Research Paper

Forensic Phytochemistry: A Bibliometric Analysis of Analytical Methods for Plant Toxin Detection (2016–2026)

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ABSTRACT

Background: Plant toxins cause accidental, occupational, food-borne, and deliberate poisoning, and ricin and abrin are recognized forensic threat agents. Because they occur as trace-level mixtures in difficult matrices, progress depends on analytical capability. This study maps a decade of detection research.

Methods: A cross-sectional bibliometric analysis of 305 English-language articles indexed in Scopus between 2016 and 2026, retrieved on 28 August 2026. Indicators were computed in bibliometrix/Biblioshiny, keyword co-occurrence mapped in VOSviewer, and analytical platform, toxin class, matrix, and orientation coded in Python.

Results: The corpus comprised 305 articles from 163 sources and 1,683 authors in 63 countries, with 4,261 citations (mean 13.97; h-index 34). Output rose from 19 articles in 2016 to 49 in 2025 (R^2=0.436, P=0.038). Chromatography dominated: liquid chromatography 37.4%, tandem mass spectrometry 33.1%, high-resolution mass spectrometry 14.1%; metabolomics showed the largest proportional increase, from 2.5% in 2016–2020 to 8.6% in 2021–2026. Keyword mapping resolved four clusters, separating clinical poisoning from analytical, omics-based, and agronomic strands. Food matrices appeared in 33.4% of articles, human clinical specimens in 15.1%, and forensic casework in 10.5%; method validation was the most common orientation (25.6%), and risk assessment the rarest (11.5%). Europe accounted for 43.3% of country appearances, compared with 3.4% from sub-Saharan Africa.

Conclusion: Detection capability is advancing faster than its clinical, forensic, and risk-assessment applications. Priorities are forensic reference libraries for botanical toxins, published poison-center and autopsy case series, and analytical capacity where the poisoning burden is greatest.

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Introduction

Plant poisoning remains a live problem in clinical and forensic practice, arising from accidental ingestion, misidentified foraged species, herbal medicine, veterinary exposure, and deliberate self-harm; ricin and abrin are further classified as threat agents.

What distinguishes these compounds is analytical difficulty: they occur as trace-level mixtures in hostile matrices, many lack certified reference standards, and congeners differ by a single hydroxyl or N-oxide group. Progress is bounded by detection capability rather than clinical recognition.

The clinical stakes rose during the study period. Pyrrolizidine alkaloids (PAs) have been shown to cause hepatic sinusoidal obstruction syndrome in people [1] and reach consumers through honey, herbal infusions, and milk [2]. Aristolochic acids are linked to endemic nephropathy [3], adulterated supplements pose consumer risk [4], and Aconitum poisoning is still reported [5].

Plant toxins thus span clinical toxicology, forensic medicine, food-safety regulation, and analytical chemistry. Plant pathologists also use “phytotoxin” to refer to microbial metabolites that damage plants rather than animals, complicating retrieval.

Bibliometric analysis describes, in a reproducible manner, how a field is structured and which themes are neglected [6]. Such studies exist for forensic genetics [7] and forensic science generally [8], but not for plant toxin detection. This study maps its volume, growth, structure, platforms, toxin classes, and matrices, and locates gaps relevant to forensic and medical toxicology.

Materials and Methods

Study design

Reporting of this cross-sectional bibliometric study follows the STROBE checklist (Strengthening the Reporting of Observational Studies in Epidemiology) wherever its items are applicable to bibliographic observation.

Search strategy

Scopus was searched on 28 August 2026 for its coverage of toxicology, analytical chemistry, food science, and veterinary journals:

("forensic phytochemistry" OR "plant toxin" OR "plant poison" OR "phytotoxin") AND ("analytical method" OR "detection" OR "LC-MS" OR "GC-MS" OR "mass spectrometry" OR "fingerprinting")

This returned 779 records: restricting years to 2016–2026 left 362; filtering by document type Article 314 and English left the final 305 (Figure 1). Because 2026 was incomplete, growth modeling was restricted to 2016–2025.

