

DETERMINATION OF PARABEN IN READY-TO-EAT FOOD PRODUCTS OF THAILAND USING HPLC-PDA

Pussadee Laor, Ananya Ouamthong, Chonthicha Khamto, Phusuda Saleedang, Jantana Taen-in, Warapon Paenkhokuard, and Vivat Keawdoungek*

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Abstract

Parabens are synthetic preservatives added to food products to extend shelf life by suppressing microbial growth in consumer products. Their application in food manufacturing is common, particularly in beverages, seasonings, canned products and snack items. However, parabens are classified as endocrine-disrupting chemicals (EDCs), and their presence in food has become a public health concern. This study assessed the occurrence and levels of parabens in ready-to-eat food products. A total of 113 samples representing nine food categories, beverages, dairy products, fats and oils, canned fish, grains and nuts, processed fruits, pickled vegetables, snacks, and condiments, were collected and analyzed. A high-performance liquid chromatography system equipped with a photodiode array detector (HPLC–PDA) was optimized and validated to quantify five parabens after liquid–liquid extraction. The method demonstrated appropriate analytical performance and enabled reliable detection of methyl (MeP), ethyl (EtP), propyl (PrP), isobutyl (iso-BuP), and butyl paraben (BuP). Concentrations of MeP, EtP, PrP, iso-BuP, and BuP ranged from <LOD to 12,787.97 µg/g, <LOD to 526.36 µg/g, <LOD to 1,962.03 µg/g, <LOD to 3,431.49 µg/g, and <LOD to 2,018.39 µg/g, respectively. Beverages exhibited the highest proportion of samples exceeding the legal limit, with 25.81% surpassing the maximum concentration permitted by Thailand’s Ministry of Public Health (Notification No. 418). This study provides the first quantitative evidence in Thailand of the simultaneous determination of five parabens in ready-to-eat foods using a validated HPLC–PDA method, highlighting the importance of regulatory monitoring and consumer protection.

Keywords: Chemical Hazards in Food; HPLC; Paraben; Thai Food Products

Program of Environmental Health, School of Health Science, Mae Fah Luang University, Chiang Rai, Thailand.
E-mail: pussadee.lao@mfu.ac.th; 6431807034@lamduan.mfu.ac.th; 6431807049@lamduan.mfu.ac.th;
6431807055@lamduan.mfu.ac.th; 6431807058@lamduan.mfu.ac.th; 5931807016@lamduan.mfu.ac.th; vivat.kea@mfu.ac.th*

* Corresponding author

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Introduction

Parabens are synthetic preservatives originating from p-hydroxybenzoic acid, and they are effective at suppressing microbial contamination in various products (Kang *et al.*, 2016; Ang *et al.*, 2013). The compounds commonly used in the food and consumer-product industry include methyl paraben (MeP), ethyl paraben (EtP), propyl paraben (PrP), and butyl paraben (BuP). Differences in the substituent chain length, either straight or branched, affect their physical and chemical behaviors, while some derivatives, such as benzyl paraben (BzP) represent aromatic ester structures (Ye *et al.*, 2006). Due to desirable characteristics such as stability, odorlessness, and broad antimicrobial activity, parabens are added to numerous goods including cosmetics, pharmaceuticals, and processed food products (Nowak *et al.*, 2018; Isaac *et al.*, 2025).

Human exposure can occur through dietary intake, inhalation, or dermal absorption. Biomonitoring studies have confirmed the presence of parabens and their metabolites in urine samples worldwide, demonstrating ongoing population-level exposure (Ye *et al.*, 2006). Although these compounds are quickly metabolized and excreted, concerns have emerged regarding potential endocrine-disrupting effects and oxidative damage associated with repeated exposure (Tomar *et al.*, 2026). Parabens have increasingly been detected in environmental compartments as well, likely due to incomplete removal during wastewater treatment processes (Vale *et al.*, 2022).

Regarding food safety regulation, the Joint FAO/WHO Expert Committee on Food Additives (JECFA) previously established a combined acceptable daily intake (ADI) of 10 mg/kg-bw/day for MeP, EtP, and PrP (Soni *et al.*, 2005; World Health Organization, 2021). Within the food industry, parabens are classified as preservatives coded E200–E299 (Nowak *et al.*, 2018). Multiple market surveys worldwide have reported frequent paraben detection across a wide range of food matrices, such as beverages, bakery products, condiments, dairy items, and pickled vegetables, with MeP being the most frequently found compound (Liao *et al.*, 2013; González-Palacios *et al.*, 2025).

