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Bioactive Potential of *Dendrocalamus asper* (Betung Bamboo Shoot) Against Colorectal Cancer: A Scoping Review of Preclinical Mechanisms and Research Gaps

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ABSTRACT

Colorectal cancer is one of the leading causes of morbidity and mortality globally. Bamboo shoots (*Dendrocalamus asper*) are known to contain dietary fiber, polyphenols, flavonoids, phytosterols, and oligosaccharides that have the potential to provide biological effects on the prevention of colorectal cancer. This study aims to map the latest scientific evidence regarding the bioactive content of *D. asper*, the mechanism of action relevant to colorectal cancer, and its opportunities for use as a candidate for phytopharmaceuticals and complementary therapies. This study is a scoping review with a systematic search approach. Literature searches were conducted on PubMed, ScienceDirect, SpringerLink, Google Scholar, and Garuda with a publication period of January 2018-August 2025. The selection of articles follows the inclusion-exclusion criteria and PRISMA guidelines. A total of 9 articles met the criteria and were analyzed through thematic synthesis. The results of the study showed that *D. asper* has an important phytochemical profile, including phenolics, flavonoids, and phytosterols that play a role in antioxidant, antiproliferative, anti-inflammatory, and apoptotic induced activity. Bamboo fiber and oligosaccharides have also been shown to promote beneficial bacterial growth and the production of short-chain fatty acids (SCFAs), specifically butyrates, which protect the colon mucosa and lower the risk of preneoplastic lesion formation. In vitro and in vivo evidence consistently supports bamboo's potential as a colorectal cancer prevention agent, although human clinical trials are not yet available. The conclusion of this study is that bamboo shoots show strong prospects as well as a candidate for phytopharmaceuticals as well as complementary therapies in efforts to prevent colorectal cancer.

INTRODUCTION

Colorectal cancer is one of the most common cancers in the world and has a fairly high mortality rate. Based on the GLOBOCAN 2020 report, there were more than 1.9 million new cases of colorectal cancer and nearly 935 thousand deaths due to this disease, placing it in the third most diagnosed and second as the leading cause of cancer death globally (Sung et al., 2021). In Indonesia, colorectal cancer is also included in the top five cancers with increasing prevalence, making it a major challenge for the national health system (Gondhowiardjo et al., 2021; Rahadiani et al., 2022). Risk factors for colorectal cancer include a high-fat, low-fiber diet, processed meat consumption, obesity, and a sedentary lifestyle (Sawicki et al., 2021). This condition suggests that colorectal cancer is not only a medical problem, but also closely related to environmental factors and people's lifestyle. Conventional treatment options for colorectal cancer generally include surgery, chemotherapy, and radiotherapy, which have been shown to increase patients' life expectancy (Adebayo et al., 2023; Fadlallah et al., 2024). Nevertheless, the limitations of conventional therapy often pose new problems. Side effects of chemotherapy such as diarrhea, nausea, vomiting, peripheral neuropathy, decreased blood cells, and immune disorders often cause patients to experience a significant decrease in quality of life (Colvin, 2019). In addition, drug resistance can also occur in colorectal cancer, so patients do not respond well to treatment (Haynes & Manogaran, 2025; Wang et al., 2022). High medical costs also weigh on patients and healthcare systems, especially in developing countries. This situation demands efforts to find alternatives to therapies that are safer, more affordable, and still effective to support primary treatment.

In the last two decades, attention to complementary and alternative therapies, including phytopharmaceuticals, has been increasing. Phytopharmacists are herbal products that are standardized in quality, safety, and efficacy, and are

supported by scientific evidence (Edo et al., 2024). Research shows that many local food crops have bioactive compounds that can act as chemopreventive and therapeutic agents against colorectal cancer (Amintas et al., 2023; Sorrentino et al., 2022). Its mechanism of action includes antioxidant, anti-inflammatory, apoptotic induction, and improvement of the intestinal microbiota (Delgado-Gonzalez et al., 2023). Changes in the composition of the gut microbiota have been associated with an increased risk of colorectal cancer, so the consumption of high-fiber, polyphenol-rich foods can have a protective effect. This opens up opportunities for the use of local Indonesian plants as a source of phytopharmaceuticals in the treatment of colorectal cancer (Iwo et al., 2023).

Betung bamboo shoots (*Dendrocalamus asper*) are one of the local Indonesian foods that have the potential to be developed as phytopharmaceutical ingredients. Bamboo shoots are known to be rich in dietary fiber, polyphenols, flavonoids, and phytosterols that have a variety of biological activities (Pattarathitiwat et al., 2021). The fiber content in bamboo shoots can be fermented by the gut microbiota into short-chain fatty acids (SCFAs), such as butyrate, which play an important role in maintaining colon homeostasis, suppressing inflammation, and inhibiting the growth of cancer cells (Zhou et al., 2023). In addition, the flavonoids and polyphenols in bamboo shoots can inhibit the proliferation of abnormal cells, protect DNA from oxidative damage, as well as induce the mechanism of apoptosis in cancer cells. Thus, the bioactive content of bamboo shoots has the underlying biological potential for its use as a complementary therapy candidate, although the current evidence is still preclinical therapy of colorectal cancer. A number of preclinical studies have provided preliminary evidence regarding the potential of bamboo shoots. In vitro studies of *D. asper* extract showed the presence of cytotoxic activity against MCF-7 breast cancer cells, indicating antiproliferative potential and apoptosis induction (Ontaha et al., 2021). Although this study has not been directly conducted on colorectal cancer cells, the results provide a scientific basis that bamboo shoots contain active compounds that can be studied further. In addition, studies on the phytochemical characterization of *D. asper* bamboo shoots showed phenolic content with strong antioxidant activity, supporting its potential as a chemopreventive agent (Putri et al., 2020). These findings are important because oxidative stress and chronic inflammation are key mechanisms in colorectal carcinogenesis.