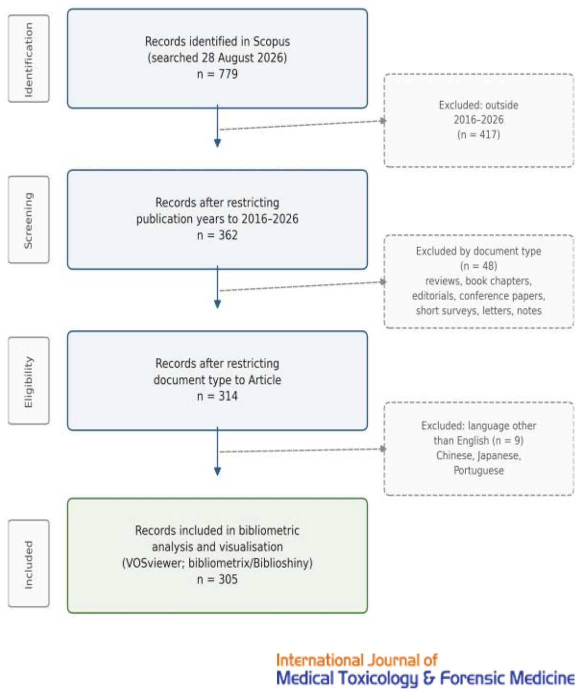

Figure 1. Flow of record identification, screening and inclusion.

Data analysis

The export was analyzed using bibliometrix/Biblioshiny [9] for performance indicators, VOSviewer [10] for author-keyword co-occurrence mapping, and Python 3.12 for content coding and statistical analysis. The country was extracted from the terminal element of each affiliation string and counted once per article. The h-index followed Hirsch [11], and the g-index followed Egghe [12]. Local citations, those from other corpus articles, were identified by normalized title matching.

Content coding applied predefined regular-expression dictionaries to concatenated title, abstract, and keyword fields, covering fourteen platforms, ten toxin classes, seven matrices, and six research orientations; categories were not mutually exclusive. Yearly counts were modeled by regression; open- versus closed-access citations were contrasted with the

Mann–Whitney U statistic (two-sided, 0.05).

Results

Corpus characteristics and growth

The 305 articles came from 163 sources and 1,683 authors in 63 countries and had attracted 4,261 citations, a mean of 13.97 (median 9; maximum 111), with 37 (12.1%) uncited; the h-index was 34 and the g-index 45.

Output climbed from 19 articles in 2016 to 49 in 2025 (Figure 2), increasing by 1.98 articles per year (R^2=0.436; P=0.038), at a compound annual growth rate of 11.10%. The climb was uneven: 34 articles in 2021 gave way to 23 in 2023. Mean citations declined with recency, from 31.79 for 2016 to 3.14 for 2025.

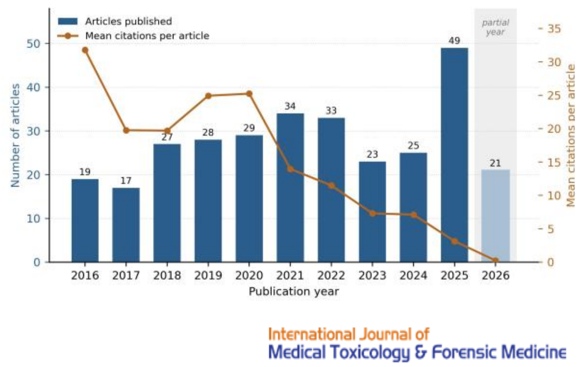

Figure 2. Annual output (bars) and mean citations per article (line), 2016–2026; 2026 is incomplete.

Sources, authors, and collaboration

Journal scattering followed a Bradford-like pattern: 11 journals (6.7% of sources) carried 106 articles (34.8%), led by Toxins (33), Toxicon (15), and PLOS ONE (9).

Authorship was dispersed: 1,463 authors (86.9%) contributed a single article, and only 18 contributed five or more, with a mean of 6.80 authors per article. The most prolific, A. Evidente (15) and M. Masi (13), work on fungal phytotoxins in the agronomic tradition.

China led with 68 articles, then the United States (52), Germany (40), and Italy (29); twelve countries contributed ten or more (Table 1). International co-authorship appeared in 97 articles (31.8%): China's output was mainly domestic, whereas the United Kingdom and Austria worked almost entirely through international partnerships. Europe accounted for 43.3% of country appearances, Asia-Pacific 27.4% and North America 15.0%, against 3.4% for sub-Saharan Africa.

Analytical platforms, toxin classes, and matrices

Chromatographic separation dominated (Figure 3a, Table 2). Liquid chromatography in high- and ultra-high-performance forms (HPLC/UHPLC) appeared in 114 articles (37.4%) and its tandem mass spectrometry coupling (LC-MS/MS) in 101 (33.1%), ahead of high-resolution platforms, sample preparation, spectroscopy by nuclear magnetic resonance (NMR), and gas chromatography with mass spectrometry (GC-MS).