Despite the growing international data, systematic monitoring of paraben residues in ready-to-eat foods in Thailand remains limited, even though national regulations exist. The Ministry of Public Health of Thailand defines the maximum allowable concentration of parabens in food under Notification No. 418 (B.E. 2563/2020). However,

no studies have evaluated paraben levels with regard to this regulation. Although the presence of parabens in foods has been widely documented, dietary exposure is not determined by contamination levels alone, but also by consumption frequency and eating patterns. Individuals may experience higher cumulative intake from foods that are consumed regularly, even when paraben concentrations per unit are relatively low. Consequently, identifying specific food categories that contribute most to overall exposure is essential for understanding real-world dietary risks. However, most existing studies have focused on residue detection or intake estimation, with limited attention given to evaluating which foods act as key predictors of higher exposure at the population level. An analytical approach that integrates food consumption data with exposure modeling is therefore needed to support the targeted risks of communication and public health guidance (González-Palacios *et al.*, 2025; Li *et al.*, 2023; Ku *et al.*, 2025).

Therefore, this research aims to quantify five parabens (MeP, EtP, PrP, iso-BuP, and BuP) in ready-to-eat foods available in Thailand and determine whether any food categories exceed the permitted regulatory limits.

Materials and Methods

Chemicals for a standard solution

Methyl paraben (Labsystem Co., Ltd., Purity: 99.0%), ethyl paraben (Labvalley Co., Ltd., Concentration: 98.0%), propyl paraben (Labsystem Co., Ltd., Concentration: 99.0%), butyl paraben (Labvalley Co., Ltd., Concentration: 98.0%) were used for preparing a standard solution and Ethylparaben-d5 (ESM) was used for an internal standard solution.

Instrumentation and chromatographic conditions

The HPLC system consisted of a Waters 1525 binary HPLC pump, Waters 2707 autosampler, and Waters 2998 photodiode array detector (PDA) (Water Cooperation, 2020). 5 μ m C18 (4.6 $\times$ 150 mm) was used for chromatographic separation (Water Cooperation, 2024). Isocratic elution was performed using methanol/water (57:43, v/v) as the mobile phase, which was filtered through a 0.45 μ m membrane filter using a Millipore vacuum filtration system prior to use (Saridal & Ulusoy, 2019). The flow rate was 1 mL/min. The detection wavelength

was 257 nm, and the injection volume was 10 μ L (Maher *et al.*, 2020).

Sample collection, preparation, and extraction

Food samples were collected between October 2024 and February 2025 from convenience stores and supermarkets in Chiang Rai Province, Thailand. All sampled food products were domestically produced in Thailand. A total of 113 samples representing nine categories of ready-to-eat foods were collected, including beverages, dairy products, fats and oils, canned fish, grains and nuts, processed fruits, pickled vegetables, snacks, and condiments (Table 1). For sample preparation, 2 g of each food sample was weighed into a 50 mL centrifuge tube. Ethylparaben-d5 (ESM) was used as the internal standard due to its structural similarity and comparable chromatographic behavior to the target parabens (Proctor *et al.*, 2019; Sigma Aldric, 2026). Samples were spiked with 25 μ L of an internal standard working solution (100 μ g/L), following a modified procedure based on Laor *et al.* (2025). Subsequently, 5 mL of acetonitrile were added as the extraction solvent, as it provides satisfactory extraction efficiency for parabens while reducing matrix interference compared with more polar solvents such as methanol (Aouant & Hela, 2025). The samples were mixed using a mechanical shaker for 30 min, sonicated for 30 min at 40–45 $^{\circ}$ C, and then centrifuged at 4,000 rpm for 10 min. The supernatant was collected, filtered if necessary, transferred into vials, and subjected to HPLC–PDA analysis (Altunay & Elik, 2022).

Table 1. Ready-to-eat food product samples (n = 113)

Category	Food items (samples)
Category 1	Beverages (31 samples): Fruit juice (7), carbonated drink (9), alcoholic drink (4), energy drink (7), and coffee drink (4)
Category 2	Daily products (17 samples) : Milk samples (12), sweetened condensed milk samples (5)
Category 3	Fats and oils (5 samples)
Category 4	Canned fish (9 samples)
category 5	Grain and beans (3 samples)
category 6	Processed fruits (3 samples)
category 7	Pickled vegetables (4 samples)
Category 8	Snacks (3 samples)
Category 9	Condiments (38 samples)

Parabens analysis

The mixed standard solution was prepared by accurately weighing 0.101 g of methyl paraben, ethyl paraben, and propyl paraben, together with 0.102 g of butyl paraben and isobutyl paraben. A separate stock of the internal standard was dissolved in methanol. All solutions were stored in

refrigeration at -4° C and remained stable for approximately one month. Working standards were subsequently obtained by serial dilution of the stock solutions to final concentrations ranging from 0.5 to 50 μ g/mL.

