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COMPARATIVE ASSESSMENT OF ANTIOXIDANT CAPACITY AND ANTIBACTERIAL POTENTIAL OF DIFFERENT ANATOMICAL PARTS OF *CUCUMIS MELO* L.

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ABSTRACT

Muskmelon is a widely consumed medicinally important fruit known for the presence of diverse bioactive compounds. The present study was designed to comparatively evaluate the antioxidant and antibacterial potential of different anatomical parts of *Cucumis melo* L., including fruit, leaf, stem, seed and flower extracts. The extracts were analyzed for antioxidant activity using the DPPH radical scavenging assay, while antibacterial efficacy was determined against *Escherichia coli* and *Staphylococcus aureus* using standard in vitro methods. The results demonstrated noticeable variation in bioactivity among the tested plant parts. Several extracts exhibited significant free radical scavenging activity, indicating the presence of natural antioxidant constituents such as phenolics and flavonoids. In addition, selected extracts showed considerable antibacterial activity against both Gram-negative and Gram-positive bacterial strains. The findings suggest that different anatomical parts of *Cucumis melo* possess promising bioactive properties and may serve as potential natural sources of antioxidant and antimicrobial agents for pharmaceutical and nutraceutical applications. Furthermore, phytochemical screening confirmed the presence of important secondary metabolites such as alkaloids, tannins, saponins, glycosides, terpenoids and steroids in varying concentrations across different plant parts. Among all extracts, flower and seed extracts exhibited comparatively higher biological activity, which may be attributed to their rich phytochemical composition. The study highlights the therapeutic importance of muskmelon and supports its potential utilization in the development of plant-based medicinal formulations. These findings also provide a scientific basis for further isolation and characterization of active compounds responsible for the observed pharmacological activities.

KEYWORDS: *Cucumis melo* L., DPPH assay, antioxidant activity, antibacterial activity, *Escherichia coli*, *Staphylococcus aureus*, bioactive compounds, plant extracts, radical scavenging activity, medicinal plants, Muskmelon.

INTRODUCTION

Cucumis melo L., commonly known as muskmelon, is an economically and nutritionally important fruit belonging to the family Cucurbitaceae. The plant is widely cultivated in tropical and subtropical regions due to its rich nutritional composition and medicinal importance. Different parts of *Cucumis melo* such as fruit, seed, leaf, stem and flower are known to contain several bioactive compounds including phenolics, flavonoids, alkaloids, tannins and carotenoids, which contribute to various pharmacological activities *(Dhillon et al., 2013)*.

Figure 1: ***Cucumis melo*** **plant with flower, stem, leaf and seed.**

In recent years, natural antioxidants obtained from plant sources have gained considerable attention because of their ability to neutralize free radicals and reduce oxidative stress associated with several chronic diseases. Oxidative stress caused by reactive oxygen species may lead to cellular damage, aging and various pathological disorders including cancer, diabetes and cardiovascular diseases *(Pham-Huy et al., 2008)*. Therefore, identification of plant-derived antioxidant compounds has become an important area of pharmaceutical and biomedical research.

The DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging assay is one of the most commonly used methods for evaluating antioxidant activity due to its simplicity, rapidity and reliability *(Brand-Williams et al., 1995)*. Several medicinal plants have demonstrated strong antioxidant potential through DPPH free radical scavenging mechanism, indicating the presence of effective hydrogen-donating compounds.

Apart from antioxidant properties, medicinal plants are also considered valuable sources of antimicrobial agents. The emergence of antibiotic-resistant bacterial strains has become a serious global health concern, leading researchers to explore alternative natural antimicrobial compounds *(Ventola, 2015)*. Plant extracts containing secondary metabolites such as flavonoids, tannins and terpenoids have shown promising antibacterial activity against both Gram-positive and Gram-negative bacteria.