In addition to its bioactive content, the safety aspect of bamboo shoots consumption is also important to consider. Fresh bamboo shoots are known to contain cyanogenic glucoside that can produce cyanide, so it is potentially toxic if consumed in raw form (Ding & Wang, 2018). However, research shows that boiling and fermentation can significantly reduce the cyanide content, making it safe to consume in processed form (Qin et al., 2021). With the right processing process, bamboo shoots are not only safe to consume, but can also be used as raw materials in phytopharmaceutical formulations (Ma et al., 2024). This adds more value than bamboo shoots as a food source as well as a candidate for complementary therapy. Based on this exposure, bamboo shoots have great prospects to be developed as phytopharmaceuticals in the prevention and treatment of colorectal cancer (Sharma & Nirmala, 2020). Based on the description, *Dendrocalamus asper* has bioactive content and nutritional characteristics that show important biological potential in the mechanism of colorectal cancer prevention. However, the available scientific evidence is still limited to in vitro, in vivo, and phytochemical characterization, while studies directly using colorectal cancer models are still very few and clinical trials are not yet available. This condition shows the need for comprehensive mapping of existing preclinical evidence as well as the identification of research gaps that need to be followed up. Therefore, this scoping review aims to map the preclinical evidence regarding the bioactive potential of *D. asper* against colorectal cancer, explain the relevant mechanisms of action, and identify research gaps that can be the basis for the next direction of research with the main research question "What are the preclinical mechanisms that have been reported regarding the bioactive potential of *D. asper* against colorectal cancer, and how those research gaps can guide studies continued?".

METHODS

This study is a scoping review that aims to map and analyze scientific evidence regarding the bioactive potential of bamboo shoots extract (*Dendrocalamus asper*) as a phytopharmaceutical in the prevention and management of colorectal cancer. Article searches are carried out comprehensively through international digital databases, including PubMed, Scopus, ScienceDirect, and SpringerLink, as well as Google Scholar to reach grey literature. In addition, Garuda's national database is used to obtain relevant domestic publications. The search is performed using a combination of keywords that are tailored to the syntax of each database and linked using Boolean operators. Examples of keywords used include: "*Dendrocalamus asper*" OR "bamboo shoot" OR "bamboo shoot extract" AND "colorectal cancer" OR "colon cancer" OR "CRC" AND "bioactive compound" OR "phytochemical" OR "antiproliferative mechanism". Synonyms and word decapitation are tailored to the needs of each database. The search time range is limited to publications from 2018 to 2025, using Indonesian or English, and only includes articles with full-text access. The time frame January 2018-August 2025 was chosen to ensure that the review captures the most recent preclinical evidence, particularly because research on *Dendrocalamus asper*, especially its mechanistic relevance to colorectal cancer is still emerging and has advanced significantly only in the last few years. Selecting the last seven years allows the inclusion of contemporary phytochemical analyses, updated cancer models, and recent advances in microbiota SCFA research, while avoiding outdated or low-relevance earlier studies. All search results from various databases are exported in RIS/CSV format, merged in the reference manager, and then automatically deduplicated by DOI, title, author, and year. After that, a manual check is carried out to ensure there are no near-duplicates. The number of articles eliminated at each stage is recorded before the screening process begins.

Inclusion criteria include articles that have been published within a specified time period, have gone through a peer-review process, and examined *Dendrocalamus asper* in any cancer model or other bamboo species (e.g. Bambusa vulgaris, Guadua incana) if the study directly examines biological mechanisms relevant to colorectal cancer. Studies reporting antioxidant, anti-inflammatory, antiproliferative, proapoptotic, microbiota modulation, or other mechanisms associated with CRC are also included in the criteria. Original articles in the form of in vitro, in vivo, or ex vivo research, as well as scientific reviews presenting primary findings, are also included. On the other hand, articles that do not have

full-text access, are not relevant to the CRC mechanism, do not contain primary data, or are editorials, comments, or conference abstracts are excluded from the analysis. In addition, manual search is carried out through backward and forward citation tracking to find additional potentially relevant articles.

The screening process was carried out by two independent reviewers, starting from the selection of titles and abstracts, then continued with a full text review based on the inclusion criteria that had been set. A tested screening form is used to ensure consistency. The level of conformity between reviewers is monitored, and any differences in assessment results are recorded. In the event of disagreement, the final decision is resolved through discussion; and if a consensus is not reached, a third reviewer is involved as the determiner. Data extraction was carried out by two reviewers using a structured template, then cross-checked to minimize inconsistencies and reach mutual agreement.

