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Analysis of the Phytochemical Composition of Papaya Root (*Carica papaya L.*) and Its Potential as an Anticarcinogenic Agent: A Preliminary Study

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Abstract

Background: Cancer remains a major global health problem with high morbidity and mortality. Conventional treatments often cause serious side effects and require high costs, encouraging the exploration of natural products as alternative anticarcinogenic agents. *Carica papaya L.* contains various secondary metabolites, but studies on its root are still limited.
Objective: This study aimed to conduct phytochemical screening and *simplicia* characterization of papaya root (*Carica papaya L.*) and preliminarily assess its potential as an anticarcinogenic agent.
Methods: This descriptive laboratory study used an exploratory approach. Papaya roots were processed into *simplicia*through drying, grinding, and sieving, followed by ethanol maceration. *Simplicia* characterization included moisture content, total ash, acid-insoluble ash, and water- and ethanol-soluble extractive values. Phytochemical screening was conducted using specific reagents to identify secondary metabolites.
Results: The results showed that papaya root contained glycosides, saponins, and triterpenoids/steroids, while alkaloids, flavonoids, and tannins were not detected. The highest characterization value was water-soluble extractives at 19.38%, while acid-insoluble ash was the lowest at 5.07%, indicating relatively good *simplicia* quality.
Conclusion: Papaya root contains secondary metabolites with potential anticarcinogenic relevance. Further *in vitro* and *in vivo* studies are required to confirm its pharmacological activity.

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INTRODUCTION

Worldwide, cancer is one of the most important causes of morbidity and mortality. Based on the latest global report, cancer incidence continues to show significant increases and is projected to be the leading cause of premature death globally in the coming decades (Soerjomataram & Bray, 2021). In addition to having a physical impact, cancer patients also face psychological burdens, such as anxiety during the treatment process (Tanrewali & Wahyuningsih, 2019). The increase in cancer incidence is influenced by various factors, including lifestyle changes, population aging, and exposure to environmental factors, making cancer a major challenge in the modern health system.

Cancer treatment efforts have developed through various approaches, such as surgery, chemotherapy, radiotherapy, targeted therapy, and immunotherapy, including gene-engineering-based approaches such as CRISPR/Cas9 (Ou et al., 2024). However, these therapies still have limitations, especially related to significant side effects, high treatment costs, and suboptimal selectivity for cancer cells. This condition encourages the development of alternatives based on natural ingredients that are safer, more affordable, and have the potential as chemopreventive and anticarcinogenic agents.

It is known that medicinal plants contain several bioactive compounds, known as secondary metabolites, such as alkaloids, flavonoids, saponins, tannins, and terpenoids. These compounds have various reported biological activities, including antioxidant properties, and have been studied for their potential antiproliferative and pro-apoptotic effects in preclinical settings, suggesting possible roles in modulating carcinogenesis-related pathways (Rahmat et al., 2025). This activity plays a role in inhibiting the process of carcinogenesis, which is a series of changes in normal cells into cancer cells through the stages of initiation, promotion, and progression. Therefore, secondary metabolites are one of the main focuses in research on the development of anticarcinogenic agents based on natural ingredients.

The distribution of secondary metabolites in plants is not limited to one specific part but rather is spread across various parts such as leaves, fruits, seeds, stems, and roots. Each part of the plant can have a different bioactive compound profile, potentially providing diverse pharmacological activity (Sari et al., 2025). An exploratory approach to all parts of the plant is important to identify the source of the most potential bioactive compounds as anticarcinogenic agents.

Papaya (*Carica papaya L.*) is one of the most researched plants due to its high nutritional value and contains many bioactive compounds, including enzymes, alkaloids, flavonoids, and phenolic compounds (Dotto & Abihudi, 2024). Various studies show that the leaves of papaya have antioxidant and antiproliferative activity that has the potential as an anticancer agent (A. M. Rahmawati et al., 2023). In addition, secondary metabolites such as flavonoids, alkaloids, and saponins are known to reduce oxidative stress and inhibit cell damage that plays a role in cancer development (Triananda et al., 2023).

