



International Journal of Medical and All Body Health Research

Medicinal Plant Biochemistry Research to Prevent Cancer in Indonesia

Atik Sulistiyowati ^{1*}, Poncojari Wahyono ², Abdulkadir Rahardjanto ³

¹⁻³ Master of Biology Education, Postgraduate Program, Universitas Muhammadiyah Malang, Indonesia

* Corresponding Author: Atik Sulistiyowati

Article Info

ISSN (online): 2582-8940

Volume: 05

Issue: 03

July-September 2024

Received: 24-07-2024

Accepted: 22-08-2024

Published: 17-09-2024

Page No: 88-92

Abstract

Cancer prevention in Indonesia increasingly requires integrated strategies that combine risk reduction, early detection, and evidence-based preventive interventions. Indonesia's biodiversity and long-established herbal medicine traditions (including jamu) provide a unique opportunity for medicinal plant biochemistry research to contribute to prevention through mechanism-aligned pathways. However, many plant-based studies remain trapped at early evidence stages—single antioxidant assays, crude extracts, uncertain compound identification, limited standardization, and scarce human biomarker studies—making translation difficult and sometimes leading to overclaims. This article provides a framework synthesis (≤ 2024) of medicinal plant biochemistry research relevant to cancer prevention in Indonesia. We integrate (1) biochemical mechanisms of carcinogenesis and prevention (e.g., oxidative stress and DNA damage, inflammation, detoxification balance, apoptosis, angiogenesis, immune surveillance), (2) metabolomics standards and dereplication workflows for natural products (Fiehn, 2002; Sumner *et al.*, 2007; Wolfender *et al.*, 2019; Qin *et al.*, 2022), (3) evidence on natural products as sources of therapeutics and multi-target bioactives (Newman & Cragg, 2020; Atanasov *et al.*, 2021), and (4) governance and quality control requirements (CBD, 2011; Oberthür & Rosendal, 2014; WHO, 2011) alongside Indonesian regulatory framing for traditional medicines (BPOM, 2019). Results are presented as two conceptual figures and three implementation tables mapping key biochemical targets and assay panels, an evidence-to-translation ladder for prevention claims, and institutional strategies to strengthen governance readiness, reproducibility, quality assurance, and partnership-based biomarker studies. We argue that the highest-impact approach is to treat governance, taxonomy, metadata, QA/QC, and staged human evidence as core research outputs—supported by shared analytical infrastructure and clinical/public health partnerships. The paper concludes with a practical roadmap for Indonesian universities to produce credible, ethical, and scalable medicinal plant biochemistry research that supports cancer prevention.

DOI: <https://doi.org/10.54660/IJMBHR.2024.5.3.88-92>

Keywords: Indonesia; cancer prevention; medicinal plants; plant biochemistry; natural products; metabolomics; dereplication; chemoprevention; inflammation; oxidative stress; apoptosis; angiogenesis; immune modulation; standardization; BPOM; WHO

1. Introduction

Cancer prevention is a public health priority in Indonesia. While prevention strategies include reducing exposure to carcinogens, improving vaccination and screening programs, and strengthening lifestyle interventions, there is also sustained interest in safe, culturally accepted preventive agents that can complement public health measures. Medicinal plants are widely used and readily accessible, but their contribution to cancer prevention depends on rigorous biochemical evidence, safety assurance, and responsible translation.

Biochemistry provides the bridge from traditional use to mechanistic evidence. Plant-derived polyphenols, terpenoids, alkaloids, polysaccharides, and volatile compounds can modulate pathways relevant to carcinogenesis and early lesion progression: antioxidant responses (e.g., Nrf2), inflammation signaling (e.g., NF- κ B), detoxification balance, cell cycle control and apoptosis, angiogenesis, and immune surveillance. These pathways are multi-factorial and interconnected, implying that prevention research should prioritize mechanism-aligned assay panels rather than single screening tests.