Table 1. PEOs (Population, Exposure, Outcomes and Study Design) Framework

P (Population)	E (Exposure)	O (Outcome)	S (Study Design)
Cancer models (cancer cells, experimental animals, or preclinical studies related to colorectal carcinogenesis)	Extracts, fractions, or bioactive compounds of Dendrocalamus asper and other relevant bamboo species	Colorectal cancer-related biological mechanisms (antiproliferative, proapoptotic, antioxidant, anti-inflammatory, microbiota modulation, and SCFA enhancement)	Preclinical studies (in vitro, in vivo), phytochemical analysis, and mechanistic literature review

Table 2. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
1. Articles published in the 2018–2025 range.	1. Articles in the form of editorials, comments, letters, conference abstracts, or publications without primary data.
2. Articles written in Indonesian or English.	2. Studies irrelevant to the mechanism of colorectal cancer.
3. Articles are original research (in vitro, in vivo, ex vivo) or reviews that present related mechanistic data.	3. Studies on other bamboo species that have no mechanistic relevance to colorectal cancer.
4. Articles are available in full text.	4. Articles that are not fully accessible (abstract only).
5. Studies examining Dendrocalamus asper in any cancer model or other bamboo species directly evaluate mechanisms relevant to colorectal cancer.	5. Articles with data that do not include the biological mechanisms associated with CRC (e.g. only culinary or agronomic aspects).

Table 3. PICO (Population, Intervention, Comparison, Outcome)

No	P (Population)	I (Intervention)	C (Comparison)	O (Outcome)
1	MCF-7 cancer cells as an early model of anticancer mechanisms	Dendrocalamus asper extract (phenolic, flavonoid)	No extract treatment (cancer cell control)	Cytotoxicity and inhibition of cancer cell proliferation as potential relevant mechanisms for colorectal cancer
2	Raw material of D. asper *bamboo shoots* from Thailand	Phytochemical extracts and analysis (total phenolics, flavonoids, phytosterols)	No comparison (phytochemicals and antioxidant tests)	Bioactive profile and antioxidant activity that support phytopharmaceutical potential for colon
3	Literature on various species of bamboo (including *D. asper*)	Bamboo bioactive compounds (polyphenols, lignans, fibers)	No direct comparison (review study)	Theoretical evidence of anticancer mechanisms: antiproliferative, anti-inflammatory, and apoptosis
4	Colon Cancer Cell HCT-116	Guadua incana extract (polyphenols, flavonoids)	Cancer cells without extract treatment	Modification of colon cancer cell metabolism and direct anticancer activity
5	Mouse model colorectal cancer AOM/DSS	Bambusa vulgaris + Opuntia extract (flavonoids, saponins)	AOM/DSS model mice without extract therapy	Decrease in preneoplastic lesions and colon inflammation in standard CRC models
6	Nutritional data on bamboo shoots from various sources	Analysis of the nutritional and phytochemical composition (fiber, polyphenols, phytosterols)	No comparison (review study)	Relevance of bamboo nutrients for colon health and colorectal cancer prevention
7	In vitro & in vivo models of gut microbiota	Fiber and oligosaccharides *of D. asper*	Models without fiber/oligosaccharide supplementation	Increase in good bacteria, increase in SCFAs (especially butyrates) that are protective against CRC
8	Literature of various species of bamboo	Bioactive compounds (flavonoids, phytosterols)	No comparison group (survey)	The potential of bamboo as a functional food and an anticancer phytopharmaceutical candidate
9	Literature & analysis of bamboo fiber	Soluble fiber and hemicellulose	No comparison (review + laboratory test)	Prebiotic effects, cholesterol-lowering, and SCFA production that support CRC protective mechanisms

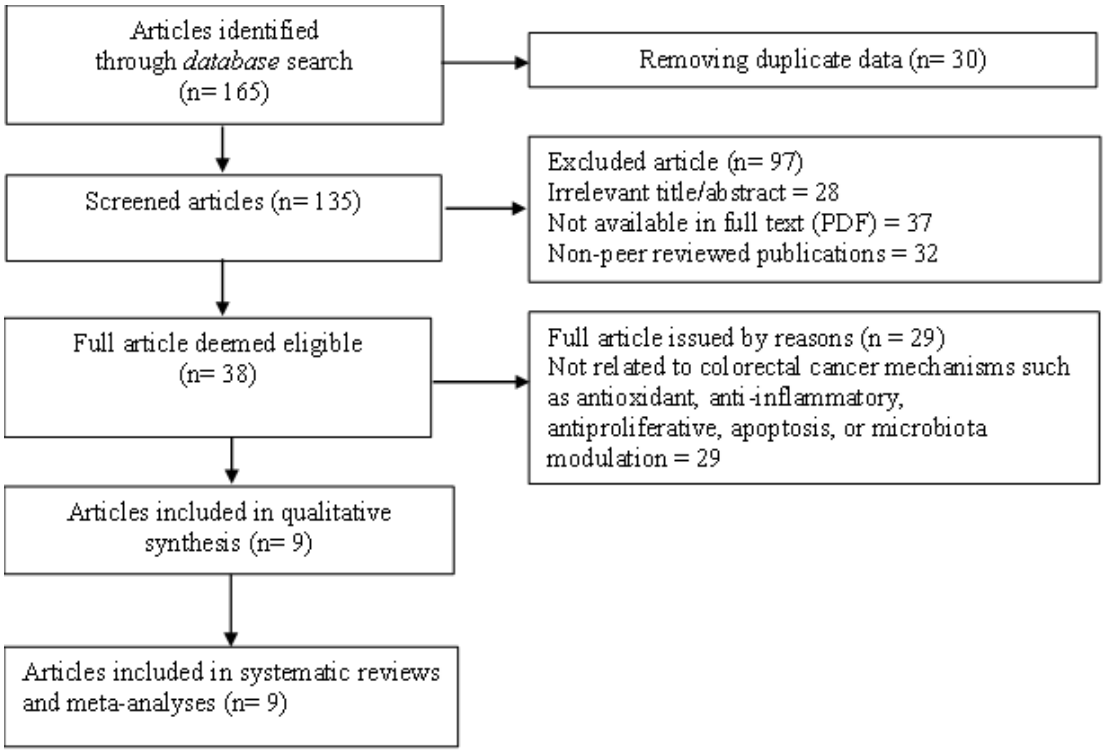

Figure 1. Prisma Flowchart

The entire process of identifying, screening, assessing eligibility, and inclusion of documented articles follows PRISMA-ScR guidelines, and is visualized using PRISMA flowcharts. In formulating the focus of the search and the preparation of research questions, the PEO (Population, Exposure, Outcome) framework is used to ensure that the literature search process is more systematic and directed in accordance with the objectives of the study.