The analytical core was stable between periods, but metabolomics rose from 2.5% to 8.6%, the largest proportional increase, while GC-MS, immunoassay,

Table 1. Dataset distribution across classes.

No.	Country	Articles	SCP	MCP	MCP (%)	Citations	Mean cit.
1	China	68	54	14	20.6	942	13.9
2	United States	52	20	32	61.5	875	16.8
3	Germany	40	26	14	35.0	625	15.6
4	Italy	29	11	18	62.1	401	13.8
5	United Kingdom	17	4	13	76.5	329	19.4
6	Spain	17	7	10	58.8	499	29.4
7	India	15	9	6	40.0	84	5.6
8	Austria	13	0	13	100.0	183	14.1
9	France	11	2	9	81.8	318	28.9
10	Brazil	11	8	3	27.3	147	13.4
11	Netherlands	10	6	4	40.0	324	32.4
12	Canada	10	6	4	40.0	59	5.9

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Note: SCP counts articles from one country of affiliation, MCP those spanning two or more; Mean cit. is citations divided by articles. Each article contributes once per country.

Table 2. Analytical and methodological platforms represented in the corpus, with uptake by period.

No.	Analytical platform	Articles	% of corpus	2016–2020 (%)	2021–2026 (%)	Mean cit.
1	HPLC / UHPLC	114	37.4	40.0	35.7	15.1
2	LC-MS/MS	101	33.1	33.3	33.0	13.1
3	High-resolution MS	43	14.1	14.2	14.1	13.9
4	Sample preparation	32	10.5	8.3	11.9	17.5
5	NMR spectroscopy	31	10.2	10.8	9.7	16.1
6	GC-MS	25	8.2	10.0	7.0	11.9
7	Genomics	21	6.9	5.8	7.6	19.7
8	Metabolomics	19	6.2	2.5	8.6	6.9
9	DNA barcoding	19	6.2	5.8	6.5	10.1
10	Proteomics	14	4.6	4.2	4.9	13.8
11	Immunoassay	13	4.3	5.0	3.8	11.3
12	Machine learning	12	3.9	3.3	4.3	13.8
13	Biosensor	7	2.3	3.3	1.6	22.1
14	Ambient ionisation MS	3	1.0	0.0	1.6	19.7

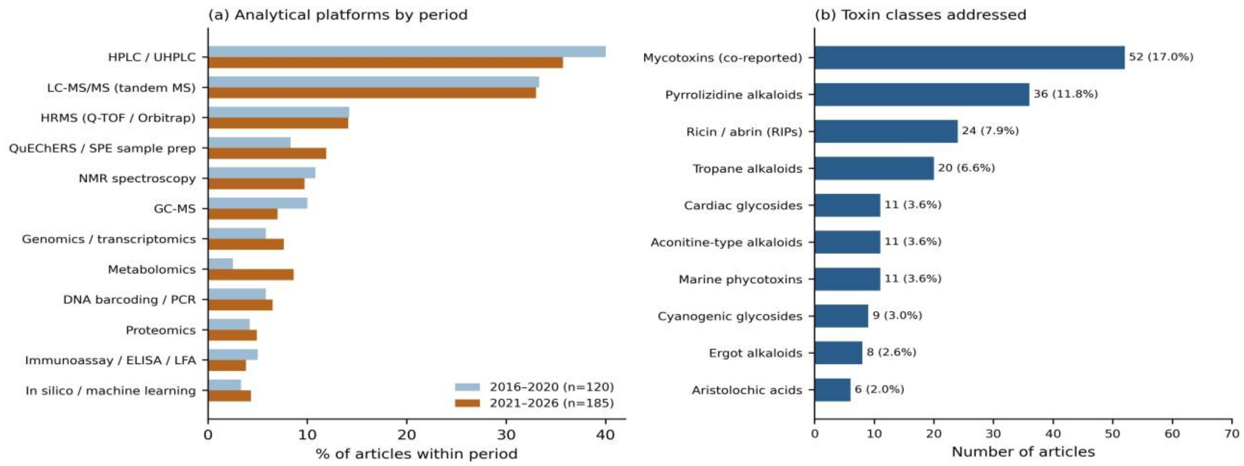

Figure 3. (a) Analytical platform use by period (% of articles within period). (b) Toxin classes (% of all articles).

and biosensor approaches declined.