However, the scientific literature also reveals common pitfalls. Many studies report “anti-cancer” potential from crude extracts based on cytotoxicity or antioxidant assays without establishing prevention relevance, human safety, or reproducibility. Extract composition varies by chemotype, season, and processing, and metabolite identification remains a bottleneck without standards and spectral libraries. In addition, research on Indonesian biodiversity must comply with access-and-benefit sharing (ABS) governance and ethical engagement with local knowledge systems, consistent with the Nagoya Protocol framework (CBD, 2011).

This article synthesizes literature up to 2024 to map the challenges and opportunities of Indonesian medicinal plant biochemistry research for cancer prevention and to propose an institutional roadmap for higher education. We address three questions: (1) Which biochemical targets and assay strategies are most relevant to prevention? (2) What challenges constrain credibility and translation in Indonesia? (3) What institutional actions can accelerate rigorous, ethical, and scalable research outputs?

2. Literature Review

2.1. Cancer prevention biochemistry: targets and evidence logic

Cancer arises through multistep processes involving genetic and epigenetic alterations, microenvironmental changes, and dysregulated signaling. Prevention research therefore emphasizes upstream drivers and early lesion control: oxidative stress and DNA damage, chronic inflammation, detoxification balance, cell cycle regulation and apoptosis, angiogenesis and invasion pathways, immune surveillance, and microbiome–metabolite interactions. A prevention-oriented medicinal plant program should map plant metabolites to these targets, prioritize realistic dosing and exposure routes, and use biomarkers that can translate into human studies.

2.2. Natural products and multi-target prevention potential

Natural products remain a major source of therapeutic discovery and offer multi-target mechanisms that are relevant to prevention. Large-scale reviews show that natural products contribute substantially to new drugs and provide diverse scaffolds and bioactivities (Newman & Cragg, 2020; Atanasov *et al.*, 2021) ^[1]. In prevention contexts, plant polyphenols and triterpenoids may modulate oxidative stress and inflammation, while alkaloids and terpenoids may affect

cell cycle and apoptosis pathways. However, multi-target potential is not a substitute for evidence: mechanistic claims must be supported by target-aligned assays, dose–response analysis, and safety evaluation.

2.3. Metabolomics, dereplication, and reproducibility in medicinal plant biochemistry

Metabolomics supports comprehensive profiling of plant extracts and can map chemotype variability and identify candidate marker compounds. Foundational framing described metabolomics as a bridge between genotype and phenotype (Fiehn, 2002) ^[4]. Minimum reporting standards were proposed to improve transparency and comparability (Sumner *et al.*, 2007) ^[11]. In natural products research, dereplication is essential to avoid rediscovery and to strengthen identification. Wolfender *et al.* (2019) ^[16] describe strategies combining LC–MS/MS, NMR, and computational tools, while MS/MS-based molecular networking provides efficient dereplication and comparative analysis (Qin *et al.*, 2022) ^[9].

2.4. Governance and quality control: ABS and herbal material standards

Research using Indonesian genetic resources must be ethically and legally grounded. The Nagoya Protocol provides an international framework for access to genetic resources and fair benefit-sharing, requiring prior informed consent and mutually agreed terms (CBD, 2011). Governance analyses highlight practical complexities in implementation and collaborations (Oberthür & Rosendal, 2014) ^[8]. In parallel, herbal research must address quality and safety: WHO guidance emphasizes contaminants, residues, and quality control methods for herbal materials (WHO, 2011). Indonesian regulatory frameworks further differentiate traditional medicine categories and define safety and quality requirements (BPOM, 2019) ^[2].

3. Method

This article uses a framework synthesis approach. We integrated peer-reviewed literature and authoritative standards and governance sources published up to 2024 to construct an evidence-informed synthesis of medicinal plant biochemistry research relevant to cancer prevention in Indonesia.

We organized sources into five clusters: (1) prevention-relevant cancer biochemistry targets and biomarkers; (2) natural products and multi-target bioactivity; (3) metabolomics and dereplication workflows for medicinal plants; (4) governance and ethics under ABS frameworks; and (5) quality control and standardization guidance for herbal materials and traditional medicines.

Results are reported as design-oriented guidance. Figure 1 maps prevention pathways and plant intervention points. Figure 2 presents an evidence-to-translation ladder for prevention claims. Tables summarize (1) biochemical targets and assays, (2) challenges and mitigations for Indonesian contexts, and (3) an institutional roadmap and metrics for universities.