The chromatographic system provided clear separation of the target analytes with retention times of 3.64 min (MeP), 5.37 min (EtP), 9.01 min (PrP), 15.60 min (iso-BuP), and 16.48 min (BuP). Calibration curves demonstrated strong linearity, with correlation coefficients of 0.998 for MeP and EtP, 0.997 for PrP, 0.998 for iso-BuP, and 0.996 for BuP. The limits of detection (LOD) and quantification (LOQ) were calculated according to the ICH Q2 guidelines using the standard deviation of the response (σ) and the slope (S) of the calibration curve. The LOD and LOQ were calculated as $3.3\sigma/S$ and $10\sigma/S$, respectively (Ermer, 2025). For this study, the LOD values for MeP, EtP, PrP, iso-BuP, and BuP were 0.02, 0.50, 0.32, 0.50, and 0.04 μ g/g, respectively, while the corresponding LOQ values were 0.06, 1.88, 1.07, 0.55, and 0.40 μ g/g. The internal standard (ESM) was eluted at 6.53 min.

Ethical approval for this research was obtained from the Mae Fah Luang University Ethics Committee for Human Research (Protocol No. EC 24182-18, COE 201/2024).

Results and Discussion

Quantification of parabens in samples of food products

Paraben concentrations in food samples categorized by food type are summarized in Figure 1 and Table 2. Overall, MeP was the most frequently detected compound, with a detection rate (DR) of 47.79% among all samples (n = 113), followed by PrP (41.59%) and EtP (30.97%). Iso-BuP and BuP were detected less frequently, with detection rates of 23.01% and 18.58%, respectively. Across all samples, the arithmetic mean (AM) concentrations ranged from 23.24 μ g/g for EtP to 136.45 μ g/g for MeP, while the corresponding geometric means (GM) were substantially lower, indicating a skewed distribution influenced by a limited number of samples with high paraben levels.

Beverage samples (Category 1, n = 31) exhibited the highest detection rates for all analyzed parabens, ranging from 45.16% for BuP to 64.52% for PrP. MeP showed the highest mean concentration in this category, with an AM of 489.32 μ g/g and a concentration range extending from below the limit of detection (LOD) to 12,787.97 μ g/g. Similarly, relatively high AM values were observed for iso-BuP (184.47 μ g/g) and

BuP (220.82 µg/g), with wide concentration ranges, reflecting considerable variability among beverage samples.

In daily products (Category 2, $n = 17$), parabens were detected at moderate frequencies, with detection rates ranging from 5.88% for BuP to 64.71% for MeP. Mean concentrations in this category were generally lower than those observed in beverages, with AM values below 25 µg/g for most compounds and narrower concentration ranges.

Fats and oils (Category 3, $n = 5$) showed high detection rates for several parabens, with MeP, PrP, and iso-BuP detected in all samples (DR = 100%). In this category, AM and GM values were comparable for most compounds, suggesting relatively uniform concentration distributions. In contrast, BuP was not detected in any fat and oil samples.

In canned fish products (Category 4, $n = 9$), parabens were detected sporadically. MeP and PrP were detected in 33.33% of samples, while iso-BuP was detected in 22.22% of samples. EtP and BuP were not detected in this category. Concentration levels in canned fish were generally low, with AM values below 5.1 µg/g.

Grain and bean products (Category 5, $n = 3$) showed variable detection patterns, with EtP detected in 33.33% of samples and PrP, iso-BuP, and BuP detected in 66.67% of the samples. Mean concentrations in this category were moderate, particularly for PrP and iso-BuP, although the small sample size limits generalization.

No parabens were detected in processed fruit samples (Category 6, $n = 3$), with all concentrations below the limits of detection. In pickled vegetables (Category 7, $n = 4$), only PrP was detected, with a detection rate of 25.00% and a maximum concentration of 96.88 µg/g, while other parabens were not detected. Snack products (Category 8, $n = 3$) exhibited low to moderate detection rates (33.33% for all compounds), with relatively low mean concentrations compared with beverages. Condiments (Category 9, $n = 38$) showed moderate detection rates for MeP (44.74%) and lower detection rates for other parabens, with concentration levels generally below those observed in beverages.

As seen in Figure 2, the analysis of parabens in beverages (category 1) revealed that the highest concentration was of MeP at 12,787.97 µg/g, which exceeds the standard limit set for beverages under the Ministry of Public Health's Notification No. 418 (B.E. 2563) issued under the Food Act B.E. 2522 (Thailand Food and Drug Administration, 2020). The maximum allowed concentration for beverages is 1,000 µg/g. Beverages permitted to use parabens include non-alcoholic beverages such as soft drinks, fruit juices, ready-to-drink tea and coffee, and bottled beverages. Exceptions may apply to specific beverages, such as bottled water or drinks with standards. Unacceptable percentages of MeP, EtP, PrP, iso-BuP, and BuP in beverages were 12.90, 6.45, 9.68, 16.13, and 25.81, respectively. In dairy products, fats and oils, canned fish, grain and beans, processed fruits, pickled vegetables, and snacks, were within the acceptable percentage.