RESULTS OF STUDY

A literature search on various electronic databases yielded 165 relevant articles. After going through the process of screening titles and abstracts, assessing the feasibility of the full text, and applying inclusion and exclusion criteria, there are 9 articles that are eligible for further analysis in this scoping review. The nine articles included represent research from various countries, covering developing and developed countries. The studies involved literature from Indonesia, Thailand, Colombia, China, as well as an international review that discussed several species of bamboo including *Dendrocalamus asper*. This regional diversity enriches understanding of the bioactive potential of bamboo shoots and other bamboo species in the mechanism of prevention and treatment of colorectal cancer.

Table 4. Distribution of countries in articles

Country	Frequency
Indonesia	2
Thailand	1
Colombia	1
China	1
International (multi-country reviews)	4

Table 5. Synthesis result of article

Theme	Sub-Theme	Articles
Bioactive Compounds and Phytochemical Potential of Bamboo Shoots	Phytochemical profile of D. asper (phenolic, flavonoids, phytosterols)	[2][6][8]
	The role of nutrients and bamboo fiber for colon health	[6][9]
	Antioxidant mechanism and consumption safety	[2]
Anticancer Mechanisms of Bamboo Extracts	Antiproliferative and cytotoxic activity in cancer models	[1][3][4]
	Anti-inflammatory, apoptosis, and modulatory effects of oxidative stress	[3]
	Therapeutic effects on the preneoplastic model of the colon AOM/DSS	[5]
Gut Microbiota and SCFA-Mediated Protective Effects	The role of D. asper oligosaccharides in increasing good bacteria	[7]
	Increase in short-chain fatty acids (SCFAs), especially butyrate	[7][9]
Cross-Species Insights for CRC Prevention	Relevance of other bamboo (Guadua incana, Bambusa vulgaris) to the mechanism of CRC	[4][5]
	Suitability of cross-species mechanisms to be applied to D. asper	[3][5][8]

Table 6. Summary of Studies on Bioactivity of Bamboo Shoots Relevant to Colorectal Cancer

Author (Year)	Bamboo Species	Study Design	Bioactive Compounds Identified	Main Findings	Reported Mechanisms
Ontaha et al., 2021	*Dendrocalamus asper* (bamboo shoots)	In vitro (MCF-7 cells)	Phenolics, flavonoids	Extract shows cytotoxic and antiproliferative activity on cancer cells	Indicates antiproliferative mechanisms relevant to CRC pathways
Pattarathitiwat et al., 2021	*D. asper* (Thailand)	Phytochemical & antioxidant analysis	Total phenolics, flavonoids, phytosterols	Strong antioxidant activity; cyanide content reduced after processing	Supports antioxidant-based chemopreventive mechanisms in CRC
Sharma & Nirmala, 2020	Various bamboo species (incl. *D. asper*)	Review	Polyphenols, lignans, fiber	Summarizes evidence on anti-inflammatory, antiproliferative, apoptotic properties	Provides theoretical foundation linking bamboo compounds to CRC prevention
Chitiva et al., 2024	*Guadua incana* (bamboo leaves)	In vitro (HCT-116 CRC cells)	Polyphenols, flavonoids	Extract modulates metabolism of colon cancer cells	Direct evidence of antiproliferative effects on CRC cells
Komala et al., 2022	*Bambusa vulgaris* + *Opuntia*	In vivo (AOM/DSS mouse CRC model)	Flavonoids, saponins	Reduces preneoplastic lesions and colonic inflammation	Demonstrates protective effects in a standard CRC preclinical model
Wang et al., 2020	Various bamboo species	Review	Nutrients, polyphenols, phytosterols	Reviews composition and processing effects on bamboo shoots	Highlights nutritional and phytochemical mechanisms supporting CRC prevention
Sittiya et al., 2025	*D. asper*	In vitro + in vivo (prebiotic study)	Oligosaccharides	Enhances growth of beneficial bacteria and increases SCFA production	Butyrate production supports anti-inflammatory and anticancer mechanisms in CRC
Sharma & Nirmala, 2020	Various species (incl. *D. asper*)	Review	Flavonoids, phytosterols	Bamboo shoots as functional food and phytopharmaceutical source	Supports scientific basis for bamboo in CRC prevention
Wu et al., 2020	Various bamboo species	Review + in vitro fiber analysis	Soluble fiber, hemicellulose	Bamboo fiber decreases cholesterol, acts as prebiotic, increases SCFAs	Relevant to butyrate-mediated protective pathways in CRC

Research on the bioactivity of bamboo shoots (*Dendrocalamus asper*) is still limited, but the available evidence covers several phases of non-clinical to preclinical research. In the most basic phase (phytochemical and safety characterization), Pattarathitiwat et al. (2021) showed that *D. asper* contains phenolics, flavonoids, and phytosterols with strong antioxidant activity. The study also found that the boiling and fermentation process can lower cyanide levels, confirming the safety aspect of consumption as an initial prerequisite for the development of phytopharmaceuticals.