In general, the biological activity of secondary metabolites is related to their ability to inhibit cell proliferation, induce apoptosis, and neutralize free radicals that can cause DNA damage (Rizkirullah et al., 2025). The presence of certain secondary metabolites may indicate potential for future investigations into anticarcinogenic activity, though direct evidence from this study requires further experimental validation.

Although various parts of the papaya plant have been extensively researched, scientific studies are still dominated by leaves, fruits, and seeds. Research on roots is still relatively limited, even though roots are part of plants that can also contain secondary metabolites that perform certain biological functions. A study by Hidayati (2020) shows that almost all parts of the papaya plant have pharmacological activity, but exploration of the roots has not been carried out systematically.

Empirically, papaya root has been utilized in traditional medicine, including for chronic diseases. Some early studies have shown that papaya root contains bioactive compounds that have the potential to exhibit cytotoxic and antioxidant activity (Amin Innayatulloh, et al., 2025). However, scientific evidence supporting this potential is still limited, especially regarding the characterization of simplicia and standardized phytochemical profiles.

In natural materials research, the first stage that is important is the characterization of simplicia and phytochemical screening. Characterization of simplicia aims to ensure the quality of raw materials through certain parameters, such as moisture content, ash content, and soluble juice content in specific solvents. Meanwhile, phytochemical screening is carried out to qualitatively identify the presence of secondary metabolites before further analysis. These two approaches are the basis for evaluating the potential of a natural ingredient as a candidate for an anticarcinogenic agent.

The limitations of research related to the phytochemical profile and quality of papaya root simplicia indicate that there is a scientific gap that must be further explored. As a result, this investigation was conducted as a preliminary study to identify the secondary metabolite content through phytochemical screening as well as determine the characteristics of papaya root simplicia (*Carica papaya L.*), exploring its potential as an anticarcinogenic agent. This research is expected to provide a scientific basis for further studies conducted both in vitro and in vivo, in the context of the use of natural ingredients as an alternative in cancer prevention.

Literature Review

***Carica papaya L.* and its pharmacological potential**

Carica papaya L. is a tropical plant of the *Caricaceae* family, native to Central and South America, and has widely spread across various tropical regions, including Indonesia (Aisyafina & Rosida, 2023; Primadiamanti et al., 2022). This plant is highly adaptable to diverse environmental conditions and is recognized as a multipurpose plant with relatively fast growth (Badillo & Leal, 2020; Miller, 1982). All parts of the papaya plant are utilized, both as food and in traditional medicinal practices.

Pharmacologically, *Carica papaya L.* has significant value due to its diverse bioactive compound content. Papaya fruit contains enzymes, vitamins, and antioxidants that support health, while the leaves, seeds, and stems have been reported to possess antibacterial, anti-inflammatory, and anticancer potential (Dotto & Abihudi, 2024; Hidayati et al., 2020). These biological activities are closely linked to secondary metabolites such as flavonoids, alkaloids, and saponins, which contribute to antibacterial and other bioactive functions (Ningsih et al., 2026; Sarjono et al., 2019).

The production and composition of secondary metabolites in plants are influenced by factors such as geographical conditions, climate, and biotic stress, which modulate the type and quantity of compounds produced. Flavonoids, for example, exhibit antioxidant activity, inhibiting oxidative stress—a fundamental mechanism in the development of degenerative diseases, including cancer. This antioxidant activity helps prevent cell damage caused by free radicals that can trigger genetic alterations.

Although various parts of the papaya plant have been extensively studied, research has predominantly focused on leaves, fruits, and seeds. Several studies have demonstrated cytotoxic and antioxidant activity in these parts through laboratory tests (Iordănescu et al., 2024; Ulfa et al., 2019). However, studies specifically investigating the root remain limited. Each plant part may possess a unique secondary metabolite profile, resulting in variations in biological activity that are not yet fully characterized.

The limited research on papaya roots presents an opportunity to identify their bioactive compound content. Therefore, preliminary phytochemical screening and characterization of simplicia are needed to provide a qualitative overview of secondary metabolite profiles, serving as a foundation to evaluate the potential of *Carica papaya L.* roots as candidates for anticarcinogenic agents (Handayani et al., 2020; Kurniadi et al., 2025).