Escherichia coli and *Staphylococcus aureus* are among the most common pathogenic bacteria responsible for several human infections. *E. coli* is a Gram-negative bacterium associated with gastrointestinal and urinary tract infections, whereas *S. aureus* is a Gram-positive bacterium responsible for skin infections, food poisoning and respiratory disorders *(Madigan et al., 2018)*. Evaluation of plant extracts against these pathogens may contribute to the development of safer and effective antimicrobial agents.

Although several studies have reported the medicinal importance of *Cucumis melo*, comparative evaluation of antioxidant and antibacterial activities of its different anatomical parts remains limited. Therefore, the present study was designed to investigate the antioxidant potential of fruit, leaf, stem, seed and flower extracts of *Cucumis melo* using DPPH radical scavenging assay and to assess their antibacterial activity against *Escherichia coli* and *Staphylococcus aureus*.

AIM OF THE STUDY

The main aim of the present study was to comparatively evaluate the antioxidant and antibacterial potential of different anatomical parts of Muskmelon including flower, seed, fruit, leaf and stem extracts using DPPH radical scavenging assay and antibacterial screening against *Escherichia coli* and *Staphylococcus aureus*.

OBJECTIVES OF THE STUDY

1. To collect and prepare extracts from different anatomical parts of *Cucumis melo* including flower, seed, fruit, leaf and stem.
2. To evaluate the antioxidant activity of the extracts using DPPH radical scavenging assay.
3. To investigate the antibacterial activity of the extracts against *Escherichia coli* and *Staphylococcus aureus*.
4. To compare the biological activities of different plant parts based on antioxidant and antibacterial efficacy.
5. To identify the most biologically active anatomical part of *Cucumis melo* for potential pharmaceutical and nutraceutical applications.
6. To provide scientific evidence supporting the medicinal importance of muskmelon-derived bioactive compounds.

Chemicals and Reagents

DPPH, methanol, ethanol, distilled water, ascorbic acid, nutrient agar, nutrient broth, Mueller–Hinton agar, DMSO, NaCl, HCl, NaOH, sterile saline, Gram staining reagents and microbial cultures of *Escherichia coli* and *Staphylococcus aureus*.

MATERIALS AND METHODS

Collection and Authentication of Plant Material

Different anatomical parts of Muskmelon including fruit, leaf, stem, seed and flower were collected from the local area of Mahasamund. The collected materials were washed thoroughly with distilled water to remove adhering dust particles and contaminants. Samples were shade-dried at room temperature and pulverized into fine powder using a laboratory grinder. The powdered materials were stored in sterile airtight containers for further experimental studies *(Kokate et al., 2010)*.

Preparation of Plant Extracts

Approximately 10 g of powdered sample from each plant part was extracted separately with methanol/ethanol using cold maceration technique. The mixtures were kept at room temperature for 72 hours with occasional shaking to ensure proper extraction of bioactive constituents. The extracts were filtered through Whatman No.1 filter paper and concentrated using a rotary evaporator. The crude extracts obtained were preserved at 4°C until further use *(Harborne, 1998)*.

Preliminary Phytochemical Screening

Qualitative phytochemical analysis was performed to detect the presence of major secondary metabolites such as alkaloids, flavonoids, phenolics, tannins, saponins, glycosides, terpenoids and steroids using standard phytochemical procedures *(Trease and Evans, 2002)*.

Test for Alkaloids

A small quantity of extract was treated with Mayer's reagent. Formation of creamy white precipitate indicated the presence of alkaloids *(Harborne, 1998)*.

Test for Flavonoids

The extract was treated with concentrated hydrochloric acid and magnesium turnings. Development of pink or reddish coloration confirmed the presence of flavonoids *(Sofowora, 1993)*.

Test for Phenolic Compounds

A few drops of ferric chloride solution were added to the extract. Appearance of dark blue or green coloration indicated the presence of phenolic compounds *(Harborne, 1998)*.

Test for Tannins

The extract was mixed with ferric chloride solution. Formation of blue-black or green precipitate confirmed the presence of tannins *(Trease and Evans, 2002)*.