In the non-clinical phase in vitro, Ontaha et al. (2021) reported that *D. asper bamboo shoots extract* had cytotoxic activity against MCF-7 breast cancer cells. Although not a model of colorectal cancer, these findings provide preliminary evidence that the phenolic and flavonoid components in bamboo shoots have the potential to inhibit the proliferation of cancer cells. The antiproliferative mechanism is relevant for further testing in colon cancer cell cultures. In the in vitro phase that is more relevant to colorectal cancer, Chitiva et al. (2024) showed that Guadua incana bamboo leaf extract can modulate the metabolism of colon cancer cells HCT-116. Although they are of different species, these results suggest that the bioactive components of bamboo have the capacity to target metabolic pathways important in the survival of colon cancer cells, thus providing a mechanistic basis for *D. asper*.

In the in vivo preclinical phase, Komala et al. (2022) evaluated Bambusa vulgaris in an AOM/DSS animal model which is the gold standard in pre-clinical studies of colon cancer. The results showed a decrease in preneoplastic lesions, a decrease in colon inflammation, and an improvement in mucosal health. Although the species used are different, the same methodology can be applied to *D. asper* to test preventive effects on colon cancer, so these findings provide a clear direction for translational research. In the cross-species mechanistic phase, Sharma & Nirmala (2020) summarized evidence for anti-inflammatory, antiproliferative, and pro-apoptosis from various bamboo species, including *D. asper*. This article provides a theoretical foundation that various bamboo phytochemicals, such as polyphenols, lignans, and dietary fibers, have relevant mechanisms in the prevention of carcinogenesis. In the mechanistic phase of the microbiota–SCFA, Sittiya et al. (2025) provide specific evidence regarding the role *of D. asper oligosaccharides* as prebiotics. The study showed an increase in beneficial bacteria as well as the production of short-chain fatty acids (SCFAs), especially butyrate, which is known to play a role in colon cancer cell apoptosis, decreased proliferation, and mucosal inflammatory modulation. These findings link the consumption *of D. asper*

bamboo shoots to biological mechanisms that are directly protective against colorectal cancer. In the phase of the functional nutrition and food study, Sharma & Nirmala (2020) and Wu et al. (2020) confirmed that bamboo shoots are rich in soluble fiber, flavonoids, and phytosterols, which support metabolic health and modulation of the gut microbiota. Bamboo fiber is known to have the potential to lower cholesterol, improve the microbiota profile, and suppress inflammatory pathways associated with the development of colon cancer, thereby strengthening the prospects *of D. asper* bamboo shoots as candidates for phytopharmaceuticals and functional foods.

Based on the grouping of evidence from the most basic to preclinical phases, it can be concluded that *D. asper* bamboo shoots show strong mechanistic potential to be developed as a chemopreventive agent or complementary therapy for colorectal cancer. However, no clinical trials are available yet so further research using more specific colorectal models is needed.

Thematic Synthesis

This section of results follows Table 6 and combines findings from all nine studies. In the first theme, "Bioactive Compounds and Phytochemical Potential of Bamboo Shoots," the entire article affirms that *Dendrocalamus asper bamboo shoots* and several other bamboo species contain phenolics, flavonoids, phytosterols, and dietary fiber that play a role in the mechanism of colorectal cancer prevention. Studies from Thailand show that the processing process can lower cyanide levels and maintain significant antioxidant activity, thus supporting the consumption safety and phytopharmaceutical potential of bamboo (Pattarathitiwat et al., 2021). The comprehensive review also emphasizes the contribution of nutrients, polyphenols, and bamboo fiber to colon health, including decreased oxidative stress and inflammatory modulation (Wang et al., 2020; Wu et al., 2020). The subtheme regarding the role of nutrition and fiber is reinforced by the findings that bamboo fiber increases SCFA production and functions as a prebiotic, both of which are important mechanisms in colorectal cancer protection (Sittiya et al., 2025). The second theme, "Anticancer Mechanisms of Bamboo Extracts," shows the consistency of evidence regarding antiproliferative, anti-inflammatory, and apoptosis-induced activity. *D. asper bamboo shoots* extract shows cytotoxic activity in breast cancer cells that can be translated to colon cancer mechanisms through similar antiproliferative pathways (Ontaha et al., 2021). Studies on colon cancer cells HCT-116 provide direct evidence that Guadua incana leaf extract can modulate the metabolism of colon cancer cells (Chitiva et al., 2024). At the in vivo level, the combination of Bambusa vulgaris and Opuntia decreased preneoplastic lesions and colon inflammation in the AOM/DSS model, which is the experimental standard model of colorectal cancer (Komala et al., 2022). Reviews by Sharma & Nirmala (2020) reinforce that lignans, flavonoids, and phytosterols have anti-inflammatory and apoptosis mechanisms as the theoretical cornerstone of CRC prevention. The third theme, "Gut Microbiota and SCFA-Mediated Protective Effects," brings together findings that the oligosaccharide content in *D. asper bamboo shoots* can promote beneficial bacterial growth and production of SCFAs, especially butyrates, which have been known to protect the intestinal epithelium from malignant transformations (Sittiya et al., 2025; Wu et al., 2020). This mechanism provides a bridge between bamboo's nutritional potential and anticancer effects through modulation of the microbiota. The fourth theme, "Cross-Species Insights for CRC Prevention," underscores that although some studies do not use *D. asper* directly, the biological mechanisms found in other bamboo species, e.g. Guadua incana and Bambusa vulgaris are relevant and applicable to *D. asper* due to the similarity of polyphenol, flavonoid and fiber content (Chitiva et al., 2024; Komala et al., 2022). The internationally reviewed literature also confirms that bamboo species generally have phytochemical profiles that support colon health and CRC prevention (Sharma & Nirmala, 2020; Wang et al., 2020).