4. Results and Discussion

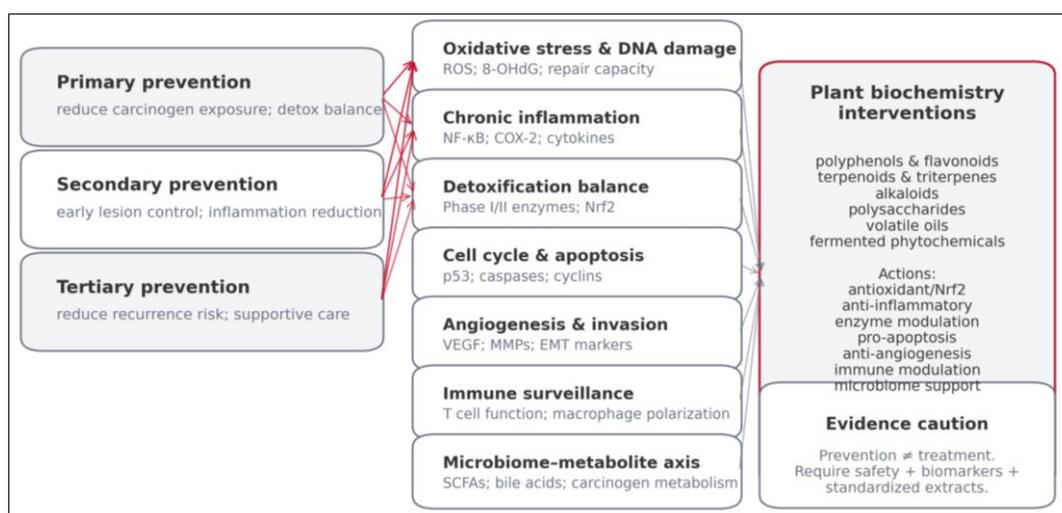


Fig 1: Cancer prevention pathways and medicinal plant biochemistry intervention points



Fig 2: Evidence-to-translation ladder for Indonesian medicinal plant biochemistry in cancer prevention

Results are presented as a structured synthesis of targets, evidence standards, and institutional strategies. Figure 1 highlights shared prevention-relevant pathways and shows how medicinal plant biochemistry can intervene through multi-target mechanisms. Figure 2 describes an evidence-to-translation ladder designed for prevention claims, emphasizing standardization and human biomarker endpoints.

4.1. Mechanism-aligned targets for prevention and early lesion control.

Prevention research differs from treatment research: the objective is to reduce risk, delay onset, or slow early progression rather than to cure established malignancy. Therefore, mechanism-aligned targets should prioritize upstream drivers (oxidative stress, inflammation, detoxification balance) and early lesion biology (apoptosis and cell cycle checkpoints, angiogenesis signaling, immune surveillance). A credible study should align its assays to a target panel, report dose–response relationships, and include negative controls and cytotoxicity checks to avoid

confounding general toxicity with prevention-relevant modulation.

4.2. Moving beyond the “antioxidant-only” trap.

Many herbal studies use DPPH/FRAP assays as primary outcomes. Such assays can support chemical characterization, but they do not establish cancer prevention efficacy *in vivo* or in humans. Robust research should incorporate cell-based and pathway-based assays (e.g., Nrf2 activation, NF-κB inhibition, DNA damage markers) and should connect observed effects to specific metabolites. Integrating metabolomics and dereplication early clarifies chemical identity and supports reproducibility (Fiehn, 2002; Sumner *et al.*, 2007; Wolfender *et al.*, 2019; Qin *et al.*, 2022) [4, 11, 16, 9].

4.3. Standardization and safety as prerequisites for translation.

Prevention interventions are typically long-term, making safety and quality non-negotiable. Research should therefore incorporate QA/QC systems: marker panels or fingerprints,

contaminant screening, stability tests, and batch-to-batch control. WHO guidance provides a framework for quality control of herbal materials (WHO, 2011), while BPOM regulations define national requirements and categories for traditional medicines (BPOM, 2019) [2]. In practice, the ability to generate standardized extracts often distinguishes publishable mechanistic research from translatable programs.