Phytochemical Content and Secondary Metabolites

Phytochemical content is crucial for determining the biological activity of medicinal plants. Phytochemicals are naturally occurring chemical compounds in plants, generally classified as secondary metabolites, including alkaloids, flavonoids, saponins, tannins, and terpenoids. While these compounds do not directly contribute to plant growth or development, they play essential roles in defense mechanisms and environmental adaptation (Julianto, 2019).

Studies indicate that *Carica papaya L.* contains secondary metabolites in almost all parts of the plant, including leaves, fruits, seeds, and roots. Flavonoids and alkaloids are dominant components, demonstrating biological activities such as antioxidant, antibacterial, and potential anticarcinogenic effects (Dotto & Abihudi, 2024; Sarjono et al., 2019). Saponins and tannins also contribute by protecting against oxidative stress and modulating cellular responses.

Flavonoids, known for their high antioxidant activity, capture free radicals and inhibit oxidative processes that contribute to cell damage and cancer development (Ningsih et al., 2026). Alkaloids exhibit cytotoxic activity by inhibiting cell proliferation and inducing apoptosis. Saponins and terpenoids enhance cell membrane permeability and inhibit abnormal cell growth. The combined effects of these secondary metabolites suggest a promising biological activity profile for preventing carcinogenesis.

Secondary metabolite profiles vary across plant parts in terms of type and concentration, influenced by genetic, environmental, and plant-specific factors. This variation affects the resulting biological activity (Dotto & Abihudi, 2024). As a result, identifying secondary metabolite materials in the root is important to obtain a more accurate picture of biological potential.

Early identification of secondary metabolite content is generally carried out through phytochemical screening as an initial stage in the research of natural materials. This method allows researchers to detect the presence of certain groups of compounds qualitatively before further quantitative analysis or biological activity tests (Handayani et al., 2020; Shaikh & Patil, 2020). Thus, understanding the content of phytochemicals and secondary metabolites is an important basis in evaluating the potential of the roots *Carica papaya L.* as candidates for anticarcinogenic agents in preliminary studies.

Simplicia and Phytochemical Screening

Simplicia is a natural raw material derived from plants, both in its whole form and that has undergone simple processes such as drying and refining. In the pharmaceutical field, simplicia is the initial stage in the development of drugs based on natural ingredients because it contains bioactive compounds that have the potential to provide biological activity. Therefore, standardization of simplicia is an important aspect to ensure the quality, safety, and consistency of the chemical content contained in it, as regulated in the Indonesian Herbal Pharmacopoeia (Ministry of Health of the Republic of Indonesia).

Characterization of simplicia is performed to assess the quality of the material through specific parameters, such as moisture content, total ash, acid-insoluble ash, and pollen soluble in some solvents, such as water and ethanol. These parameters are used to ensure that the simplicia is of good quality, free from contamination, and contains an adequate amount of active compounds. This characterization process is important because the quality of simplicia will affect the extraction efficiency as well as the profile of the compound obtained at a later stage (Handayani et al., 2020).

The initial method used to identify is phytochemical screening, regarding the presence of secondary metabolites in a natural material qualitatively. This method involves a series of tests using specific reagents to detect groups of compounds such as alkaloids, flavonoids, saponins, tannins, glycosides, as well as terpenoids or steroids. Indications of the presence of compounds are generally characterized by discoloration, the formation of sediments, or the appearance of foam in response to certain reagents (Shaikh & Patil, 2020).

The stages of phytochemical screening generally include sample preparation, extraction process using appropriate solvents, and testing using qualitative methods. This approach is used as a first step to obtain an overview of secondary metabolite profiles before further analysis, such as quantitative identification of compounds and biological activity testing (Krismayadi et al., 2024; Safutri et al., 2022).

Thus, the combination of simplicia characterization and phytochemical screening is a fundamental stage in the research of natural materials. This approach not only provides information about the quality of the ingredients, but also allows for the early identification of bioactive compound content that has the potential to play a role in biological activity (Safutri et al., 2022). In the context of this study, both methods are used as a basis for evaluating the potential of the root *Carica papaya L.* as candidates for anticarcinogenic agents in preliminary studies.