Cross-country Comparison of Findings

The nine articles reviewed came from Indonesia (2 studies), Thailand (1), Colombia (1), China (1), as well as four international reviews that were not limited to one specific country. Overall, cross-border evidence shows a consistent pattern that bamboo species, including *D. asper*, have relevant phytochemical potential in the prevention and treatment of colorectal cancer through a combination of antioxidant, antiinflammatory, antiproliferative, and microbiota-modulating mechanisms.

Research in Indonesia emphasizes the cytotoxic activity and phytochemical profile *of D. asper* and its potential as a candidate for local phytopharmaceuticals. The Thai study reinforces the safety aspects of consumption and the effectiveness of antioxidants after the processing process. The Colombian study makes an important contribution in the form of direct evidence against colon cancer cells (HCT-116), suggesting that bamboo extract can significantly affect the metabolism of cancer cells. The Chinese study highlights the role of nutrients and bamboo fiber in colon health, positioning bamboo as a potential functional food source in the prevention of CRC.

Differences in country contexts affect the focus of the study: countries such as Colombia and China are more oriented towards the direct biological mechanisms of the colon, while Southeast Asian studies (Indonesia and Thailand) have more emphasis on phytochemicals, safety of consumption, and the potential for the translation of bamboo as phytopharmaceuticals. Although the distribution of countries is uneven, common mechanisms such as antioxidant activity, inflammatory regulation, and SCFA production show consistency across contexts.

Comparison of Findings Across Study Designs

In vitro studies show strong evidence regarding the antiproliferative and cytotoxic mechanisms of bamboo extract, both in colon cancer cells and in other types of cancer cells whose mechanisms can be translated (Ontaha et al., 2021; Chitiva et al., 2024). In vivo studies, such as the AOM/DSS model, provide physiological evidence that bamboo extract is able to reduce preneoplasia and colon inflammation, corroborating the translation of mechanisms to the organism level (Komala et al., 2022). The review study offers a comprehensive picture of the anticancer mechanisms, nutritional roles, and contribution of bamboo fiber in the production of SCFAs that protect the colon (Sharma & Nirmala, 2020; Wang et al., 2020; Wu et al., 2020). The review also linked the phytochemical potential of bamboo to its potential in functional foods and phytopharmaceuticals.

The consistency between research designs is very high, especially in supporting anti-inflammatory, antioxidant, and microbiota regulation mechanisms. The main difference lies

in the depth of the mechanisms: in vitro studies map molecular pathways, in vivo studies prove systemic effects, while reviews integrate evidence to construct a theoretical framework for colorectal cancer prevention. The need for clinical trials became clear, as there have been no direct human studies evaluating the effects of *D. asper* in populations at risk of CRC.

Comparative Analysis

Cross-country comparisons, bamboo species, and study designs show that the research context strongly influences the focus of the findings and the mechanisms underlined. In Indonesia, studies examining *Dendrocalamus asper* mainly highlight its cytotoxic activity, polyphenol–flavonoid content, and the potential for translation of antiproliferative mechanisms (Ontaha et al., 2021). This focus is consistent with the trend of local research that places bamboo shoots as a traditional food ingredient that has the opportunity to be developed into phytopharmaceuticals. Meanwhile, Thailand emphasizes aspects of consumption safety and phytochemical stability, suggesting that a decrease in toxic components such as cyanide does not reduce antioxidant activity (Pattarathitiwat et al., 2021). This confirms that traditional processing does not eliminate anticancer potential, and provides the basis for the development of a safe bamboo supply chain for consumption.

The study from Colombia makes a different contribution, namely direct evidence on colon cancer cells (HCT-116), which suggests that bamboo extract can significantly modulate the metabolism of cancer cells (Chitiva et al., 2024). These findings are important because they provide specific mechanistic data on CRCs, different from in vitro studies in Indonesia using other cancer cells (MCF-7) but relevant through similar antiproliferative pathways. Thus, the two regions provide complementary pieces of evidence: Indonesia shows a phytochemical basis and basic cellular activity, while Colombia shows direct effectiveness on CRC target cells.

Meanwhile, studies in China and international reviews place fiber, oligosaccharides, and SCFAs as the main pathways in the prevention of CRC. The content of soluble fiber and hemicellulose in bamboo increases the production of short-chain fatty acids, especially butyrate, which are known to suppress colon inflammation, improve mucosal integrity, and inhibit preneoplastic cell transformation (Wu et al., 2020; Sittiya et al., 2025). Reviews from China and India confirm that the anticancer mechanisms of bamboo are multifactorial including antioxidant, anti-inflammatory, apoptotic triggering, and microbiota repair pathways (Sharma & Nirmala, 2020; Wang et al., 2020). The consistency of this mechanism, despite coming from different country contexts, suggests that the biological effects of bamboo are quite universal and not limited to a single species or population.