4.4. Governance and ethics as strategic capabilities.

ABS compliance and ethical engagement with local knowledge are sometimes seen as administrative burdens. This synthesis suggests reframing them as strategic capabilities: universities that build ABS workflows, PIC/MAT templates, and benefit-sharing plans can form long-term partnerships and sustain access to biodiversity in a legitimate manner (CBD, 2011; Oberthür & Rosendal, 2014) [8]. Ethical best practice also emphasizes respectful

engagement and transparency in ethnopharmacology (Heinrich *et al.*, 2020) [6].

4.5. Institutional roadmap for Indonesian universities.

A robust university program should combine: (1) taxonomy and voucher practices, (2) shared analytical infrastructure (LC-MS/MS, NMR, bioinformatics), (3) mechanistic assay platforms aligned to prevention targets, (4) QA/QC and contamination screening capacity, and (5) clinical/public health partnerships for biomarker studies. Stage-gates aligned to the evidence ladder (Figure 2) can prioritize projects and prevent overclaims. Investment in local spectral libraries and open repositories can reduce annotation bottlenecks for Indonesian flora, while cultivation partnerships can support sustainability and consistent chemistry for standardization.

Table 1: Prevention-relevant biochemical targets for cancer and recommended assays for medicinal plant biochemistry research.

Target domain	Representative targets/biomarkers	Recommended assays/models	Notes for prevention claims
Oxidative stress & DNA damage	ROS, 8-OHdG, DNA repair markers	Cell-based ROS; comet assay; oxidative DNA markers	Interpret with dose realism; control for cytotoxicity and solvent effects.
Inflammation	NF-κB, COX-2, cytokine surrogates	Reporter assays; cytokine panels; inflammation challenge models	Prioritize chronic low-dose contexts relevant to prevention.
Detoxification balance	Phase I/II enzymes; Nrf2 pathway	Nrf2 reporter; GST/UGT activity; transcript markers	Link to carcinogen metabolism models when feasible.
Cell cycle & apoptosis	p53, caspases, cyclins	Apoptosis assays; cell cycle profiling; caspase activation	Use early lesion/preneoplastic models when available; avoid overgeneralization.
Angiogenesis & invasion	VEGF, MMPs, EMT markers	Endothelial tube formation; MMP assays; migration assays	Relevant to early progression; interpret cautiously for prevention.
Immune surveillance	T cell activation markers; macrophage polarization	Co-culture models; cytokine profiling; immune signaling assays	Prevention includes immune modulation; requires careful controls.

Table 2: Challenges and mitigation strategies for cancer-prevention medicinal plant biochemistry research in Indonesia.

Challenge	Why it matters	Mitigation strategy	Evidence anchor (≤2024)
ABS governance & permits	Legitimacy, delays, partnership risk	ABS workflow; PIC/MAT templates; legal support	CBD (2011); Oberthür & Rosendal (2014) [8]
Taxonomy/voucher gaps	Misidentification undermines reproducibility	Herbarium vouchers; barcoding; expert validation	Good practice in plant sciences
Chemotype variability	Batch inconsistency; weak standardization	Sampling design + metadata; metabolomics mapping	Fiehn (2002) [4]; Sumner <i>et al.</i> (2007) [11]
Annotation bottleneck	Weak novelty and mechanism claims	Dereplication; molecular networking; local libraries	Wolfender <i>et al.</i> (2019) [16]; Qin <i>et al.</i> (2022) [9]
Antioxidant-only evidence	Overclaims; poor translation	Mechanism-aligned assay panels; dose-response	Prevention evidence logic
QA/QC and contaminants	Safety and credibility	WHO-aligned QC; SOPs; stability testing	WHO (2011); BPOM (2019) [2]

Table 3: Institutional roadmap metrics for Indonesian universities conducting prevention-oriented medicinal plant biochemistry research.

