

Pesticide and Polycyclic Aromatic Hydrocarbon Residues in Edible
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Pesticide and Polycyclic Aromatic Hydrocarbon Residues in Edible Oils Marketed in Al-Bayda, Libya

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Abstract

Edible oils may contain pesticide residues and polycyclic aromatic hydrocarbons (PAHs), but evidence from Libya remains limited. This cross-sectional pilot study screened ten edible-oil samples marketed in Al-Bayda, Libya, in three analytical batches during 2025. Eight mixed vegetable-oil samples were analysed by gas chromatography–tandem mass spectrometry (GC–MS/MS) for selected pesticides and for benzo[a]pyrene and benzo[e]pyrene. Two branded samples (corn and sunflower oil) were analysed by liquid chromatography–tandem mass spectrometry (LC–MS/MS) after quick, easy, cheap, effective, rugged, and safe (QuEChERS) extraction. Prochloraz was detected in 7 of 8 mixed-oil samples (87.5%; 26.24–49.57 µg/kg), and procymidone in 6 of 8 samples (75.0%; 11.33–35.37 µg/kg); permethrin was not detected. Neither PAH was detected above the method limit of quantification (LOQ) of 10 µg/kg. Piperonyl butoxide and pirimiphos-methyl were below 0.01 mg/kg or not detected in the two branded oils. The frequent fungicide detections warrant further investigation, but regulatory interpretation requires the exact oilseed composition, applicable residue definitions, and verified current maximum residue limits. Because the PAH LOQ exceeded the European Union maximum level for benzo[a]pyrene in most oils, non-detection does not

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establish compliance. Larger, representative surveillance using harmonised analytical methods, a complete PAH4 panel, and sufficiently low LOQs is recommended.

Keywords: edible oils; food safety; Libya; pesticide residues; polycyclic aromatic hydrocarbons; prochloraz.

تقييم متبقيات المبيدات والهيدروكربونات العطرية متعددة الحلقات في زيوت الطعام المتداولة في مدينة البيضاء، ليبيا

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الملخص

قد تحتوي زيوت الطعام على بقايا المبيدات والهيدروكربونات العطرية متعددة الحلقات، إلا أن الأدلة المتاحة من ليبيا ما تزال محدودة. هدفت هذه الدراسة المقطعية الاستطلاعية إلى فحص عشر عينات من زيوت الطعام المتداولة في مدينة البيضاء بليبيا ضمن ثلاث دفعات تحليلية خلال عام 2025. حُللت ثماني عينات من الزيوت النباتية المخلوطة باستخدام كروماتوغرافيا الغاز المقترنة بمطياف الكتلة الترادفي للكشف عن مبيدات مختارة وعن مركبي بنزو[a]بيرين وبنزو[e]بيرين. كما حُللت عينتان تجاريتان من زيت الذرة وزيت دوار الشمس باستخدام كروماتوغرافيا السائل المقترنة بمطياف الكتلة الترادفي بعد الاستخلاص بطريقة QuEChERS. كُشف عن البروكلوراز في 7 من 8 عينات (87.5%؛ 26.24–49.57 ميكروغرام/كغ)، وعن البروسيميدون في 6 من 8 عينات (75.0%؛ 11.33–35.37 ميكروغرام/كغ)، بينما لم يُكشف عن البيرميثرين. ولم يُكشف عن أي من مركبي الهيدروكربونات العطرية متعددة الحلقات فوق حد التقدير الكمي البالغ 10 ميكروغرام/كغ. وكانت تراكيز بيبيرونيل بوتوكسيد وبيريميفوس-ميثيل أقل من 0.01 ملغم/كغ أو غير مكتشفة في العينتين التجاريتين. تستدعي كثرة الكشف عن بقايا المبيدات

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الفطريين مزيدًا من الدراسة، غير أن التفسير التنظيمي يتطلب معرفة التركيب الدقيق للزيوت المخلوطة، وتعريفات البقايا المنطبقة، والحدود القصوى الحالية الموثقة. ولأن حد التقدير الكمي للهيدروكربونات العطرية متعددة الحلقات تجاوز الحد الأقصى الأوروبي لبنزو[a]بيرين في معظم الزيوت، فإن عدم الكشف لا يثبت الامتثال. ويوصى بتنفيذ رصد أوسع بعينة ممثلة، وطرق تحليلية موحدة، وتحليل مجموعة PAH4 كاملة، وحدود تقدير كمي منخفضة بما يكفي.

