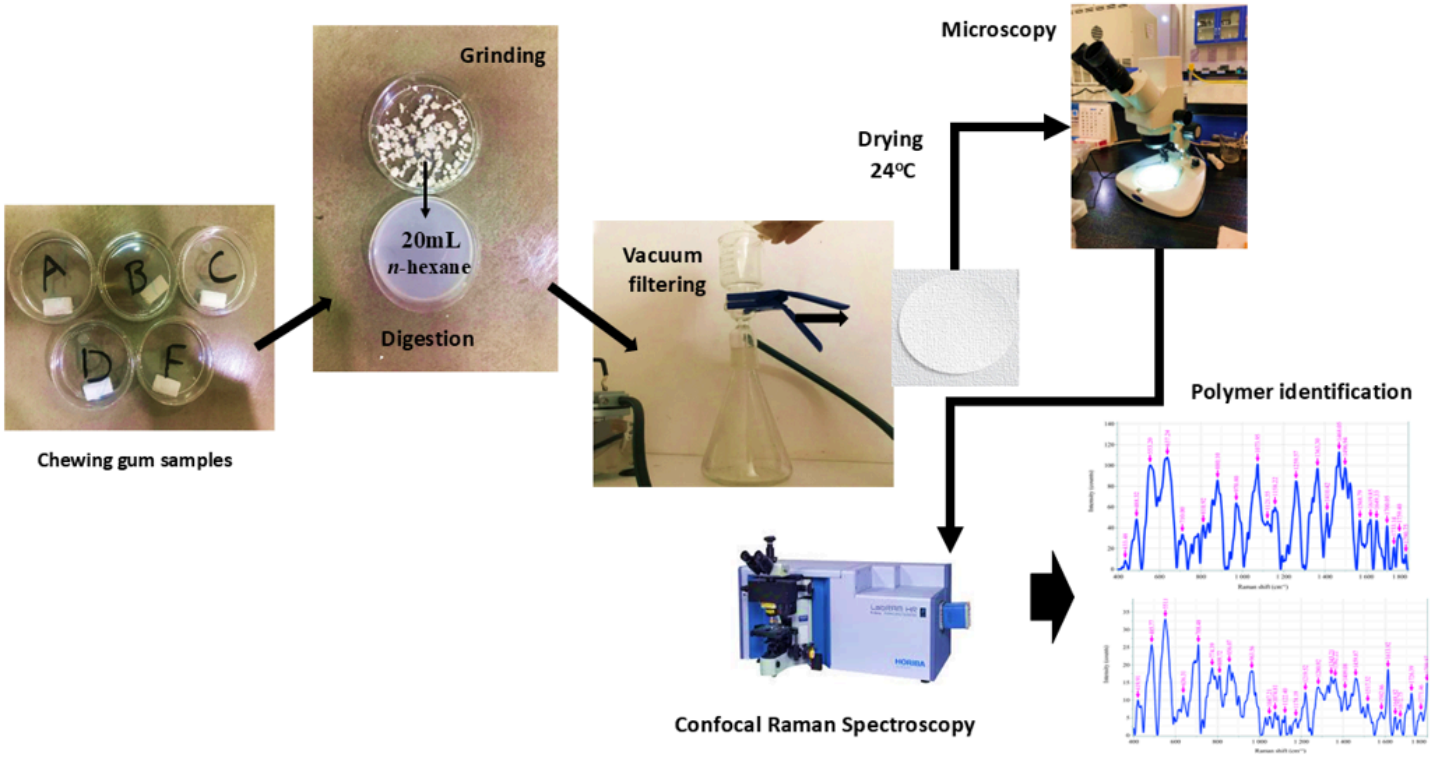


Figure 1

Workflow for processing and analysing chewing gum samples.

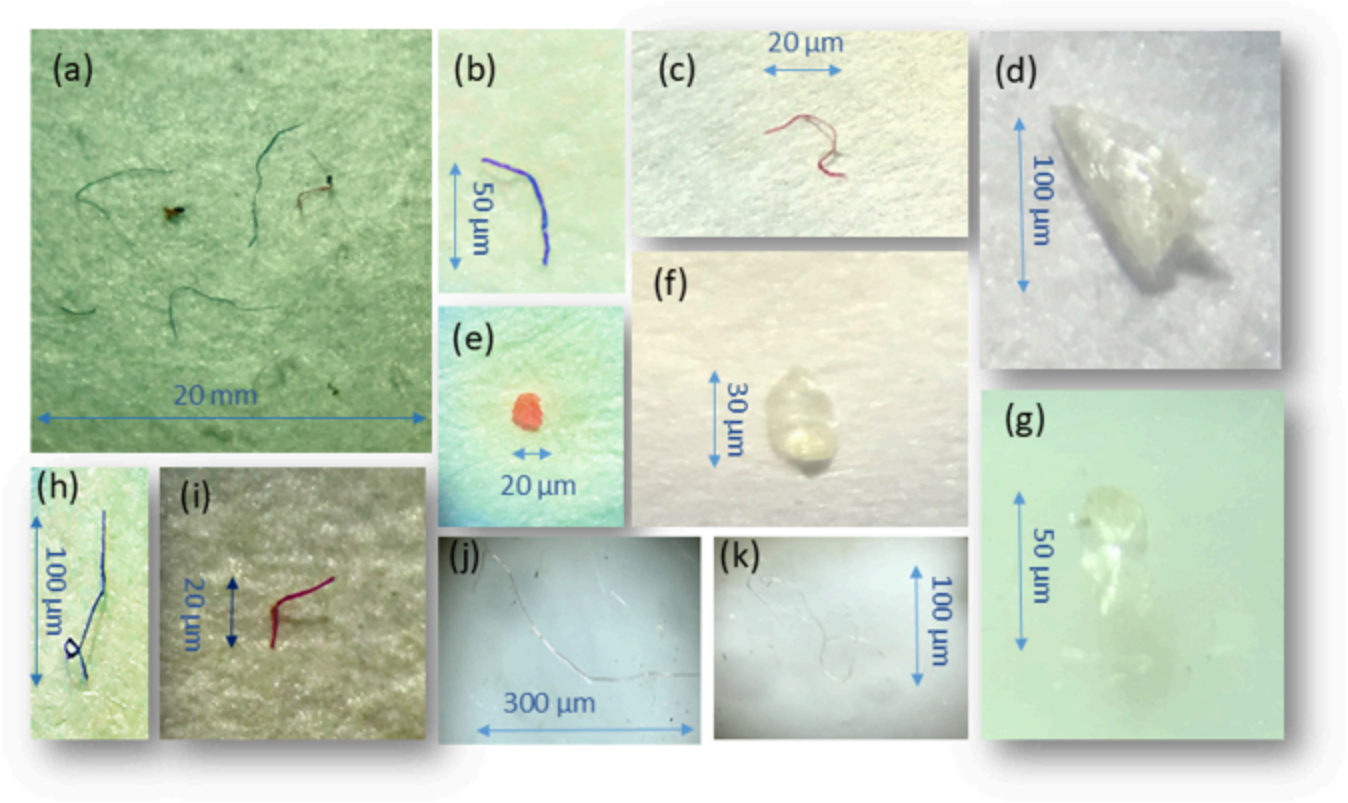


Figure 2

Microscopic images of MPs encountered in the chewing gum samples.(a) A group of the predominant forms of MPs, (b), (c), (h), (i), (j) and (k) various fibres of different lengths and colours, and (d), (e), (f) and (g) various fragments and films of different sizes and colours.

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