Metric category	Example indicator	How to measure	Benefit
Governance readiness	% projects with PIC/MAT + benefit-sharing plan	annual compliance audit	Legitimacy and durable partnerships
Reproducibility	% studies with vouchers + complete metadata + QC	methods checklist	Higher reliability and publishability
Analytics capacity	Shared LC-MS/NMR uptime and training	core facility dashboard	Faster dereplication and identification
QA/QC	Batch-to-batch marker variability ≤ threshold	QC analytics report	Standardization and safety support
Translation	# biomarker-based pilot studies with partners	trial registry and reports	Evidence ladder progression
Sustainability	% projects with cultivation/sourcing plan	project governance review	Reduced overharvesting risk

5. Conclusion

Medicinal plant biochemistry research can contribute to cancer prevention in Indonesia if it is designed around prevention-relevant biochemical targets, rigorous metabolite identification, and evidence ladders that include standardization, safety, and human biomarker studies. This synthesis provides a practical toolkit: a pathway map (Figure 1), an evidence-to-translation ladder (Figure 2), and

tables summarizing targets, challenges, and institutional actions. The key recommendation is to treat governance readiness, taxonomy, metadata, QA/QC, and staged human evidence as core research outputs supported by shared analytics and partnerships. With these capabilities, Indonesian universities can produce credible, ethical, and scalable medicinal plant biochemistry programs that support prevention without overclaiming therapeutic effects.

6. References

1. Atanasov AG, Zotchev SB, Dirsch VM, International Natural Product Sciences Taskforce. Natural products in drug discovery: advances and opportunities. *Nat Rev Drug Discov.* 2021;20(3):200-216.
2. BPOM. Peraturan Badan Pengawas Obat dan Makanan Republik Indonesia No. 32 Tahun 2019 tentang Persyaratan Keamanan dan Mutu Obat Tradisional. Jakarta: Badan POM Republik Indonesia; 2019.
3. Convention on Biological Diversity. Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from Their Utilization. Montreal: Secretariat of the Convention on Biological Diversity; 2011.
4. Fiehn O. Metabolomics--the link between genotypes and phenotypes. *Plant Mol Biol.* 2002;48(1-2):155-171.
5. Hanahan D, Weinberg RA. Hallmarks of cancer: the next generation. *Cell.* 2011;144(5):646-674.
6. Heinrich M, Jalil B, Potocnik T, *et al.* Best practice in ethnopharmacology and ethnobotany: a review and recommendations. *J Ethnopharmacol.* 2020;249:112376.
7. Newman DJ, Cragg GM. Natural products as sources of new drugs over the nearly four decades from 01/1981 to 09/2019. *J Nat Prod.* 2020;83(3):770-803.
8. Oberthür S, Rosendal GK, editors. Global governance of genetic resources: access and benefit sharing after the Nagoya Protocol. Abingdon: Routledge; 2014.
9. Qin GF, Zhang X, Zhu F, *et al.* MS/MS-based molecular networking: an efficient approach for natural products dereplication. *Molecules.* 2022;28(1):157. doi:10.3390/molecules28010157
10. Sporn MB. Approaches to prevention of epithelial cancer during the preneoplastic period. *Cancer Res.* 1976;36(7 Pt 2):2699-2702.
11. Sumner LW, Amberg A, Barrett D, *et al.* Proposed minimum reporting standards for chemical analysis. *Metabolomics.* 2007;3(3):211-221.
12. Surh YJ. Cancer chemoprevention with dietary phytochemicals. *Nat Rev Cancer.* 2003;3(10):768-780.
13. Thomson CA, McCullough ML, Wertheim BC. Nutrition and cancer prevention. In: *Nutrition in the Prevention and Treatment of Disease.* 3rd ed. Academic Press; 2014. (Note: This appears to be a book chapter or review; full bibliographic details may vary depending on the exact source.)
14. World Health Organization. Quality control methods for herbal materials. Geneva: World Health Organization; 2011.
15. Wishart DS. Emerging applications of metabolomics in drug discovery and precision medicine. *Nat Rev Drug Discov.* 2016;15(7):473-484.
16. Wolfender JL, Litaudon M, Touboul D, Queiroz EF. Innovative strategies for natural product dereplication and identification in the metabolomics era. *Nat Prod Rep.* 2019;36(6):855-868.