الكلمات المفتاحية: زيوت الطعام؛ سلامة الأغذية؛ ليبيا؛ بقايا المبيدات؛ الهيدروكربونات العطرية متعددة الحلقات؛ بروكلوراز.

1. Introduction

Edible oils are staple foods and important trade commodities. Because pesticides may be applied to oilseed crops before harvest and oils are lipid-rich matrices, residue determination requires efficient extraction and selective clean-up. QuEChERS-based multiresidue methods coupled with tandem mass spectrometry are widely used for this purpose (Anastassiades et al., 2003; Hakme et al., 2018; Kardani et al., 2025; Parrilla Vázquez et al., 2016).

Polycyclic aromatic hydrocarbons (PAHs) may enter edible oils during seed drying, roasting, smoke exposure, or inadequately controlled processing. Several PAHs are genotoxic and carcinogenic. For oils and fats placed on the market for the final consumer or used as food ingredients, European legislation sets maximum levels of 2.0 µg/kg for benzo[a]pyrene and 10.0 µg/kg for the sum of four marker PAHs (PAH4) (European Commission, 2023). Analytical sensitivity must therefore be sufficient for these limits; validated GC–MS/MS methods can achieve LOQs of approximately 0.9 µg/kg in edible-oil matrices (Zhao, 2023).

Published residue data for Libya are scarce, and routine food-control data are not readily available in the international literature. This evidence gap constrains risk-based decisions concerning edible oils marketed in eastern Libya.

This pilot study aimed to screen edible oils marketed in Al-Bayda for selected pesticide residues and two PAHs by GC–MS/MS and

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LC–MS/MS, describe the concentrations observed, and identify analytical and regulatory priorities for future surveillance. The study was exploratory because it used convenience sampling and different analytical target lists across three batches.

2. Materials and Methods

2.1 Study Design and Samples

A cross-sectional pilot survey was conducted in Al-Bayda, Libya. Ten edible-oil samples were purchased in three batches during 2025: six mixed vegetable-oil samples in February, two mixed vegetable-oil samples in March, and two branded oils in October. Samples were retained in their original sealed containers, protected from heat and direct sunlight, and transported to the analytical laboratory. Table 1 summarises the available sample metadata.

Table 1. Sample identification and collection details

Sample ID	Batch	Oil type	Lot/batch no.	Volume (mL)	Date received
S1	1	Mixed vegetable oil	Jan-2025-01	1000	01/02/2025
S2	1	Mixed vegetable oil	Jan-2025-02	1000	01/02/2025
S3	1	Mixed vegetable oil	Jan-2025-03	1000	01/02/2025
S4	1	Mixed vegetable oil	Jan-2025-04	1000	01/02/2025
S5	1	Mixed vegetable oil	Jan-2025-05	1000	01/02/2025
S6	1	Mixed vegetable oil	Jan-2025-06	1000	01/02/2025
S7	2	Mixed vegetable oil	Feb-2025-07	1000	01/03/2025
S8	2	Mixed vegetable oil	Feb-2025-08	1000	01/03/2025
B1	3	Corn oil	Oct-2025-01	1800	12/10/2025
B2	3	Sunflower oil	Oct-2025-02	1800	12/10/2025

2.2 Chemicals and Standards

High-performance liquid chromatography (HPLC)-grade acetonitrile, n-hexane, acetone, ethyl acetate, methanol, and formic

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acid were used. Anhydrous magnesium sulfate (MgSO_4), sodium chloride (NaCl), primary–secondary amine (PSA), and octadecylsilane (C18) sorbent were used for extraction and clean-up. Certified pesticide and PAH reference standards and deuterated PAH internal standards were used for identification and quantification.