Table 2. Distribution of Paraben concentrations (Unit: µg/g)

Compound	MeP	EtP	PrP	iso-BuP	BuP
<i>Total (n = 113)</i>					
DR (%)	47.79	30.97	41.59	23.01	18.58
AM	136.45	23.24	36.18	56.38	68.64
GM	1.91	0.11	1.40	0.47	0.06
Range	<LOD-12787.97	<LOD-526.36	<LOD-1962.07	<LOD-3431.50	<LOD-2018.39
<i>Category 1 beverages (n = 31)</i>					
DR (%)	61.29	58.06	64.52	32.26	45.16
AM	489.32	36.00	93.87	184.47	220.82
GM	5.39	0.66	4.18	0.78	0.46
Range	<LOD-12787.97	<LOD-362.09	<LOD-1962.07	<LOD-3431.50	<LOD-2018.39
<i>Category 2 daily products (n = 17)</i>					
DR (%)	64.71	47.06	58.82	47.06	5.88
AM	3.66	23.07	5.66	21.71	0.84
GM	2.03	0.24	1.86	1.78	0.02
Range	<LOD-11.24	<LOD-354.11	<LOD-22.93	<LOD-130.24	<LOD-14.17
<i>Category 3 fats and oils (n = 5)</i>					
DR (%)	100.00	40.00	100.00	100.00	0.00
AM	2.86	1.22	3.19	9.15	0.01
GM	2.85	0.10	2.95	9.14	0.01
Range	2.67-3.22	<LOD-3.09	2.41-6.12	8.89-9.58	0.01

Table 2. Distribution of Paraben concentrations (Unit: µg/g) (Continued)

Compound	MeP	EtP	PrP	iso-BuP	BuP
<i>Category 4 canned fish (n = 9)</i>					
DR (%)	33.33	0.00	33.33	22.22	0.00
AM	1.34	0.01	5.03	4.50	0.01
GM	0.80	0.01	0.92	0.37	0.01
Range	<LOD-3.44	<LOD	<LOD-15.98	<LOD-19.99	<LOD
<i>Category 5 grain and beans (n = 3)</i>					
DR (%)	0.00	33.33	66.67	66.67	66.67
AM	0.40	2.87	30.82	50.03	28.13
GM	0.40	0.10	5.59	8.72	2.47
Range	< LOD	<LOD-8.59	<LOD-83.06	<LOD-84.58	<LOD-58.68
<i>Category 6 processed fruits (n = 3)</i>					
DR (%)	0.00	0.00	0.00	0.00	0.00
AM	<LOD	<LOD	<LOD	<LOD	<LOD
GM	<LOD	<LOD	<LOD	<LOD	<LOD
Range	<LOD	<LOD	<LOD	<LOD	<LOD
<i>Category 7 pickled vegetables (n = 4)</i>					
DR (%)	0.00	0.00	25.00	0.00	0.00
AM	<LOD	<LOD	NC	<LOD	<LOD
GM	<LOD	<LOD	NC	<LOD	<LOD
Range	<LOD	<LOD	96.88	<LOD	<LOD
<i>Category 8 snacks (n = 3)</i>					
DR (%)	33.33	33.33	33.33	33.33	33.33
AM	3.02	1.94	5.00	13.72	1.23
GM	1.10	0.08	0.92	0.84	0.07
Range	<LOD-8.27	<LOD-5.79	<LOD-14.53	<LOD-40.91	<LOD-3.66
<i>Category 9 condiments (n = 38)</i>					
DR (%)	44.74	18.42	18.42	0.00	13.16
AM	3.91	28.89	21.46	0.12	21.27
GM	1.46	0.05	0.55	0.12	0.04
Range	<LOD-17.34	<LOD-526.36	<LOD-381.88	<LOD	<LOD-216.80

Note: DR (%) is the detection rate (%); AM is the arithmetic mean; GM is the geometric mean