Comparisons between study designs reveal similar patterns: in vitro studies consistently demonstrated antiproliferative effects through modulation of cell cycle and cancer cell metabolism; in vivo studies showed a decrease in preneoplastic and inflammatory lesions in animal models of AOM/DSS (Komala et al., 2022); while review studies integrated evidence on bamboo bioactivity to support the theoretical framework for CRC prevention. The presence of evidence from various designs reinforces the consistency of the mechanism, although there have been no human clinical trials that assess the direct effect of *D. asper* consumption on CRC risk.

The variation in findings between countries can be traced from the differences in the bamboo species studied, ecological conditions, processing methods, and national research priorities. For example, Southeast Asia emphasizes the use of bamboo shoots as a functional food, while Latin America focuses more on leaf extracts. However, the anticancer biological pathways found tended to be similar, suggesting that phytochemical collaboration across bamboo species contributes to colon protection mechanisms. Nevertheless, the uneven distribution of research with most studies originating from Asia limits the generalizing power of the findings, especially since the ecological relevance of bamboo can differ between regions.

Comparative analysis showed that although the research approach, bamboo species, and geographic context varied, the main mechanisms related to colorectal cancer prevention (antioxidant, anti-inflammatory, antiproliferative, and microbiota modulation) appeared consistently throughout the study. The stability of this mechanism strengthens the chances of bamboo, especially *D. asper*, to be developed as a candidate for phytopharmaceuticals and functional foods that support colon health.

DISCUSSION

Colorectal cancer (CRC) remains one of the major contributors to global morbidity and mortality, and its burden continues to rise due to dietary shifts, obesity, sedentary lifestyles, and environmental factors (Rawla et al., 2019; Yang et al., 2025). While advances in surgery, chemotherapy, and radiotherapy have significantly improved survival, these interventions are often accompanied by substantial adverse effects such as mucositis, gastrointestinal disturbances, neuropathy, immunosuppression, and long-term metabolic changes (Anand et al., 2023). Consequently, there is a growing scientific interest in identifying natural bioactive compounds that may complement primary therapies through mechanisms such as oxidative stress reduction, inflammation control, and microbiota modulation. Within this context, *Dendrocalamus asper* is increasingly recognized as a locally available plant with promising preclinical potential (Ahmad et al., 2025; Mustafa et al., 2021). However, the extent to which this species exerts direct activity on colorectal cancer remains poorly established, highlighting the need for a comprehensive synthesis of existing evidence.

Preclinical studies included in this review reveal that *D. asper* contains phenolic compounds, flavonoids, and phytosterols, bioactive groups widely documented for their antiproliferative, pro-apoptotic, and antioxidant properties (Cao et al., 2022; Yansen et al., 2023). Findings from Ontaha et al. (2021) demonstrate cytotoxicity of *D. asper* extract against MCF-7 breast cancer cells, suggesting a possible involvement of phenolic-flavonoid pathways in inhibiting cell proliferation through mechanisms such as ROS modulation or caspase activation (Ontaha et al., 2021). Although these findings cannot be directly extrapolated to CRC, they provide preliminary mechanistic signals that warrant further exploration using CRC-specific cell lines such as HCT-116 or HT-29. Similarly, Pattarathitiwat et al. (2021) highlight the strong antioxidant capacity of *D. asper*, indicating its potential relevance in counteracting oxidative DNA damage one of the key processes driving colorectal carcinogenesis (Pattarathitiwat et al., 2021). Nevertheless, the absence of studies directly testing *D. asper* on CRC

models marks a critical evidence gap requiring targeted in vitro experiments.

Beyond phenolics and flavonoids, bamboo shoots also contain dietary fiber and oligosaccharides with documented prebiotic effects (Dadwal et al., 2023; Ma et al., 2024). These fibers can be metabolized by gut microbiota into short-chain fatty acids (SCFA), particularly butyrate. Butyrate plays a crucial role as an energy source for colonocytes and functions as a histone deacetylase (HDAC) inhibitor thereby inducing differentiation and apoptosis in colorectal cancer cells (Chakraborty & Laird, 2025). SCFA also modulate immune responses, reduce mucosal inflammation, and maintain epithelial integrity (Ney et al., 2023). Findings from Sittiya et al. (2025) confirm that *D. asper* oligosaccharides enhance SCFA production, supporting the hypothesis that bamboo shoots may exert chemopreventive effects indirectly through microbiota-mediated pathways (Sittiya et al., 2025). However, no studies have yet investigated whether *D. asper* fibers directly increase butyrate levels in CRC-risk human populations, representing a key gap for future clinical and nutritional intervention studies.

Cross-species evidence further supports the notion that bamboo may possess anticancer properties relevant to CRC. Chitiva et al. (2024) demonstrate that Guadua incana extract modulates metabolic pathways in HCT-116 colon cancer cells, while Komala et al. (2022) show that Bambusa vulgaris suppresses preneoplastic lesions and inflammation in the established AOM/DSS mouse model (Chitiva et al., 2024; Komala et al., 2022). These findings confirm the general anticancer potential of the bamboo genus. Importantly, they also underscore the feasibility and relevance of testing *D. asper* using similar models. Given the close phylogenetic relationship and overlapping phytochemical profiles, replication of AOM/DSS in vivo studies using *D. asper* constitutes an essential next step toward validating its mechanistic activity in CRC (Pan et al., 2017; Sui et al., 2025).