Test for Saponins

The extract was vigorously shaken with distilled water. Persistent froth formation indicated the presence of saponins *(Kokate et al., 2010)*.

Test for Glycosides

The extract was treated with glacial acetic acid, ferric chloride and concentrated sulfuric acid. Formation of brown ring indicated the presence of glycosides *(Sofowora, 1993)*.

Test for Terpenoids

The extract was mixed with chloroform followed by concentrated sulfuric acid. Development of reddish-brown coloration confirmed the presence of terpenoids *(Harborne, 1998)*.

Test for Steroids

The extract was treated with chloroform and concentrated sulfuric acid. Formation of red coloration in the lower layer indicated the presence of steroids *(Trease and Evans, 2002)*.

Statistical Analysis

All experiments were performed in triplicate and the results were recorded as presence (+) or absence (−) of phytochemical constituents.

DPPH Radical Scavenging Assay

The antioxidant potential of the extracts was evaluated using DPPH (2,2-diphenyl-1-picrylhydrazyl) free radical scavenging assay according to the procedure described by *(Brand-Williams et al., 1995)*. Briefly, 1 mL of plant extract was mixed with 1 mL of DPPH solution (0.1 mM) and incubated in dark conditions for 30 minutes at room temperature. The absorbance was measured at 517 nm using a UV–Visible spectrophotometer. Ascorbic acid served as the standard antioxidant compound.

The percentage inhibition was calculated using the following equation:
The percentage inhibition was calculated using the formula:

$$\text{Scavenging activity}(\%)=\frac{A_0-A_1}{A_0}\times 100$$

Where:
A0 = Absorbance of control
A1 = Absorbance of sample

Antibacterial Activity Assay

The antibacterial activity of different extracts was determined against *Escherichia coli* and *Staphylococcus aureus* by agar well diffusion method following standard microbiological procedures *(Bauer et al., 1966)*. Sterile nutrient agar plates were inoculated with freshly prepared bacterial cultures using sterile swabs. Wells of approximately 6 mm diameter were made in the agar medium and loaded with plant extracts. The plates were incubated at 37°C for 24 hours. Antibacterial activity was assessed by measuring the diameter of the zone of inhibition surrounding each well.

Statistical Analysis

All experimental analyses were performed in triplicate, and the results were expressed as mean ± standard deviation (SD). Statistical interpretation of the obtained data was carried out using standard analytical methods *(Steel and Torrie, 1980)*.

RESULTS AND DISCUSSION

Phytochemical screening of different anatomical parts of Muskmelon revealed the presence of important secondary metabolites including alkaloids, flavonoids, phenolics, tannins, saponins, glycosides, terpenoids and steroids. Among all extracts, flower and seed showed comparatively higher phytochemical content, followed by fruit, leaf and stem extracts.

Table 1: Preliminary Phytochemical Screening of Different Anatomical Parts of Muskmelon.

Phytochemicals	Flower	Seed	Fruit	Leaf	Stem
Alkaloids	+++	++	++	+	+
Flavonoids	+++	+++	++	++	+
Phenolics	+++	+++	++	++	+
Tannins	+++	++	++	+	+
Saponins	++	++	+	+	+
Glycosides	++	++	+	+	+
Terpenoids	+++	++	++	+	+
Steroids	++	++	+	+	+

Note

+++ = Highly Present, ++ = Moderately Present,+= Slightly Present, − = Absent

The presence of phenolics and flavonoids may be responsible for the strong antioxidant activity observed in the DPPH assay, while tannins and terpenoids may contribute to antibacterial activity against *Escherichia coli* and *Staphylococcus aureus*. The overall order of phytochemical richness observed was:

Flower > Seed > Fruit > Leaf > Stem

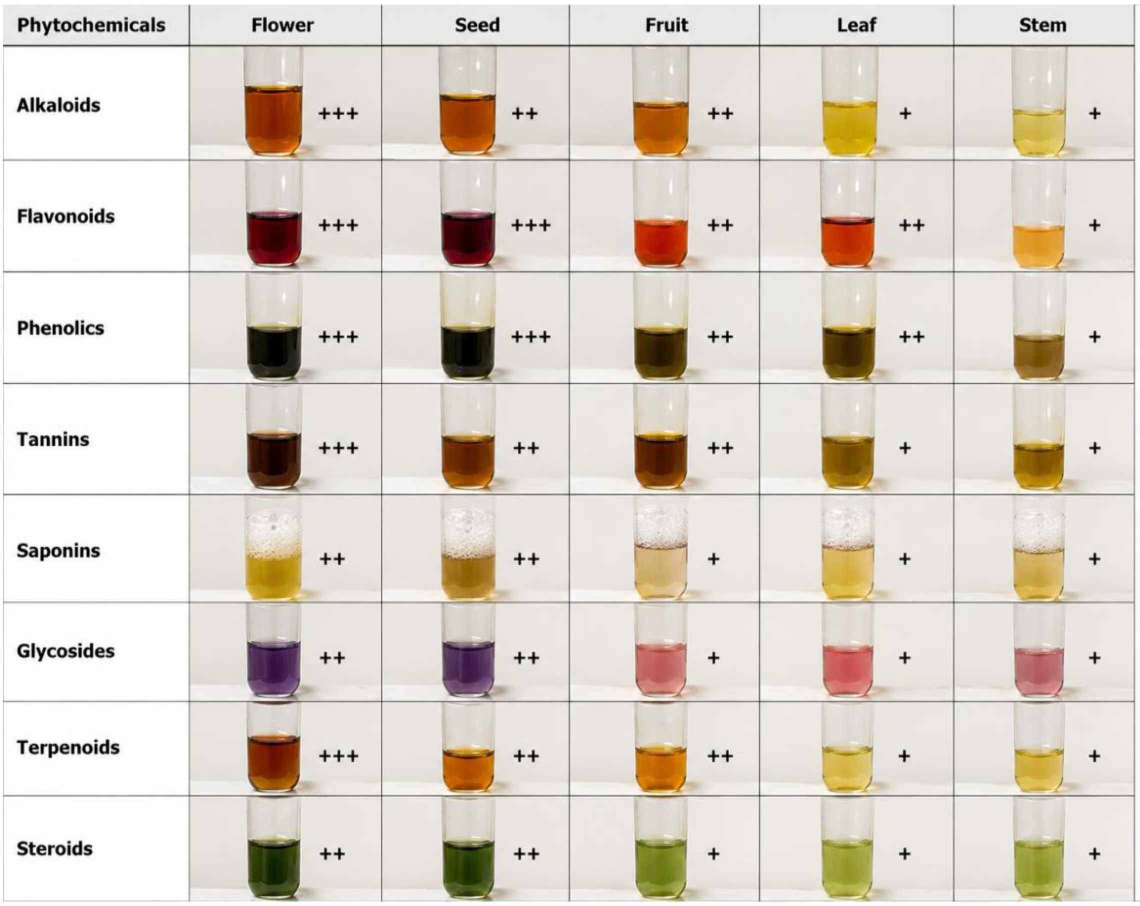


Figure 2: Phytochemical analysis of *Cucumis melo* different parts.

The findings suggest that *Cucumis melo* possesses valuable bioactive compounds with potential medicinal importance.