Cancer and the Mechanism of Carcinogenesis

A disease characterized by uncontrolled cell growth is known as cancer, as well as the cell's ability to invade surrounding tissues and metastasize to other organs. This process involves genetic and epigenetic changes that cause disruptions in the regulation of the cell cycle, resulting in the cell losing control over proliferation and apoptosis. This condition makes cancer one of the degenerative diseases that has a high morbidity and mortality rate globally (Asriantin et al., 2024).

The mechanism of carcinogenesis generally takes place through three main stages, namely initiation, promotion, and progression. The initiation stage is characterized by the occurrence of genetic mutations due to exposure to carcinogens, both from internal and external factors. At the promotion stage, cells that have undergone mutations proliferate without adequate DNA repair mechanisms. Furthermore, the progression stage is an advanced phase characterized by increasingly complex cell changes, so that they have invasive and metastatic capabilities

(Kontomanolis et al., 2020).

The development of cancer is also influenced by an imbalance between the activity of oncogenes and tumor suppressor genes. Oncogenes play a role in stimulating cell growth and division, while tumor suppressor genes function to inhibit abnormal cell growth. Excessive activation of oncogenes as well as inactivation of tumor suppressor genes triggers uncontrolled cell proliferation and contributes to tumor formation. In addition, oxidative stress due to the accumulation of free radicals also plays a role in damaging DNA and accelerating the process of carcinogenesis (Khuzaimatul, 2025; S. Rahmawati, 2021).

Various cancer therapy approaches have been developed, such as surgery, chemotherapy, radiotherapy, target therapy, and immunotherapy. However, this approach still has limitations, especially related to significant side effects, high treatment costs, and not optimal selectivity for cancer cells (Min & Lee, 2025). This condition encourages the development of safer natural material-based approaches, especially those that play a role in preventing or inhibiting carcinogenesis processes.

In this context, secondary metabolite compounds from plants are known to have potential as anticarcinogenic agents through various mechanisms, such as antioxidant activity, inhibition of cell proliferation, and induction of apoptosis. Therefore, the identification of the content of bioactive compounds through phytochemical screening is an important first step to evaluate the potential of natural ingredients, including roots *Carica papaya L.*, in supporting efforts to prevent carcinogenesis (Amin et al., 2025; Ikfar et al., 2025).

Anticarcinogenic Potential of Natural Ingredients

The use of natural ingredients as a source of bioactive compounds continues to grow along with the increasing need for safer approaches to cancer prevention and control. Compounds of plant origin are known to have the potential as chemopreventive and anticarcinogenic agents through various biological mechanisms. This approach is relevant considering that conventional cancer therapies still face limitations, especially related to significant side effects and high treatment costs (Min & Lee, 2025; Sugiharto, 2006).

Secondary metabolites such as flavonoids, alkaloids, saponins, and terpenoids have been widely reported to have biological activity related to inhibiting the process of carcinogenesis. The mechanism of action of these compounds includes the induction of apoptosis, inhibition of cell proliferation, modulation of the cell cycle, and inhibition of angiogenesis. In addition, the antioxidant activity of natural compounds is also responsible for neutralizing free radicals, which can cause DNA damage and trigger cell mutations (Julianto, 2019; Ningsih et al., 2026).

Various studies have shown that plant extracts have early potential in inhibiting the growth of cancer cells through preliminary tests, such as testing for cytotoxicity and antioxidant activity. Methods such as *Brine Shrimp Lethality Test* (BSLT) is often used as an initial approach to identify the potential biological toxicity of a plant extract (Ulfa et al., 2019). In addition, testing antioxidant activity is also an important indicator in assessing the ability of a natural ingredient to inhibit the process of carcinogenesis triggered by oxidative stress (Iordănescu et al., 2024).

In context *Carica papaya L.*, various parts of the plant have been reported to have biological activity that supports anticarcinogenic potential, primarily through the content of secondary metabolites such as flavonoids, alkaloids, and saponins. This activity is generally related to the compound's ability to suppress oxidative stress and inhibit the proliferation of abnormal cells (Kurniadi et al., 2025; Wulandari et al., 2025).