Mycotoxins were co-reported in 52 articles (17.0%), typically in multi-analyte surveillance (Figure 3b); among plant-derived compounds, PAs were most common (11.8%), followed by ricin and abrin (7.9%). Food and supplements were the most common matrix (33.4%), followed by veterinary settings (20.0%), human clinical specimens (15.1%), and forensic casework (10.5%). Method development and validation was the most common orientation (25.6%), followed by surveillance (24.6%) and clinical poisoning (23.6%); risk assessment was the least common (11.5%). Open access reached 57.0% without citation advantage (P=0.673).

Keyword structure and citation relationships

VOSviewer mapping of author keywords resolved four clusters (Figure 4): clinical (plant toxin, poisoning, food safety); analytical (pyrrolizidine alkaloids, LC-MS/MS, honey, validation); omics-based detection (ricin, proteomics, metabolomics); and agronomic (phytotoxins, mycotoxins). The

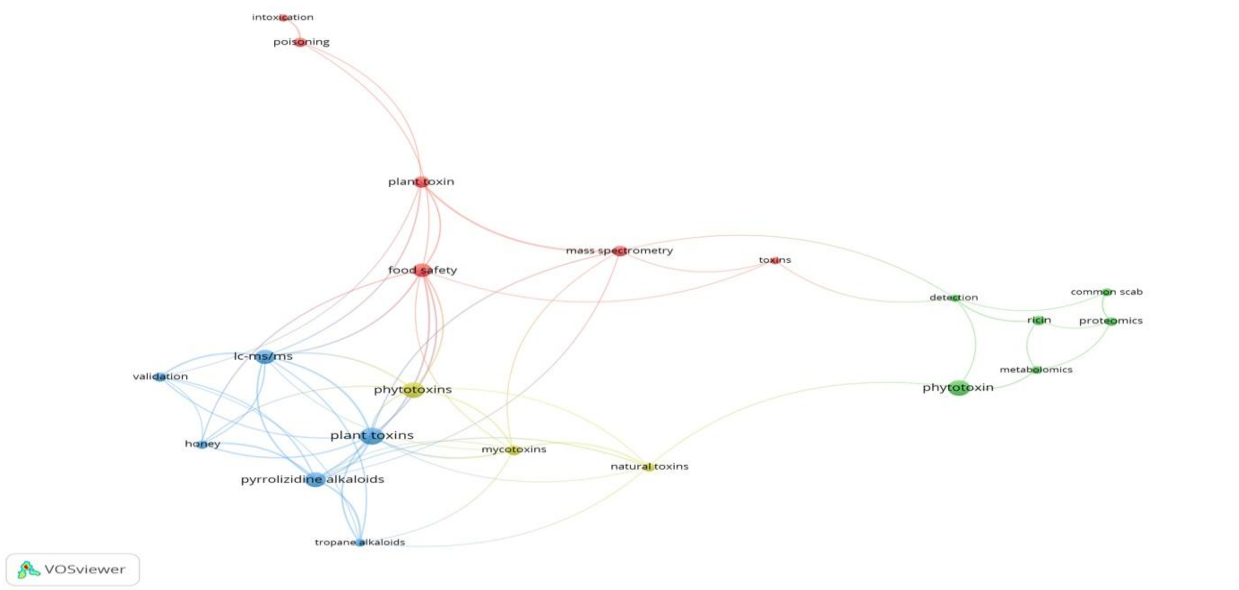

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Figure 4. Author keywords appearing together, drawn in VOSviewer; larger nodes mark more frequent terms, and color marks clusters.