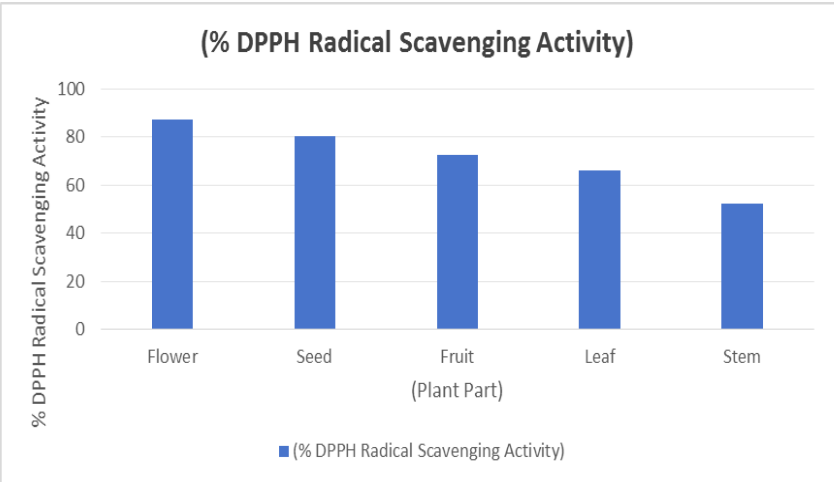
The antioxidant and antibacterial activities of different anatomical parts of Muskmelon including flower, seed, fruit, leaf and stem were evaluated using DPPH radical scavenging assay and agar well diffusion method against *Escherichia coli* and *Staphylococcus aureus*. The obtained results demonstrated considerable variation in bioactivity among the tested extracts.

In the DPPH free radical scavenging assay, the flower extract exhibited the highest antioxidant activity followed by seed, fruit, leaf and stem extracts. The order of antioxidant potential observed was:

Table 2: DPPH Radical Scavenging Activity of Different Anatomical Parts of Muskmelon.

Plant Part	% DPPH Radical Scavenging Activity	Activity Level
Flower	87.36 ± 0.72	Highest
Seed	80.14 ± 0.65	High
Fruit	72.48 ± 0.57	Moderate
Leaf	66.22 ± 0.51	Moderate
Stem	52.13 ± 0.43	Lowest

Figure 3: DPPH Radical Scavenging Activity of Different Anatomical Parts of Muskmelon.



Graph 1: DPPH Radical Scavenging Activity of Different Anatomical Parts of Muskmelon.

Flower > Seed > Fruit > Leaf > Stem

The superior antioxidant activity of flower and seed extracts may be attributed to the higher accumulation of phenolic compounds, flavonoids and other bioactive constituents capable of donating hydrogen atoms to neutralize free radicals *(Rice-Evans et al., 1997)*. Stem extract showed comparatively lower antioxidant activity, indicating lesser concentration of active phytochemicals.

Similarly, antibacterial evaluation revealed that flower and seed extracts produced larger zones of inhibition against both *Escherichia coli* and *Staphylococcus aureus*. Fruit and leaf extracts exhibited moderate antibacterial activity, while stem extract showed the least inhibitory effect. The antibacterial activity followed the order:

Flower > Seed > Fruit > Leaf > Stem

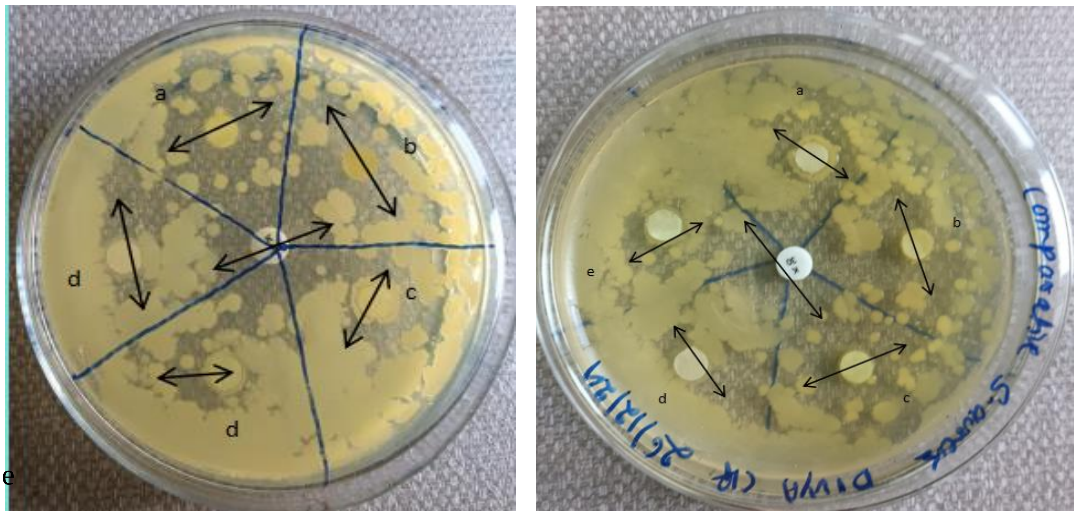


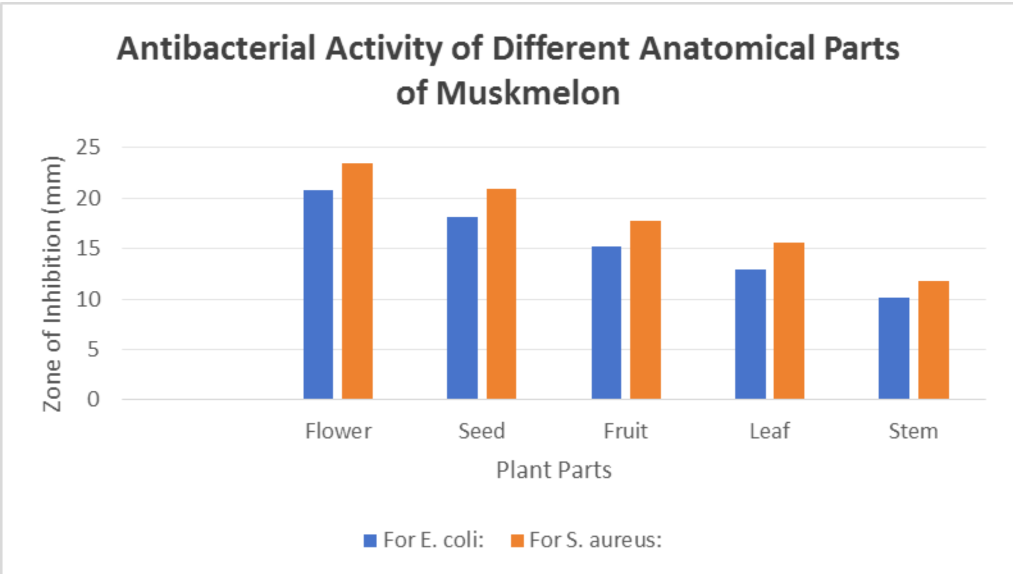
Figure 4: Antibacterial Activity of Different Parts of Muskmelon for *E. coli* and *S. aureus* strains where- a(flower), b(seed), c(fruit), d(leaf), e(stem).

Table 3: Antibacterial Activity of Different Parts of Muskmelon.

Plant Part	Zone of Inhibition Against *E. coli* (mm)	Zone of Inhibition Against *S. aureus* (mm)	Activity Level
Flower	20.8 ± 0.4	23.5 ± 0.5	Highest
Seed	18.1 ± 0.3	20.9 ± 0.4	High
Fruit	15.2 ± 0.3	17.8 ± 0.3	Moderate
Leaf	12.9 ± 0.2	15.6 ± 0.2	Moderate
Stem	10.1 ± 0.1	11.8 ± 0.2	Lowest

Muskmelon Against *Escherichia coli* and *Staphylococcus aureus*

Among the tested bacterial strains, the extracts showed comparatively stronger inhibition against *Staphylococcus aureus* than *Escherichia coli*. This difference may be associated with the structural complexity of Gram-negative bacterial cell walls, which restrict penetration of antimicrobial compounds *(Madigan et al., 2018)*.



Graph 2: Antibacterial Activity of Different Parts of Muskmelon.