Processing and safety aspects also require further examination. Although bamboo shoots naturally contain cyanogenic glucosides, studies consistently show that boiling and fermentation significantly reduce cyanide content (Urugo & Tringo, 2023), ensuring safety for consumption. Yet, no standardized extraction or processing protocols currently exist for *D. asper* intended for phytopharmaceutical development. Variability in processing methods may alter phenolic and flavonoid stability, thereby affecting reproducibility of research outcomes. Standardization of preparation procedures particularly for preclinical testing is therefore essential to strengthen reliability and translational potential (Correa et al., 2025; de Wit et al., 2025).

Based on the overall findings analyzed in this scoping review, preclinical evidence regarding the potential of *Dendrocalamus asper* shows the existence of several promising biological mechanisms, especially antioxidant, antiproliferative, anti-inflammatory, and modulatory activities of the gut microbiota. These mechanisms were obtained from the identification of phenolics, flavonoids, phytosterols, and functional fibers contained in bamboo shoots, as well as from the results of in vitro and in vivo studies on other bamboo species that have similar bioactive profiles (Watanabe et al., 2021). However, the overall strength of the evidence is still limited because most of the available studies do not directly use colorectal cancer models, but rather other cancer models or descriptive phytochemical studies. This condition has led to an understanding of the specific biological effects of *D. asper* on colorectal cancer pathogenesis that cannot be comprehensively explained.

The major gaps identified in this study include the absence of in vitro assays that directly evaluate *D. asper* extracts in colorectal cancer cell lines such as HCT-116, HT-29, or SW480, so that the antiproliferative effects and apoptosis mechanisms relevant to colorectal cancer are still assumed based on extrapolation from other cancer models. In addition, there are no validated in vivo studies on validated colorectal cancer models, especially the AOM/DSS model, which has been considered the gold standard for evaluating chemopreventive agents and complementary therapies. This gap hinders the assessment of biological translations from initial findings to more robust preclinical applications. In addition to the lack of data on colorectal cancer models, the exploration of the molecular mechanisms of bioactive *D. asper* is also very limited. No studies have assessed important pathways such as apoptosis (e.g., caspase-3/9), oxidative stress (e.g., Nrf2), inflammation (e.g., NF-κB, COX-2), and the potential of butyrate as an inhibitor of HDAC, even though these pathways play a major role in colorectal carcinogenesis. Similarly, no clinical studies or nutritional interventions in humans have been found that assess changes in colon biomarkers, short-chain fatty acid production, or microbiota profiles after consumption of bamboo shoots, so the clinical implications remain inconclusive.

These findings suggest that although bamboo shoots have strong biological potential, the available scientific evidence is not yet sufficient to draw definitive conclusions regarding their effectiveness against colorectal cancer. To strengthen the scientific foundation, further research needs to integrate relevant molecular biology approaches, nutritional sciences, microbiome, as well as pre-clinical animal models. With the development of a more holistic and mechanism-based research methodology, *D. asper* has the potential to be further developed as a phytopharmaceutical candidate that has scientific and applicative value in the prevention and management of colorectal cancer.

CONCLUSIONS AND RECOMMENDATION

The results of this scoping review show that *Dendrocalamus asper* contains a variety of bioactive components, including dietary fiber, polyphenols, flavonoids, phytosterols, and oligosaccharides, which play a role in preclinical mechanisms related to colorectal cancer prevention. The available in vitro and in vivo evidence report antiproliferative, antioxidant, antiinflammatory, apoptosis-induced activity, as well as increased production of short-chain fatty acids (SCFAs), specifically butyrate, which are biologically relevant for maintaining colon homeostasis and inhibiting carcinogenesis. This mechanism provides an initial scientific basis regarding the potential of bamboo shoots as a phytochemical agent that supports the prevention of colorectal cancer. Nevertheless, there is a significant research gap. Direct evidence testing *D. asper* extract on colorectal cancer cells is still very limited, while in vivo tests using AOM/DSS models and clinical trials are not yet available. Most studies also still focus on the characterization of phytochemicals and antioxidant activity without evaluating the specific molecular pathways involved in the regulation of proliferation, inflammation, and apoptosis in colorectal cancer. Therefore, further research is needed, including testing on CRC cell lines (e.g. HCT-116, HT-29), deeper

mechanistic studies, toxicity evaluations, as well as in vivo and clinical trials to validate the benefits and safety of using *D. asper*. Overall, these findings answer the key research question of what preclinical mechanisms have been reported regarding the bioactive potential of *D. asper* against colorectal cancer and how these gaps can guide future research by confirming that the existing evidence is still in its early stages and cannot yet be translated into clinical practice. Strengthening the evidence through preclinical and clinical studies is urgently needed before bamboo shoots can be considered as a complementary intervention in colorectal cancer management.

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DECLARATION

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3. All individuals listed as authors have consented to their inclusion and fulfill the authorship requirements in accordance with the journal′s guidelines.
4. The authors declare that there are no conflicts of interest. All authors have reviewed, contributed to, and approved the final version of this manuscript.

Consent for publication

Not applicable.

Availability of data and materials

The data generated or analyzed in this study are available from the corresponding author upon reasonable request.

Conflicts of Interest Statement

Not applicable.

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Statement on the Use of Artificial Intelligence (AI)

The authors confirm that no generative artificial intelligence (AI) tools were employed in the preparation, writing, or editing of this manuscript.

Authors' contributions

Arie Jefry Ka'arayeno was responsible for formulating the research concept and design, carrying out the scoping review, methodological quality assessment, and preparing the initial draft of the manuscript. Errick Endra Cita assisted with data extraction and manuscript refinement. The authors reviewed and approved the final manuscript for publication.

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