2.3 Pesticide Extraction

2.3.1 Gas Chromatography–Tandem Mass Spectrometry (GC–MS/MS) Batches

For batches 1 and 2, 2.0 g of homogenised oil was placed in a 50 mL polypropylene tube. Acetonitrile (10 mL) containing 1% formic acid was added; the sample was vortex-mixed for 1 min and sonicated for 10 min; and an extraction-salt mixture containing 4 g MgSO_4 and 1 g NaCl was added. After immediate shaking for 1 min and centrifugation at $4,000 \times g$ for 5 min, 6 mL of the acetonitrile layer was transferred to a dispersive solid-phase extraction (d-SPE) tube containing 900 mg MgSO_4 , 150 mg PSA, and 150 mg C18. The extract was vortex-mixed for 30 s and centrifuged at $5,000 \times g$ for 5 min. One millilitre of supernatant was filtered through a $0.22 \mu\text{m}$ polytetrafluoroethylene (PTFE) membrane into an autosampler vial. The extraction principle followed the QuEChERS approach (Anastassiades et al., 2003), adapted for the lipid matrix.

2.3.2 Liquid Chromatography–Tandem Mass Spectrometry (LC–MS/MS) Batch

For batch 3, 5.0 g of oil was extracted with 10 mL acetonitrile containing 0.1% formic acid. Citrate-buffered quick, easy, cheap, effective, rugged, and safe (QuEChERS) extraction salts were added according to EN 15662:2018, and the tube was shaken for 10 min (European Committee for Standardization, 2018). After centrifugation, an aliquot was cleaned by d-SPE containing MgSO_4 , PSA, and C18. The final extract was filtered through a $0.22 \mu\text{m}$ PTFE membrane and analysed by liquid chromatography–tandem mass spectrometry (LC–MS/MS).

2.4 Polycyclic Aromatic Hydrocarbon (PAH) Extraction

For batches 1 and 2, 0.5 g of oil was dissolved in 5 mL hexane–acetone (1:1, v/v) and vortex-mixed for 1 min. A silica solid-phase extraction (SPE) cartridge (500 mg/6 mL), conditioned with 5 mL hexane, was used for clean-up. The sample was loaded, the cartridge was washed with 5 mL hexane, and PAHs were eluted with 10 mL hexane–dichloromethane (3:1, v/v). The eluate was evaporated under nitrogen at 40 °C, reconstituted in 1.0 mL toluene, vortex-mixed, filtered through a 0.22 µm PTFE membrane, and transferred to a gas-chromatography vial.

2.5 Instrumental Analysis

2.5.1 GC–MS/MS Conditions

Pesticides and PAHs in batches 1 and 2 were analysed using a Trace 1310 gas chromatograph coupled to a TSQ 8000 Evo triple-quadrupole mass spectrometer with electron ionisation (EI). A TG-5SilMS column (30 m × 0.25 mm internal diameter × 0.25 µm film thickness) was used for pesticides, and a TG-5MS column with the same dimensions was used for PAHs. Helium was the carrier gas at 1.2 mL/min. The injection volume was 1 µL in splitless mode. Data were acquired in selected-reaction monitoring (SRM) mode. The reported transitions are presented in Tables 2 and 3; the GC–MS/MS validation framework was informed by Hollosi et al. (2013).

Table 2. GC–MS/MS transitions reported for pesticides

Compound	Quantifier SRM (m/z)	Qualifier SRM (m/z)	LOQ (µg/kg)
Permethrin	183.1 → 153.0	183.1 → 168.0	5
Prochloraz	180.1 → 138.1	308.0 → 147.1	5
Procymidone	95.9 → 67.1	283.0 → 96.1	5

Table 3. GC–MS/MS transitions reported for PAHs

Compound	Molecular ion (m/z)	Quantifier SRM (m/z)	Qualifier SRM (m/z)	LOQ (µg/kg)
Benzo[a]pyrene	252.0	252 → 250	125.1 → 124.1	10
Benzo[e]pyrene	252.0	251.8 → 251.8	251.8 → 249.8	10

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2.5.2 LC–MS/MS Conditions

Batch 3 was analysed by reversed-phase LC–MS/MS using positive-mode electrospray ionisation (ESI). The analytical laboratory reported EN 15662:2018 sample preparation and an LOQ of 0.01 mg/kg for both target compounds (European Committee for Standardization, 2018). The available multiple-reaction monitoring (MRM) transitions are listed in Table 4.