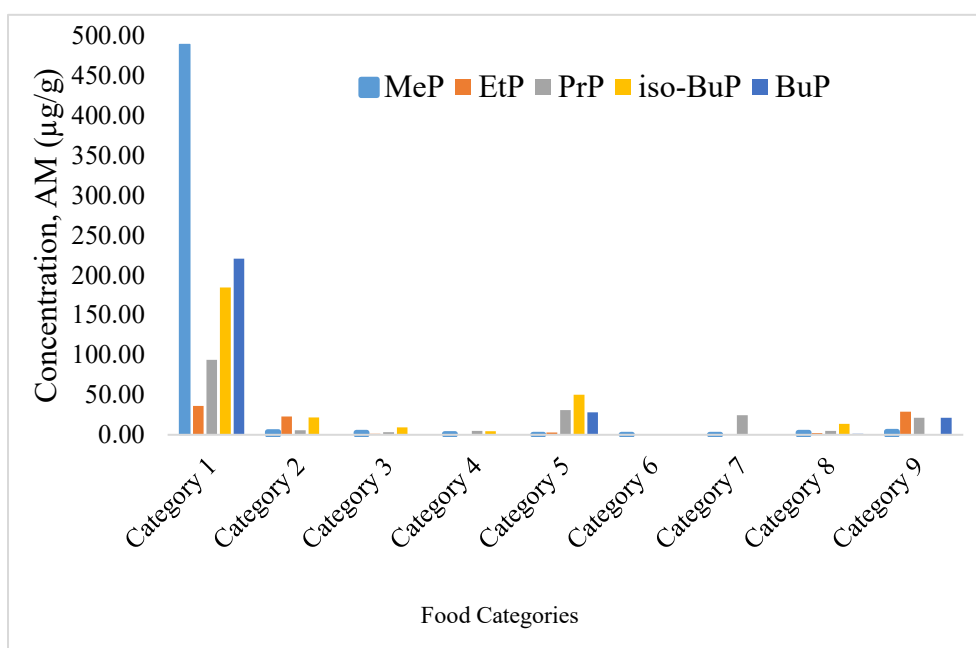


Figure 1. Arithmetic mean (AM) concentrations (µg/g) of methyl paraben (MeP), ethyl paraben (EtP), and propyl paraben (PrP) across different food categories. Category definitions are provided in Table 1

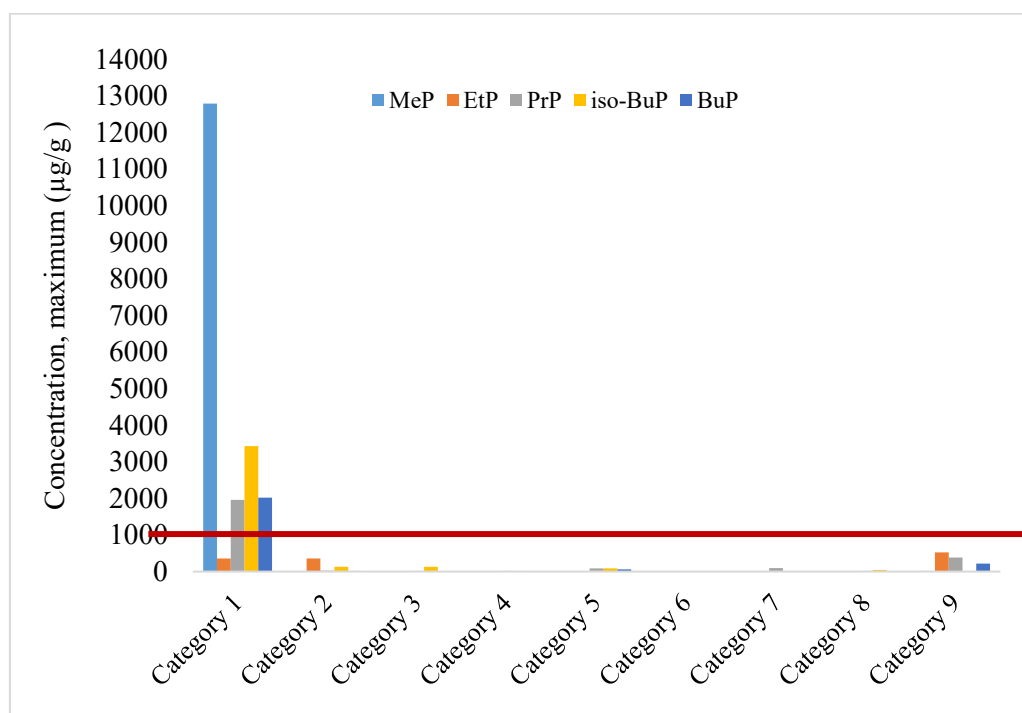


Figure 2. Maximum concentrations (µg/g) of five parabens detected in different food categories. The horizontal line indicates the regulatory limit for total parabens in food products (1,000 µg/g)

In this study, parabens were quantified across nine categories of ready-to-eat foods-beverages, dairy products, fats and oils, canned fish, grains and nuts, processed fruits, pickled vegetables, snacks, and condiments. Based on an HPLC-PDA analysis, the concentrations of parabens detected in these samples ranged from <0.02 to 12,787.97 µg/g. Several products exceeded the legal limit established under Thailand's Ministry of Public Health Notification No. 418 (B.E. 2563), which regulates the maximum allowable amount of parabens in food, issued in accordance with the Food Act B.E. 2522 (1979). When compared with findings reported by Maher *et al.* (2020), who analyzed ready-to-eat food items from the Saudi market, including cereals, meat, fish, dairy products, legumes, fruits, vegetables, cookies and snacks, beverages, and condiments. The concentration ranges of MeP, EtP, and PrP in their study were 0.025-496 µg/g, 0-13 µg/g, and 0-20 µg/g, respectively. In contrast, our results demonstrated substantially higher levels: MeP (<LOD-12,787.97 µg/g), EtP (<LOD-526.36 µg/g), and PrP (<LOD-1,962.07 µg/g). Maher *et al.* (2020) observed the highest residues in cereals and condiments, whereas our study found the highest levels in beverages and condiments. MeP and PrP are commonly incorporated into processed vegetables, bakery products, fats and oils, seasonings, and frozen dairy