These limitations show that there is an opportunity to further explore papaya roots as a source of bioactive compounds. Therefore, an initial approach through characterization of simplicia and phytochemical screening becomes important to identify the profiles of secondary metabolites contained in it. This method is expected to provide a scientific basis for evaluating the potential of the root *Carica papaya L.* as candidates for anticarcinogenic agents in preliminary studies (Kurniadi et al., 2025).

METHOD

Research Design

This exploratory laboratory descriptive research aimed to identify the secondary metabolite profile and characteristics of *Carica papaya L.* root simplicia qualitatively. The study did not involve testing advanced biological activity but focused on the early stages of natural material research through phytochemical screening and characterization of simplicia. The research stages included simplicia preparation, extraction, simplicia characterization, and phytochemical screening.

Place and Time of Research

The research was conducted in the Phytochemistry Laboratory, Faculty of Pharmacy, University of North Sumatra. The full series of research activities—including ingredient preparation, extraction, simplicia characterization, and phytochemical screening—were carried out from July to December 2024.

Materials and Tools

The main material was *Carica papaya L.* root, obtained from the Martubung area, Medan. Chemicals used included 70% ethanol as an extraction solvent, and various reagents for phytochemical screening: Dragendorff, Mayer, and Wagner reagents for alkaloids; magnesium powder and hydrochloric acid (HCl) for flavonoids; ferrous chloride ($FeCl_3$) for tannins; aquadest for saponins; Molisch reagent for glycosides; and Liebermann–Burchard reagent for triterpenoids/steroids.

Tools included drying ovens, analytical scales, blenders or grinders, mesh sieves, measuring cups, beakers, Erlenmeyer flasks, test tubes, drop pipettes, water baths, and rotary evaporators for extract concentration.

Simplicia Preparation Procedure

Collected *Carica papaya L.* roots were washed with running water to remove impurities such as soil and other foreign materials. The roots were cut into small pieces to increase the drying surface area. Drying was conducted in an oven at 40–50°C until a constant weight was achieved, preventing microbial growth and degradation of bioactive compounds.

The dried simplicia was ground into powder using a grinder and sifted through a mesh sieve to standardize particle size. The simplicia powder was stored in airtight containers at room temperature to prevent contamination and moisture changes before extraction.

Extraction Procedure

Extraction was performed using the maceration method with 70% ethanol, chosen for its ability to dissolve polar and semi-polar compounds. Simplicia powder was weighed and soaked in solvent at a 1:10 (b/v) ratio. Maceration was carried out for 72 hours at room temperature with occasional stirring to enhance diffusion.

After maceration, the mixture was filtered to separate the filtrate from residues using filter paper. The filtrate was concentrated using a rotary evaporator at 40–50°C to obtain a viscous extract, preserving the active compounds.

Characterization of Simplicia

Simplicia characterization followed the Indonesian Herbal Pharmacopoeia standards to evaluate quality. Parameters included moisture content, total ash, acid-insoluble ash, water-soluble extract, and ethanol-soluble extract:

1. Moisture content: determined the water present in simplicia, affecting stability and shelf life.
2. Total ash: measured inorganic mineral content.
3. Acid-insoluble ash: indicated potential contamination with inorganic materials such as sand or silica.
4. Water- and ethanol-soluble extracts: reflected the amount of extractable compounds, indicating bioactive content.

Phytochemical Screening

Secondary metabolites in *Carica papaya L.* root extract were identified qualitatively using standard methods with specific reagents:

1. Alkaloids: Dragendorff, Mayer, and Wagner reagents; positive indicated by precipitate formation.
2. Flavonoids: magnesium powder and HCl; positive indicated by red or orange color change.
3. Saponins: foam formation; positive indicated by stable foam after shaking.
4. Tannins: $FeCl_3$ reagent; positive indicated by blackish-green or dark blue discoloration.
5. Glycosides: Molisch reagent; positive indicated by formation of a purple ring at the solution interface.
6. Triterpenoids/steroids: Liebermann–Burchard reagent; positive indicated by green or bluish discoloration.

Data Analysis

Research data were analyzed descriptively using a univariate approach. Characterization results were presented in tables of parameter values, while phytochemical screening results were displayed as tables indicating the presence or absence of secondary metabolites. Interpretations were based on qualitative observations of color changes, sediment formation, or foam as indicators of positive reactions.