Table 4. LC–MS/MS transitions reported for batch 3

Compound	ESI mode	Quantifier MRM	Qualifier MRM	LOQ (mg/kg)
Piperonyl butoxide	ESI+	356.1 → 177.1	356.1 → 119.1	0.01
Pirimiphos- methyl	ESI+	306.1 → 164.1	306.1 → 108.1	0.01

2.6 Quality Assurance

Blank oils, procedural blanks, matrix spikes, calibration standards, and replicate analyses were reported as quality-control measures. Identification was based on retention time and two transitions, and calibration coefficients were reported to exceed 0.995. Batch acceptance criteria were 70–120% recovery and a relative standard deviation below 20%. The raw validation records were not available for independent verification; accordingly, the analytical results are presented as reported screening data rather than as independently confirmed regulatory measurements.

2.7 Statistical Analysis

Concentrations were summarised using detection frequencies, means, standard deviations, medians, and ranges. Descriptive statistics were calculated for quantified values only. As a sensitivity analysis, Pearson correlation included all eight mixed-oil samples, with non-detects assigned zero solely for this exploratory calculation. Because the sample was small and the data were left-censored, the correlation was not used to infer causation. One-way analysis of variance was not performed because there was only one analytical observation per sample and therefore no valid within-group error term.

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3. Results and Discussion

3.1 Pesticide Residues

Prochloraz was detected in 7 of 8 mixed vegetable-oil samples (87.5%), at quantified concentrations of 26.24–49.57 µg/kg. Procymidone was detected in 6 of 8 samples (75.0%), at 11.33–35.37 µg/kg. Permethrin was not detected above the reported LOQ of 5 µg/kg. The two October samples were analysed with a different LC–MS/MS target list and were therefore not pooled with the GC–MS/MS results.

Table 5. Pesticide residues in mixed vegetable oils (µg/kg)

Sample	Permethrin	Prochloraz	Procymidone
S1	ND (<5)	49.57	35.37
S2	ND (<5)	39.99	ND (<5)
S3	ND (<5)	26.24	21.64
S4	ND (<5)	32.98	14.72
S5	ND (<5)	ND (<5)	ND (<5)
S6	ND (<5)	26.31	11.33
S7	ND (<5)	28.33	12.08
S8	ND (<5)	34.22	12.45
Detected, n (%)	0 (0%)	7 (87.5%)	6 (75.0%)

Table 6. Descriptive statistics for quantified pesticide values

Statistic	Prochloraz	Procymidone
Detected, n (%)	7 (87.5%)	6 (75.0%)
Mean ± SD (µg/kg)	33.95 ± 8.47	17.93 ± 9.34
Median (µg/kg)	32.98	13.59
Range (µg/kg)	26.24–49.57	11.33–35.37
Coefficient of variation	25.0%	52.1%

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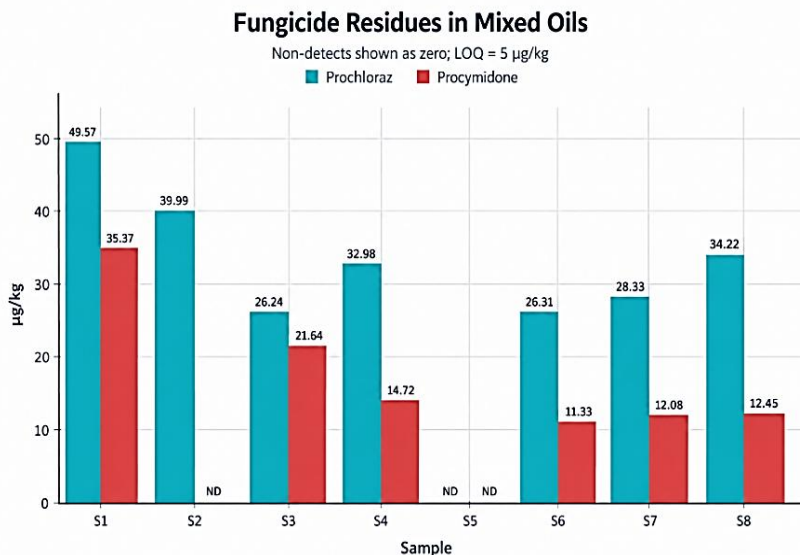


Figure 1. Prochloraz and procymidone concentrations in samples S1–S8.
Non-detects are plotted as zero for display only; LOQ = 5 µg/kg.