products at concentrations up to 0.1%. In addition, regulations in the European Union allow MeP and EtP in food at levels not exceeding 300 mg/kg of product (Pisanello, 2014; Le *et al.*, 2022; Pereira *et al.*, 2023). According to European Union regulations, the maximum permitted level for methyl paraben (MeP) and ethyl paraben (EtP) in food is 300 mg/kg. In the present study, 2 soft drink samples out of a total of 113 samples (1.77%) exceeded the EU regulatory limit for MeP. In addition, 4 samples (3.54%) exceeded the limit for EtP, including two food seasoning products, one energy drink, and one condensed milk sample. These exceedances were mainly observed in beverage and condiment products, whereas the majority of samples complied with the EU regulatory standards. The relevant literature indicates that parabens are commonly detected in food products worldwide. For example, Liao *et al.* reported measurable paraben levels in 99% of Chinese food samples, with sum concentrations (Σ Parabens) of up to ~2530 ng/g in certain items. A global scoping review similarly noted extremely high paraben levels (e.g., up to ~495700 ng/g methylparaben in processed condiments) in non-EU food matrices, illustrating geographical differences in contamination patterns (Liao *et al.*, 2013; González-Palacios *et al.*, 2025). The relatively high concentrations of parabens observed in certain food

categories, particularly beverages, may be attributed to intentional preservative use, carry-over from raw materials, or contamination during food processing, packaging, and storage. As beverages are frequently consumed across different population groups, elevated concentrations in specific products may contribute to cumulative dietary exposure, even when most products comply with regulatory limits. Although dietary intake assessment was beyond the scope of this study, these findings highlight the importance of continued monitoring. In terms of regulatory comparison, while some samples exceeded the maximum limits established under Thailand's food regulations, only a limited number exceeded the permissible levels set by European Union regulations, reflecting differences in regulatory frameworks and risk management approaches (Gálvez-Ontiveros *et al.*, 2021).

The finding that a considerable proportion of beverage samples exceeded Thailand's regulatory limits, particularly for BuP, raises important considerations for consumer exposure and food safety. Although parabens are generally regarded as safe when used within established limits, excessive intake from frequent consumption of contaminated beverages may contribute to increased dietary exposure. International safety assessments by the World Health Organization (WHO) and the Joint FAO/WHO Expert Committee on Food Additives (JECFA) have established acceptable daily intake (ADI) frameworks for certain parabens, indicating that chronic exposure above recommended thresholds (e.g., up to 10 mg/kg body weight per day) may pose potential health concerns (World Health Organization, 2021). This is particularly relevant for vulnerable populations, such as children and high-frequency consumers of beverages. Therefore, the observed exceedance of regulatory limits suggests a need for continued monitoring and regulatory enforcement, as well as improved compliance with food additive regulations to ensure consumer protection.

However, future studies should include comprehensive method validation parameters, such as recovery and matrix effects, to further strengthen analytical robustness (Rigkos *et al.*, 2021; Piechocka & Głowacki, 2024).

Conclusion

This study developed an HPLC–PDA method for the determination of parabens in food products that can be considered simple, fast, and convenient due to its straightforward sample preparation based on direct extraction with acetonitrile. Compared with conventional analytical methods that rely on solid-

phase extraction (SPE) or multi-step cleanup procedures, the proposed approach minimizes sample pretreatment, thereby reducing analytical time and procedural complexity.

This method enabled the identification and quantification of five parabens (MeP, EtP, PrP, iso-BuP, and BuP) using a C18 column and a methanol-water mobile phase (57:43, v/v). Good analytical performance was achieved, with satisfactory linearity ($r = 0.996$ – 0.998), limits of detection (LOD) ranging from 0.02 to 0.50 µg/g, and limits of quantification (LOQ) ranging from 0.06 to 1.88 µg/g.

Application of this method to a variety of food products showed that parabens were frequently detected, particularly in beverage samples, where MeP, PrP, iso-BuP, and BuP were observed at relatively high concentrations. Some beverage samples exceeded the permissible levels established by Thailand's Ministry of Public Health for total parabens in food. Overall, the proposed method provides a practical tool for routine monitoring of paraben contamination in foods and may support future studies on dietary exposure assessment and food safety surveillance.

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Author Contributions

Pussadee Laor: Conceptualization, Methodology, Investigation, Writing – Original Draft, and Validation

Ananya Ouamthong: Data collection and Formal Analysis

Chonthicha Khamto: Data collection and Formal Analysis

Phusuda Saleedang: Data collection and Formal Analysis

Jantana Taen-in: Data collection and Formal Analysis

Warapon Paenkhokuard: Data collection and Formal Analysis

Vivat Keawdunglek: Investigation, Formal Analysis, Validation, Writing-Original Draft, Writing-Review & Editing, Supervision, Project Administration, and Funding Acquisition

Ethics Approval and Consent to Participate

Ethical approval for this research was obtained from the Mae Fah Luang University Ethics Committee for Human Research (Protocol No. EC 24182-18, COE 201/2024).