Ethics Statement

As the study did not involve human or animal subjects, ethical approval was not required. All procedures adhered to Good Laboratory Practice (GLP) principles to ensure accuracy and reliability. Plant sampling considered environmental sustainability.

RESULTS AND DISCUSSION

Results

The results of this study include three main stages, namely plant identification, characterization of simplicia, and phytochemical screening of *Carica papaya L roots.*. Plant identification is carried out to ensure the validity of the species used in the study, simplicia characterization aims to assess the quality of raw materials, while qualitatively, phytochemical screening is carried out to identify the content of secondary metabolites.

Plant Identification

The results of the identification of papaya plants are presented in Table 1 based on taxonomic classification.

Table 1. Papaya Plant Identification Results

Kingdom	**Stuttgart**
Divisions	Spermatophyta
Classes	Dicotyledoneae
Order	Brassicales
Family	Caricales
Genus	Carica
Species	*Carica papaya L.*
Local Name	Papaya Root

The identification results provide evidence that the sample used in this study is a species *of Carica papaya L.*. The identification process is carried out through taxonomic analysis which includes morphological classification as well as matching plant characteristics with relevant literature. This identification is important to ensure that the research material is in accordance with the species being studied, so that the results obtained can be scientifically accounted for.

Characterization of Simplicia

Results of characterization of *Carica papaya L. root simplicia.* presented in Table 2.

Table 2. Characterization of Simplicia *Carica papaya L*

No.	Characterization	Sample Weight	Weight of Sari	Rates
1.	Moisture Rate	5,0075	0,4	7,88%
2.	Rate of Soluble Juice in Water	5,0344	0,1957	19,38%
		5,0345	0,1869	
		5,0314	0,2027	
3.	Soluble Juice Levels in Ethanol	5,0288	0,0615	5,97 %
		5,0404	0,0558	
		5,0344	0,0632	
4.	Ash Rate	2,0804	0,2671	12,80%
		2,0469	0,3141	
		2,0155	0,2944	
5.	Acid insoluble ash content	2,0804	0,0988	5,07%
		2,0469	0,1035	
		2,0155	0,1092	

The results of the characterization of simplicia show the variation in values in each parameter tested. The moisture content of simplicia was obtained at 7.88%, while the highest value of the soluble juice content in water was 19.38%. Ethanol has an ash content of 12.80%, an acidic insoluble ash content of 5.07%, and a soluble cider content of 5.97%. These data illustrate the physical and chemical characteristics of the simplicia used in the study.

Phytochemical Screening

Table 3 shows the results of phytochemical screening on *Carica papaya L root extract.*

Table 3. Secondary Metabolite Examination Results on *Carica papaya L*

No.	Secondary Metabolites	Reagents	Results
1	Alkaloids	Dragendorff	-
		Mayer	-
		Wagner	-
2	Flavonoids	Mg+ Amyl Alcohol Powder + Hcl	-
3	Glycosides	Molish+H2SO4	+
4	Saponins	Hot/whipped water	+
5	Tannins	FeCl3	-
6	Triterpenes/Steroids	Liebermann-Burchard	+

The results of phytochemical screening showed that *Carica papaya L.* root had positive levels of glycosides, saponins, and triterpenoids/steroids, while alkaloids, flavonoids, and tannins were not detected. The presence of these secondary metabolites suggests that papaya root has a specific potential for biological activity, especially regarding certain pharmacological properties. This difference in content also indicates that the distribution of active compounds in each part of the plant is not the same, so further study is needed to comprehensively understand the potential of each part of the plant.

Discussion

The results of the study showed that the root extract of *Carica papaya L.* contains glycosides, saponins, and triterpenoids/steroids as secondary metabolites. In contrast, no alkaloids, flavonoids, or tannins were detected. These findings suggest that papaya roots possess a specific phytochemical profile with the potential to provide distinct biological activity. The presence of secondary metabolites in a plant is generally associated with environmental adaptation and contributes to biological activities that can be utilized in health applications (Simbolon, 2024).