When all eight samples figure (1) were included and non-detects were assigned zero, the correlation between prochloraz and procymidone was moderate and not statistically significant (Pearson $r = 0.589$, $p = 0.125$). This substitution-based sensitivity analysis does not establish co-application, a shared contamination source, or causation; larger datasets and statistical methods appropriate for left-censored measurements are needed.

The frequent detection of two fungicides may reflect residues originating from oilseed production, storage, processing, or blending. Recent analytical studies confirm that pesticide residues can occur in edible oils and that selective matrix clean-up is important (Hakme et al., 2018; Kardani et al., 2025; Parrilla Vázquez et al., 2016). However, the present design cannot estimate prevalence in Al-Bayda or identify the source of the residues.

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3.2 Polycyclic Aromatic Hydrocarbon (PAH) Results

Table 7. PAH results in mixed vegetable oils

Sample	Benzo[a]pyrene (µg/kg)	Benzo[e]pyrene (µg/kg)
S1	ND (<10)	ND (<10)
S2	ND (<10)	ND (<10)
S3	ND (<10)	ND (<10)
S4	ND (<10)	ND (<10)
S5	ND (<10)	ND (<10)
S6	ND (<10)	ND (<10)
S7	ND (<10)	ND (<10)
S8	ND (<10)	ND (<10)
Detected, n (%)	0 (0%)	0 (0%)

Benzo[a]pyrene and benzo[e]pyrene were not detected above the reported LOQ of 10 µg/kg in any of the eight samples. This finding does not demonstrate compliance with the European maximum level of 2.0 µg/kg for benzo[a]pyrene in most oils because concentrations between 2 and 10 µg/kg could not be quantified. The study also cannot assess the PAH4 limit because benz[a]anthracene, benzo[b]fluoranthene, and chrysene were not included. Future testing should include the full PAH4 panel and an LOQ of approximately 0.9 µg/kg or lower (European Commission, 2023; Zhao, 2023).

3.3 Branded Oil Results

Table 8. LC–MS/MS results for the two branded oils

Sample ID	Laboratory code	Oil type	Piperonyl butoxide	Pirimiphos-methyl
B1	FD037156	Corn oil	<LOQ (<0.01 mg/kg)	<LOQ (<0.01 mg/kg)
B2	FD037157	Sunflower oil	ND	ND

Piperonyl butoxide and pirimiphos-methyl were below 0.01 mg/kg or not detected in the corn- and sunflower-oil samples. These two observations are screening findings only; they do not represent branded oils marketed in Al-Bayda and provide no information about pesticides outside the LC–MS/MS target list.

3.4 Regulatory Interpretation

Pesticide results were not classified as compliant or non-compliant because maximum residue limits are defined for specific combinations of active substance, commodity, and residue definition under Regulation (EC) No 396/2005 (European Commission, 2005). The label “mixed vegetable oil” does not identify the constituent oilseeds required for reliable commodity matching. Before any regulatory conclusion is made, each analyte should be checked against the current applicable database using the exact product composition and residue definition, with the date of verification recorded.

3.5 Public-Health Interpretation

A formal dietary risk assessment was not undertaken because representative Libyan oil-consumption data, age-specific body weights, and a fully documented set of current toxicological reference values were unavailable. Moreover, a limited target list cannot support a cumulative assessment. Future risk characterisation should use nationally representative consumption data, validated occurrence data, current toxicological benchmarks, transparent treatment of non-detects, and quantitative uncertainty analysis.

3.6 Study Limitations

The findings should be interpreted in view of the small convenience sample, the use of different analytical platforms and target lists across batches, incomplete product-composition information, and the absence of independently reviewable raw chromatograms and batch-level validation records. In addition, the PAH method was insufficiently sensitive to establish compliance with the European benzo[a]pyrene limit, and only two PAHs rather than the complete PAH4 group were reported. These limitations do not invalidate the screening observations, but they restrict generalisation and regulatory inference.

