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Effect of Solvent Polarity on Extraction Yield and Phytochemical Profile of *Carica papaya L.* Seed Extracts

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ABSTRACT

Extraction efficiency of bioactive compounds from natural materials is strongly influenced by solvent polarity, which determines the selectivity of extracted secondary metabolites. This study aimed to evaluate the effect of solvent polarity on extraction yield and phytochemical profile of papaya seed (Carica papaya L.) extracts. Extraction was performed using the maceration method with hexane and ethyl acetate solvents. Extraction yield was calculated based on the ratio between extract weight and initial material weight, followed by phytochemical screening to identify major bioactive compound groups. The results showed extraction yields of 50% for hexane extract and 54% for ethyl acetate extract. Phytochemical analysis revealed that the hexane extract contained alkaloids, steroids, and triterpenoids, whereas the ethyl acetate extract contained alkaloids, flavonoids, steroids, and triterpenoids. These findings indicate that solvent polarity plays an important role in extraction efficiency and selective recovery of bioactive compounds from papaya seeds.

Keywords: seeds, maceration, solvent polarity, extraction yield, phytochemical screening

1. INTRODUCTION

Medicinal plants represent an important source of bioactive compounds that can be developed for pharmaceutical, functional food, and natural health product applications. Plant secondary metabolites such as alkaloids, flavonoids, saponins, and tannins are known to exhibit diverse biological activities, making them attractive targets for extraction and chemical characterization studies. The efficiency of isolating bioactive compounds from natural materials is strongly influenced by extraction techniques and solvent selection, since solvent polarity determines the selectivity of compounds extracted from plant matrices.

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Papaya *(Carica papaya L.)* is a tropical medicinal plant widely recognized for its various biological properties. Papaya seeds have been reported to contain several secondary metabolites including alkaloids, flavonoids, saponins, tannins, and the alkaloid carpain, which are associated with multiple biological activities, including antiparasitic and anthelmintic effects.[1] Previous studies demonstrated that papaya seed extracts exhibited biological activity against nematode parasites, highlighting their potential as a natural source of bioactive compounds.[2,3] However, the biological activity of plant extracts is closely related to their chemical composition, which depends largely on the extraction process.

The effectiveness of extracting secondary metabolites is highly dependent on solvent polarity. Non-polar solvents such as hexane preferentially extract lipophilic compounds, whereas semi-polar solvents such as ethyl acetate dissolve compounds with intermediate.[4] Differences in solvent polarity may therefore lead to variations in extraction yield as well as phytochemical profiles obtained from plant materials. Consequently, preliminary chemical characterization through determination of extraction yield and phytochemical screening becomes an essential step to understand the distribution of secondary metabolites within plant extracts.[5]

Based on these considerations, this study aims to evaluate the chemical characteristics of papaya seed extracts obtained using hexane and ethyl acetate solvents through determination of extraction yield and phytochemical screening analysis. It is hypothesized that differences in solvent polarity will influence both the quantity of extract obtained and the types of secondary metabolites extracted. The extraction process was carried out using the maceration method, which allows solvent diffusion into the plant matrix and promotes selective extraction of bioactive compounds according to polarity compatibility principles.[6]

2. EXPERIMENTAL

2.1. Chemicals, Equipment and Instrumentation

The plant material used in this study was papaya seeds *(Carica papaya L.)*. The extraction solvents consisted of n-hexane (C_6H_{14}) and ethyl acetate ($C_4H_8O_2$). Distilled water was used for washing and preparation processes. Phytochemical screening reagents included Liebermann–Burchard reagent for steroid and terpenoid identification, Mayer reagent and Wagner reagent for alkaloid detection, flavonoid test reagent, saponin test reagent, and tannin test reagent. The equipment used consisted of an analytical balance, blender, 80-mesh sieve, maceration container (glass jar), rotary evaporator, filter paper, glass funnel, beaker glass, Erlenmeyer flask, test tubes and test tube rack, and drop pipettes.

2.2. Research Procedure

2.2.1. Preparation of Papaya Seeds

Sample preparation began with the collection of mature papaya seeds *(Carica papaya L.)*. The seeds were separated from the fruit pulp and washed thoroughly with running water to remove adhering mucilage and impurities. The cleaned seeds were air-dried at room temperature until the moisture content decreased. The dried seeds were then ground using a blender to obtain powdered material and sieved through an 80-mesh sieve to achieve uniform particle size. The resulting papaya seed powder was stored in a tightly closed container protected from light prior to extraction.

2.2.2. Extraction of Papaya Seed

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Extraction was carried out using the maceration method with n-hexane and ethyl acetate as solvents. A known amount of papaya seed powder was placed into a glass maceration container and soaked in solvent at a sample-to-solvent ratio of 1:5 (w/v). The maceration process was conducted for 3 × 24 h at room temperature and protected from direct sunlight, with periodic stirring to enhance solvent penetration and extraction efficiency. After maceration, the mixture was filtered using filter paper to separate the filtrate from the residue. The obtained filtrate was concentrated using a rotary evaporator at approximately 40–50°C until a viscous extract was obtained. The hexane and ethyl acetate extracts were stored in sealed containers and labeled according to the solvent used.