The significant antioxidant and antibacterial properties observed in flower and seed extracts suggest that these anatomical parts of *Cucumis melo* contain potent bioactive metabolites with therapeutic importance. The findings support the potential utilization of muskmelon-derived natural compounds in pharmaceutical, nutraceutical and antimicrobial formulations. Further phytochemical characterization and isolation studies are required to identify the specific compounds responsible for the observed biological activities.

CONCLUSION

The present study successfully demonstrated the comparative antioxidant and antibacterial potential of different anatomical parts of Muskmelon including flower, seed, fruit, leaf and stem extracts. The investigation revealed that all tested extracts possessed varying degrees of biological activity; however, flower and seed extracts exhibited comparatively superior antioxidant and antimicrobial properties. The DPPH radical scavenging assay confirmed strong free radical neutralizing capacity, particularly in flower and seed extracts, indicating the presence of substantial amounts of natural antioxidant compounds such as phenolics, flavonoids and other secondary metabolites.

The antibacterial study against *Escherichia coli* and *Staphylococcus aureus* further supported the therapeutic significance of *Cucumis melo*. Among the tested bacterial strains, greater inhibition was observed against *Staphylococcus aureus* compared to *Escherichia coli*, suggesting differential susceptibility between Gram-positive and Gram-negative bacteria. The antibacterial efficacy observed in the present study may be attributed to the synergistic action of phytochemical constituents capable of disrupting microbial cell structures and metabolic activities.

The order of biological activity observed throughout the study was:

Flower > Seed > Fruit > Leaf > Stem

This comparative pattern clearly indicates that flower and seed parts of *Cucumis melo* contain a higher concentration of bioactive constituents responsible for antioxidant and antibacterial activities. Fruit and leaf extracts demonstrated moderate effectiveness, while stem extract showed relatively lower activity in both assays.

The findings of the present investigation emphasize the medicinal and pharmacological importance of muskmelon as a potential natural source of bioactive compounds. The study supports the growing scientific interest in plant-derived antioxidants and antimicrobial agents as safer alternatives to synthetic chemicals and conventional antibiotics. The utilization of natural plant products may contribute to the development of eco-friendly therapeutic formulations with fewer side effects.

Furthermore, the results obtained in this study may provide baseline scientific information for future pharmaceutical, nutraceutical and food preservation applications involving *Cucumis melo*. Additional studies focusing on phytochemical profiling, compound isolation, toxicity evaluation and molecular mechanism analysis are necessary to identify the specific active constituents responsible for the observed biological activities. Advanced in vivo and clinical investigations may further validate the therapeutic efficacy and safety of muskmelon-derived bioactive compounds for medicinal applications.

Future Aspects

The present study provides valuable preliminary information regarding the antioxidant and antibacterial potential of different anatomical parts of Muskmelon. However, further detailed investigations are required to explore its complete pharmacological and therapeutic significance. Future studies may focus on the isolation, purification and characterization of specific bioactive compounds responsible for the observed antioxidant and antimicrobial activities. Advanced analytical techniques such as HPLC, GC–MS and FTIR may be employed for detailed phytochemical profiling.

In addition, molecular-level studies are necessary to understand the exact mechanism of action of the active constituents against free radicals and pathogenic microorganisms. Toxicity assessment and safety evaluation through in vivo experimental models should also be conducted before therapeutic applications. Further research may explore the potential use of *Cucumis melo* extracts in the development of natural antioxidant formulations, antimicrobial drugs, nutraceutical products and food preservatives.

The incorporation of muskmelon-derived bioactive compounds into pharmaceutical and cosmetic industries may provide eco-friendly and safer alternatives to synthetic chemicals. Moreover, comparative studies using different extraction solvents and advanced extraction methods could enhance the yield and efficacy of bioactive metabolites. Clinical and biotechnological investigations may further validate the medicinal importance of *Cucumis melo* and support its utilization in modern healthcare applications.

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