4. Conclusions

This pilot study detected prochloraz in seven and procymidone in six of eight mixed vegetable-oil samples marketed in Al-Bayda. Permethrin was not detected, and piperonyl butoxide and pirimiphos-methyl were below the LC–MS/MS reporting limit or not detected in two branded oils. The PAH findings are inconclusive for regulatory compliance because the LOQ exceeded the European maximum level for benzo[a]pyrene and the complete PAH4 group was not analysed. The findings support a larger probability-based surveillance programme using one harmonised multiresidue method, complete product metadata, independently documented quality control and measurement uncertainty, sufficiently low LOQs, and commodity-specific verification of current regulatory limits.

5. Acknowledgements

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6. Declarations

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Competing interests: The authors declare that they have no competing interests.

Data availability: Raw laboratory reports, chromatograms, calibration files, and anonymised sample data are available from the corresponding author upon reasonable request.

Author contributions: Seraj Abbas: Conceptualization, Methodology, Formal analysis, Data curation, Visualization, Writing—original draft, Writing—review and editing, Project

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administration, and Correspondence. Abdrousl Bosultan: Investigation, Resources, Data curation, and Writing—review and editing. Ramadan E. Abdolgader: Investigation, Resources, Validation, and Writing—review and editing.

Ethics statement: This study analysed retail food products and did not involve human participants or animals.

7. References

- Anastassiades, M., Lehotay, S. J., Štajnbaher, D., & Schenck, F. J. (2003). Fast and easy multiresidue method employing acetonitrile extraction/partitioning and dispersive solid-phase extraction for the determination of pesticide residues in produce. *Journal of AOAC International*, 86(2), 412–431. <https://doi.org/10.1093/jaoac/86.2.412>
- European Commission. (2005). Regulation (EC) No 396/2005 of the European Parliament and of the Council of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin and amending Council Directive 91/414/EEC. *Official Journal of the European Union*, L 70, 1–16.
- European Commission. (2023). Commission Regulation (EU) 2023/915 of 25 April 2023 on maximum levels for certain contaminants in food and repealing Regulation (EC) No 1881/2006. *Official Journal of the European Union*, L 119, 103–157. <http://data.europa.eu/eli/reg/2023/915/oj>
- European Committee for Standardization. (2018). Foods of plant origin—Multimethod for the determination of pesticide residues using GC- and LC-based analysis following acetonitrile extraction/partitioning and clean-up by dispersive SPE—Modular QuEChERS-method (EN 15662:2018). CEN.
- Hakme, E., Lozano, A., Ferrer, C., Díaz-Galiano, F. J., & Fernández-Alba, A. R. (2018). Analysis of pesticide residues in olive oil and other vegetable oils. *TrAC Trends in Analytical Chemistry*, 100, 167–179. <https://doi.org/10.1016/j.trac.2017.12.016>

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- Hollosi, L., Bousova, K., & Godula, M. (2013). Validation of the method for determination of pesticide residues by gas chromatography–triple-stage quadrupole mass spectrometry (Method 63899). Thermo Fisher Scientific.
- Kardani, F., Zarei Jelyani, A., Khezeli, T., Hashemi, M., Rashedinia, M., Shariati, S., Mahdavinia, M., & Noorie, S. M. A. (2025). Determination of 229 pesticide residues in edible oil samples using the conventional QuEChERS method and solid-phase microextraction based on a monolithic molecularly imprinted polymer fibre with GC–MS analysis. *BMC Chemistry*, 19, Article 144. <https://doi.org/10.1186/s13065-025-01518-x>
- Parrilla Vázquez, P., Hakme, E., Uclés, S., Cutillas, V., Martínez Galera, M., Mughari, A. R., & Fernández-Alba, A. R. (2016). Large multiresidue analysis of pesticides in edible vegetable oils by using efficient solid-phase extraction sorbents based on quick, easy, cheap, effective, rugged and safe methodology followed by gas chromatography–tandem mass spectrometry. *Journal of Chromatography A*, 1463, 20–31. <https://doi.org/10.1016/j.chroma.2016.08.008>
- Zhao, L. (2023). Determination of 14 polycyclic aromatic hydrocarbon compounds in edible oil using Captiva EMR–Lipid cleanup by GC/MS/MS (Application Note 5994-1483EN). Agilent Technologies.