Declaration of Generative AI

The authors declare that no Generative AI tools were used in the preparation of this manuscript.

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References

- Altunay, A. Ö., & Elik, A. (2022). A novel sonication-assisted dispersive liquid-liquid microextraction method for methylparaben in cosmetic samples using deep eutectic solvent. *Sustainable Chemistry and Pharmacy*, 29, 100781. <https://doi.org/10.1016/j.scp.2022.100781>
- Ang, S., Kim, S., Park, J., Kim, H. J., Lee, J., Choi, G., Choi, S., Kim, S., Kim, S. Y., Moon, H. B., Kim, S., Kho, Y. L., & Choi, K. (2013). Urinary paraben concentrations among pregnant women and their matching newborn infants of Korea, and the association with oxidative stress biomarkers. *Science of the Total Environment*, 461-462, 214-221. <https://doi.org/10.1016/j.scitotenv.2013.04.097>
- Aouant, A. D., & Hela, D. (2025). Extraction and analytical techniques for pharmaceuticals and personal care products in sediments: A critical review towards environmental sustainability. *Sustainability*, 17(22), 10025. <https://doi.org/10.3390/su172210025>
- Ermer, J. (2025). ICH Q2(R2): Validation of analytical procedures. In *Method validation in pharmaceutical analysis: A guide to best practice* (pp. 351-372). Wiley-VCH. <https://doi.org/10.1002/9783527831708.ch13>
- Gálvez-Ontiveros, Y., Moscoso-Ruiz, I., Rodrigo, L., Aguilera, M., Rivas, A., & Zafra-Gómez, A. (2021). Presence of parabens and bisphenols in food commonly consumed in Spain. *Foods*, 10(1), 92. <https://doi.org/10.3390/foods10010092>
- González-Palacios, P., Monteagudo, C., Ramírez, V., Zafra-Gómez, A., & Rivas, A. (2025). Worldwide systematic analysis of dietary paraben exposure: A scoping review of sources and food categories. *Food Chemistry*, 496(Pt. 3), 146605. <https://doi.org/10.1016/j.foodchem.2025.146605>
- Isaac, R. A. A., Subbarayalu, R., Kumar, M. S. K., Martin, T. M., Lo, S. C., & Santosh, W. (2025). Human endocrine disruption: An updated review of toxicological insights into parabens and phthalates. *Toxicology and Environmental Health Sciences*, 17(3), 335-348. <https://doi.org/10.1007/s13530-025-00264-w>
- Kang, H.-S., Kyung, M.-S., Ko, A., Park, J.-H., Hwang, M.-S., Kwon, J.-E., Suh, J.-H., Lee, H.-S., Moon, G. I., Hong, J.-H., & Hwang, I. G. (2016). Urinary concentrations of parabens and their association with demographic factors: A population-based cross-sectional study. *Environmental Research*, 146, 245-251. <https://doi.org/10.1016/j.envres.2015.12.032>
- Ku, H.-H., Yang, S.-C., Hsiao, H.-A., Chen, J.-S., & Ling, M.-P. (2025). Assessing dietary exposure risk to food preservatives among the eating-out population in Taiwan using the total diet study method. *Foods*, 14(3), 365. <https://doi.org/10.3390/foods14030365>
- Laor, P., Limpanont, Y., Phuanukoonnon, S., Kho, Y., Choi, K., Kliengchuay, W., Park, S., & Tantrakarnapa, K. (2025). Urinary paraben concentrations among children from the northernmost of Thailand: Cross-sectional study for exposure and health risks. *Ecotoxicology and Environmental Safety*, 295, 118172. <https://doi.org/10.1016/j.ecoenv.2025.118172>
- Le, T. M., Pham, P. T., Nguyen, T. Q., Nguyen, T. Q., Bui, M. Q., Nguyen, H. Q., Vu, N. D., Kannan, K., & Tran, T. M. (2022). A survey of parabens in aquatic environments in Hanoi, Vietnam and its implications for human exposure and ecological risk. *Environmental Science and Pollution Research*, 29(31), 46767-46777. <https://doi.org/10.1007/s11356-022-19254-3>
- Li, Y., Zheng, N., Sun, S., Wang, S., Li, X., Pan, J., Li, M., Lang, L., Yue, Z., & Zhou, B. (2023). Exposure estimates of parabens from personal care products compared with biomonitoring data in human hair from Northeast China. *Ecotoxicology and Environmental Safety*, 267, 115635. <https://doi.org/10.1016/j.ecoenv.2023.115635>
- Liao, C., Liu, F., & Kannan, K. (2013). Occurrence of and dietary exposure to parabens in foodstuffs from the United States. *Environmental Science & Technology*, 47(8), 3918-3925. <https://doi.org/10.1021/es400724s>
- Maher, H. M., Alzoman, N. Z., Almeshal, M. A., Alotaibi, H. A., Alotaibi, N. N., & Al-Showiman, H. (2020). Quantitative screening of parabens in ready-to-eat foodstuffs available in the Saudi market using high-performance liquid chromatography with photodiode array detection. *Arabian Journal of Chemistry*, 13(1), 2897-2911. <https://doi.org/10.1016/j.arabjc.2018.07.019>
- Nowak, K., Ratajczak-Wrona, W., Górka, M., & Jabłońska, E. (2018). Parabens and their effects on the endocrine system. *Molecular and Cellular Endocrinology*, 474, 238-251. <https://doi.org/10.1016/j.mce.2018.03.014>
- Pereira, A. R., Simões, M., & Gomes, I. B. (2023). Parabens as environmental contaminants of aquatic systems affecting water quality and microbial dynamics. *Science of the Total Environment*, 905, 167332. <https://doi.org/10.1016/j.scitotenv.2023.167332>
- Piechocka, J., & Glowacki, R. (2024). Comprehensive studies on the development of HPLC-MS/MS and HPLC-FL based methods for routine determination of homocysteine thiolactone in human urine. *Talanta*, 272, 125791. <https://doi.org/10.1016/j.talanta.2024.125791>
- Pisanello, D. (2014). EU regulations on chemicals in foods. In *Chemistry of foods: EU legal and regulatory approaches* (pp. 15-77). Springer International Publishing.
- Proctor, K., Petrie, B., Barden, R., Arnot, T., & Kasprzyk-Hordern, B. (2019). Multi-residue ultra-performance liquid chromatography coupled with tandem mass spectrometry method for comprehensive multi-class anthropogenic compounds of emerging concern analysis in a catchment-based exposure-driven study. *Analytical and Bioanalytical Chemistry*, 411(27), 7061-7086. <https://doi.org/10.1007/s00216-019-02091-8>
- Rigkos, G., Alampanos, V., Kabir, A., Furton, K. G., Roje, Ž., Vrček, I. V., Panderi, I., & Samanidou, V. (2021). An improved fabric-phase sorptive extraction protocol for the determination of seven parabens in human urine by HPLC-DAD. *Biomedical Chromatography*, 35(2), e4974. <https://doi.org/10.1002/bmc.4974>