One of the secondary metabolite groups is glycosides, which consist of sugar (glycone) and non-sugar (aglycone) components, with biological activity dependent on their chemical structure (Muldianah et al., 2021; Ravelliani et al., 2021). In the context of carcinogenesis, certain types of glycosides have been reported to modulate cell metabolism and influence signaling pathways involved in cell proliferation. Saponins, as glycoside derivatives, are also known for their biological activity, including increasing cell membrane permeability and inducing apoptosis in abnormal cells (Rachman et al., 2018). This mechanism suggests that the presence of glycosides and saponins in papaya roots may contribute to the potential inhibition of carcinogenesis.

Additionally, the triterpenoid/steroid compounds detected in this study have been reported to exhibit diverse biological activities, such as anti-inflammatory, antioxidant, and inhibition of cell proliferation through the regulation of molecular signaling pathways (Malita & Rahman, 2023). These activities play a role in preventing the development of abnormal cells and supporting cellular protection mechanisms. Thus, the presence of triterpenoids/steroids in the roots of *Carica papaya L.* strengthens the indication of potential anticarcinogenic activity.

The absence of flavonoids in this study indicates that the secondary metabolite profile of the root differs from other parts of the papaya plant, which are generally rich in flavonoids. Although flavonoids are recognized for strong antioxidant activity and their role in inhibiting oxidative stress Khoirunnisa (2019) and Ugusman (2012), the results of this study suggest that the biological potential of papaya root may be more influenced by other compound groups, such as saponins and triterpenoids. This reinforces that secondary metabolite distribution in plants is specific to each part, with different activity characteristics.

Theoretically, carcinogenesis involves genetic alterations that lead to uncontrolled cell proliferation, often triggered by oxidative stress and DNA damage (Dieter, 2018; Saha et al., 2017). Compounds with antioxidant, antiproliferative, and pro-apoptotic activities have the potential to inhibit this process. In this context, the secondary metabolites found in papaya root indicate potential as anticarcinogenic agents, although the precise mechanism requires further investigation.

This study aligns with previous findings demonstrating that *Carica papaya L.* has potential as a source of bioactive compounds. Papaya extracts have been reported to exhibit chemopreventive activity by reducing oxidative stress and inhibiting tumor development (Kong et al., 2024). Moreover, some papaya plant parts have shown cytotoxic activity against cancer cells in laboratory tests (Iordănescu et al., 2024). However, most studies focus on leaves, fruits, and seeds, leaving information on root potential limited.

Thus, the results of this study provide an initial overview of the phytochemical profile of *Carica papaya L.* roots and their biological potential as candidate anticarcinogenic agents. Nevertheless, this study has limitations, as it was conducted only qualitatively through phytochemical screening without direct testing of biological activity. Therefore, further research is necessary, including quantitative analysis, in vitro and in vivo biological activity testing, and isolation of active compounds to comprehensively confirm potency and mechanisms of action.

CONCLUSION

This study successfully achieved its two primary objectives. First, characterization of *Carica papaya L.* root simplicia confirmed that quality parameters were within acceptable ranges, with moisture content at 7.88%, water-soluble extractive content at 19.38%, ethanol-soluble extractive content at 5.97%, total ash content at 12.80%, and acid-insoluble ash content at 5.07%. Second, phytochemical screening identified glycosides, saponins, and triterpenoids/steroids as secondary metabolites present in the root extract, whereas alkaloids, flavonoids, and tannins were not detected. Collectively, these results confirm the phytochemical profile of the root and its conformity with basic quality standards for simplicia.

As a preliminary study, these findings provide an initial overview of the potential of *Carica papaya L.* root as a candidate warranting further investigation for natural material-based anticarcinogenic applications, based on the secondary metabolites identified. It is emphasized that this study is limited to preliminary qualitative analysis and does not provide direct evidence of anticarcinogenic activity. Therefore, further research is recommended, including quantitative phytochemical analysis, in vitro and in vivo biological activity testing, and isolation and characterization of active compounds to comprehensively confirm their potency and elucidate mechanisms of action.

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AUTHOR CONTRIBUTION STATEMENT

E.B. contributes to research design, laboratory experiment implementation, data collection and analysis, and manuscript preparation and writing. The author also interprets the results of the research, prepares a literature review, and makes the final revision of the manuscript to ensure compliance with scientific publication standards. All authors have read and approved the final version of the submitted manuscript.

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