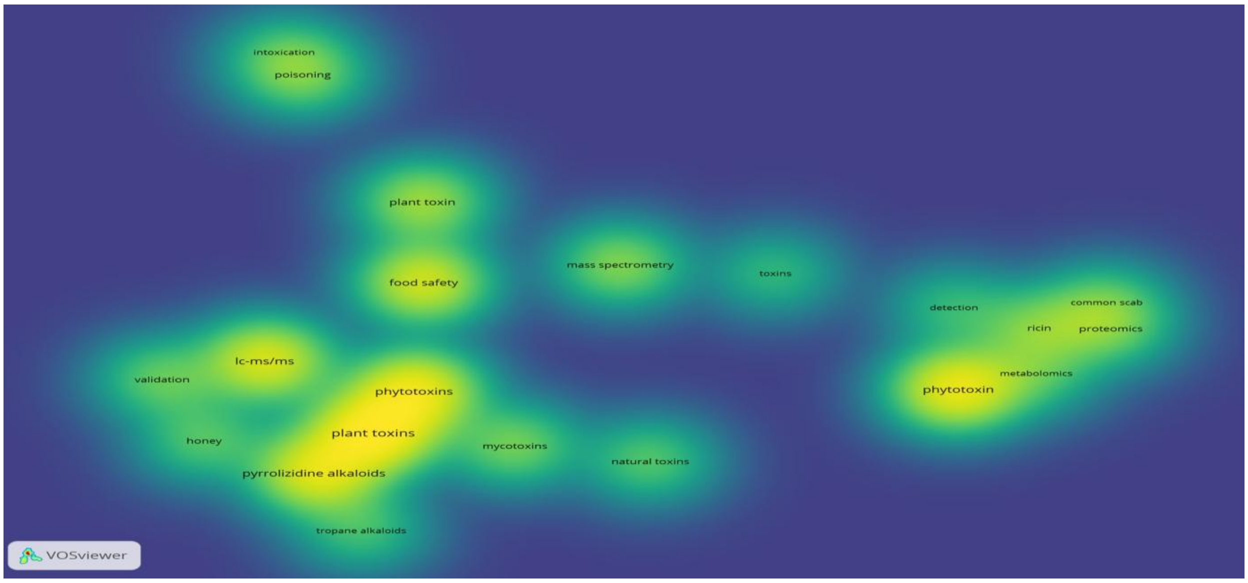

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Figure 5. Author-keyword density visualisation (VOSviewer); brighter areas indicate greater keyword frequency.

density map (Figure 5) places analytical terms at the center.

Global and local influence diverged. The most globally cited article (111 citations, fungal infection strategies in tomato) received no local citations, whereas the multi-analyte feed screening method of Steiner et al. (69 global) attracted four. Across the corpus, 153 local citation links were found among 84 articles.

Discussion

Analytical dominance is the clearest signal. Workflows from this period quantify more than 1,200 biotoxins in a single feed analysis [13], screen water by high-resolution mass spectrometry [14], and identify PAs by ambient ionization [15]. Yet risk assessment appeared in only 11.5% of articles, less than half the rate of method validation. Detection capacity is outgrowing the dose–response evidence needed to interpret it, a difficulty the threefold rise in metabolomics will sharpen.

The matrix imbalance is most pronounced: human clinical specimens appear in 15.1% of articles, and forensic casework in 10.5%. Counter-examples exist — a forensic library of 56 natural toxic substances [16], phytolaccosides in pokeweed intoxication [17], taxine B in a concealed suicide by yew [18], and plant remains identified by genetics and mass spectrometry [19] —

but they are rare. Food surveillance is governed by regulatory mandates and defined sampling frames, whereas forensic casework is sporadic and relies on reference standards that often do not exist.

The keyword mapping confirms a retrieval problem: a distinct agronomic literature shares the field's analytical vocabulary without its subject matter. Authors reporting poisoning should index using unambiguous terms such as "Plant Poisoning".

The field's profile is distinctive. Issrani et al., writing in this journal, mapped 2,139 forensic genetics articles over 22 years [8]. Plant toxin detection is far smaller. Yet collaboration is more intense here — 6.80 co-authors per article versus 5.55, and 31.8% international co-authorship versus 25.2% — consistent with methods requiring instrument platforms and reference materials that few laboratories possess on their own. Citation density is lower (13.97 vs. 20.41), largely due to a window-length artifact. Another natural-product literature has been mapped using the same workflow [20, 21].

Europe and North America together accounted for 58.3% of country appearances, compared with 3.4% from sub-Saharan Africa, roughly the inverse of the global burden of plant poisoning. Where output exists from these regions, it is largely produced through external partnerships [22], without building local capacity. This is not inevitable: China produced 54 of its 68 articles domestically. Iran contributed eight articles despite a substantial documented poisoning burden.

Several limitations apply. A single database was used, and the search was restricted to English, which probably compounded the geographical skew. Content coding matched the title, abstract, and keyword fields rather than the full text, so the proportions indicate thematic emphasis rather than exact prevalence. Citation counts are a single-date census, and cluster boundaries depend on the thresholds chosen.

Conclusion

Research on plant toxin detection between 2016 and 2026 comprised 305 articles, growing at about 11% annually. Analytical capability is improving, with metabolomics the fastest-growing platform, but translation is not proportionate: method validation and food-matrix surveillance dominate, while human clinical specimens, forensic casework, and risk assessment remain minority activities. Priorities are shared forensic reference libraries, poison-center and autopsy case series from under-represented regions, unambiguous indexing, and toxicology capacity in low- and middle-income settings.

Ethical Approval

Not applicable.

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Conflicts of Interest

The authors report there are no competing interests to declare.

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