2.2.3. Determination of Extraction Yield

The extraction yield was calculated by comparing the weight of the concentrated extract with the initial weight of papaya seed powder using the following equation:

$$\text{Yield (\%)} = (\text{weight of dried /sample weight of extract}) \times 100$$

2.2.4. Phytochemical Screening

Phytochemical screening was performed to identify secondary metabolite groups present in hexane and ethyl acetate extracts of papaya seeds, including alkaloids, flavonoids, saponins, tannins, steroids, and triterpenoids.

a Alkaloid Test (Mayer and Wagner Tests). The extract was treated with Mayer and Wagner reagents. Formation of a white precipitate with Mayer reagent or a brown/orange precipitate with Wagner reagent indicated the presence of alkaloids.

b Flavonoid Test (Shinoda Test). The extract was reacted with magnesium powder and concentrated HCl. The appearance of yellow, orange, or red coloration indicated the presence of flavonoids.

c Saponin Test (Foam Test). The extract was mixed with hot water and vigorously shaken. Formation of stable foam that persisted after acid addition indicated the presence of saponins.

d Tannin Test ($FeCl_3$ Test). Addition of $FeCl_3$ solution produced a dark blue or greenish coloration, confirming the presence of tannins.

e Steroid and Triterpenoid Test (Liebermann–Burchard Test). The extract was treated with glacial acetic acid followed by concentrated sulfuric acid. A red–orange color indicated triterpenoids, while a bluish-green color indicated steroids.

3. RESULTS AND DISCUSSION

3.1. Extraction Yield of Papaya Seed Extracts

The extraction process of papaya seeds using the maceration method produced different yield values for each solvent. This difference was influenced by the ability of each solvent to dissolve secondary metabolites according to its polarity level. The polarity compatibility principle (like dissolves like) explains that chemical compounds dissolve more readily in solvents with similar polarity characteristics.[7]

Table 1. Percentage yield of papaya seed extracts

Solvent	Sample Weight (g)	Extract Weight (g)	Yield (%)

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n-Hexane	50	25	50
Ethyl acetate	50	27	54

The ethyl acetate extract showed a higher yield compared to the n-hexane extract. Ethyl acetate, a semipolar solvent, is capable of dissolving both lipophilic compounds and certain semi-polar compounds, resulting in a greater extract quantity.[6] In contrast, n-hexane as a nonpolar solvent tends to extract hydrophobic compounds such as lipids and terpenoids, making the extracted components more selective.[8] The difference in extraction yield indicates that solvent selection is a crucial factor in optimizing the extraction of bioactive compounds from natural materials.[9]

3.2. Phytochemical Screening of Papaya Seed Extracts

3.2.1. Phytochemical Screening of n-Hexane Extract

Table 2. Phytochemical screening results of n-hexane papaya seed extract

Compound Group	Result	Description
Alkaloids	+	Weak white precipitate
Flavonoids	−	No color change
Saponins	−	No stable foam formation
Tannins	−	No $FeCl_3$ color change
Steroids	+	Weak bluish-green coloration
Triterpenoids	++	Clear reddish-brown coloration

Note: − : Not detected, + : Weak positive, ++ : Positive, +++ : Strong positive.[2]

The phytochemical screening results indicated that the n-hexane extract contained alkaloids, steroids, and triterpenoids. The dominance of steroid and triterpenoid compounds is associated with the nonpolar nature of the solvent, which effectively dissolves lipophilic compounds and terpene components.[10] The absence of flavonoids, saponins, and tannins suggests that these compounds possess higher polarity and are therefore less soluble in nonpolar solvents. The distribution of secondary metabolites during extraction is strongly influenced by polarity interactions between the solvent and target compounds.[11]

3.2.2. Phytochemical Screening of Ethyl Acetate Extract

Table 3. Phytochemical screening results of ethyl acetate papaya seed extract

Compound Group	Result	Description
Alkaloids	++	Clear white precipitate
Flavonoids	+	Weak orange coloration
Saponins	−	No stable foam formation
Tannins	−	No color change
Steroids	++	Clear bluish-green coloration
Triterpenoids	+	Weak reddish-brown coloration

Note: − : Not detected, + : Weak positive, ++ : Positive, +++ : Strong positive.[2]

The ethyl acetate extract demonstrated greater diversity of secondary metabolites compared to the n-hexane extract. In addition to alkaloids and steroids, flavonoids were also detected in this extract. Semipolar

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solvents are known to extract compounds within an intermediate polarity range, thereby increasing the number of dissolved metabolites.[6] Flavonoids are phenolic compounds widely reported to possess biological activities such as antioxidant and antiparasitic effects; therefore, their presence may contribute to the biological activity of papaya seed extracts.[12]

3.3. Relationship Between Extraction Yield and Phytochemical Profile

Differences in extraction yield were consistent with variations in the obtained secondary metabolite profiles. The higher yield observed in the ethyl acetate extract correlated with a more diverse group of compounds compared to the n-hexane extract. This finding confirms that solvent polarity variation affects both the quantity and quality of bioactive compounds extracted from natural materials.[9] In general, the n-hexane extract was more selective toward nonpolar compounds such as steroids and triterpenoids, whereas ethyl acetate was able to extract additional semi-polar compounds including flavonoids and alkaloids. This chemical profile provides a scientific basis for further investigation of the biological activity of papaya seed extracts.

4. CONCLUSION

This study demonstrated that the maceration method using solvents with different polarity levels produced varying extraction yields, namely 50% for the hexane extract and 54% for the ethyl acetate extract. Phytochemical screening revealed that the hexane extract contained alkaloids, steroids, and triterpenoids, whereas the ethyl acetate extract contained alkaloids, flavonoids, steroids, and triterpenoids. The differences in bioactive compound profiles were influenced by the polarity characteristics of the solvents used during the extraction process.

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