- Saridal, K., & Ulusoy, H. İ. (2019). A simple methodology based on cloud point extraction prior to HPLC-PDA analysis for tetracycline residues in food samples. *Microchemical Journal*, 150, 104170. <https://doi.org/10.1016/j.microc.2019.104170>
- Sigma-Aldrich. (2026). *Ethyl parahydroxybenzoate*. <https://www.sigmaaldrich.com/TH/th/product/sial/e2425000>
- Soni, M. G., Carabin, I. G., & Burdock, G. A. (2005). Safety assessment of esters of p-hydroxybenzoic acid (parabens). *Food and Chemical Toxicology*, 43(7), 985-1015. <https://doi.org/10.1016/j.fct.2005.01.020>
- Thailand Food and Drug Administration. (2020). *Food Act B.E. 2522*. <https://food.fda.moph.go.th/food-law/category/food-act-be2522>
- Tomar, C., Singh, P., & Yadav, S. (2026). Endocrine-disrupting chemicals in cosmetics: Mechanistic insights and their impact on human and skin health. *Reviews in Endocrine and Metabolic Disorders*, 27(1), 123-138. <https://doi.org/10.1007/s11154-025-10006-5>
- Vale, F., Sousa, C. A., Sousa, H., Santos, L., & Simões, M. (2022). Parabens as emerging contaminants: Environmental persistence, current practices and treatment processes. *Journal of Cleaner Production*, 347, 131244. <https://doi.org/10.1016/j.jclepro.2022.131244>
- Waters Corporation. (2020). *e2695 separation module*. <https://www.waters.com/webassets/cms/library/docs/720004547en.pdf>
- Waters Corporation. (2024). *SunFire C18 column*. <https://www.waters.com/nextgen/en/shop/columns/186002554-sunfire-c18-column-100a-35--m-46-mm-x-150-mm-1-pk.html>
- World Health Organization. (2021). *Methyl p-hydroxybenzoate*. <https://apps.who.int/food-additives-contaminants-jecfa-database/Home/Chemical/342>
- Ye, X., Kuklenyik, Z., Bishop, A. M., Needham, L. L., & Calafat, A. M. (2006). Quantification of the urinary concentrations of parabens in humans by on-line solid phase extraction-high performance liquid chromatography-isotope dilution tandem mass spectrometry. *Journal of Chromatography B: Analytical Technologies in the Biomedical and Life Sciences*, 844(1), 53-59. <https://doi.org/10.1016/j.jchromb.2006.06.037>