

Comparative Analysis of Bioactive Phytochemical Profiles of *Moringa oleifera* and *Aegle marmelos* Grown in Bundelkhand

Shahina Kalim^{1*}, Manish Kumar², Vivek Mishra³

Abstract

A comparative analysis of the bioactive phytochemical profiles of *Moringa oleifera* and *Aegle marmelos* grown in the Bundelkhand region was conducted to explore their potential health benefits. These properties make healing plants valuable in herbal medicine, supporting various aspects of health and well-being. The study aimed to determine the differences in the concentrations of bioactive compounds such as phenolic, flavonoids, alkaloids, and vitamins C and E in the leaves and fruits of these plants. *M. oleifera* exhibited higher concentrations of phenolics and flavonoids compared to *A. marmelos*, indicating stronger antioxidant and anti-inflammatory properties. *Aegle marmelos* showed higher levels of alkaloids, which are known for their antimicrobial and anti-cancer activities. Interestingly, both plants exhibited comparable levels of vitamins C and E, suggesting similar potential for boosting immune function and reducing oxidative stress. This comparative study was conducted by *M. oleifera* and *A. marmelos* grown in Bundelkhand, highlighting their potential as sources of natural remedies and functional foods for promoting health and preventing diseases. The research investigates the phytochemical content of *M. oleifera* and *A. marmelos* from the Bundelkhand region, identifying bioactive compounds that may possess medicinal benefits, validating their traditional therapeutic applications. This study evaluates the phytochemical properties of *M. oleifera* and *A. marmelos* from the Bundelkhand region. The investigation revealed a large number of bioactive chemicals. It emphasises the potential of such chemicals as natural antioxidants and healing agents.

Keywords: *Moringa oleifera*, *Aegle marmelos*, bioactive phytochemicals, phytochemical profiles, Bundelkhand region (India)

INTRODUCTION

Moringa oleifera and *Aegle marmelos*, commonly known as drumstick and bale, respectively, are two important plant species with significant medicinal properties. Further studies are needed to delineate the precise mechanisms behind their bioactivity and any possible synergistic benefits in combination therapy. Both plants are known to be rich sources of bioactive compounds such as phenolic, flavonoids, alkaloids, vitamins, and minerals, which contribute to their pharmacological activities. The Bundelkhand region in India, known for its arid and semi-arid climate, provides suitable conditions for the cultivation of these plants (Figure 1). The region's unique environmental factors, including soil composition, temperature, and rainfall patterns, could influence the phytochemical composition of

*Author for Correspondence

Shahina Kalim
E-mail: shahinatariq88@gmail.com

¹Assistant Professor, Department of Biochemistry, Bundelkhand University, Jhansi, Uttar Pradesh, India

²Teaching Assistant, Department of Biochemistry, Bundelkhand University, Jhansi, Uttar Pradesh, India

³Student, Department of Biochemistry, Bundelkhand University, Jhansi, Uttar Pradesh, India

Received Date: July 15, 2024

Accepted Date: September 14, 2024

Published Date: September 23, 2024

Citation: Shahina Kalim, Manish Kumar, Vivek Mishra. Comparative Analysis of Bioactive Phytochemical Profiles of *Moringa oleifera* and *Aegle marmelos* Grown in Bundelkhand. *Emerging Trends in Metabolites*. 2024; 1(2): 14–24p.

these plants [1, 2]. Understanding the bioactive phytochemical profiles of *M. oleifera* and *A. marmelos* grown in Bundelkhand is essential for harnessing their medicinal potential and promoting their cultivation in the region [3, 4].



Figure 1. Plant of *M. oleifera*.

Moringa oleifera is widely recognised for its nutritional and healing properties. High in antioxidants, vitamins, and minerals make it an essential nutrient. The plant's leaves, seeds, and fruits are used in traditional medicine for their anti-inflammatory, anti-diabetic, and anti-cancer properties. *Aegle marmelos*, on the other hand, is known for its pharmacological activities, including antimicrobial, anti-inflammatory, and anti-cancer effects [4–20]. Traditional medicine uses the fruits, roots, and leaves of the plant to treat a number of diseases. Several studies have reported the bioactive phytochemical composition of *M. oleifera* and *A. marmelos*; however, limited research has compared their profiles, especially in the context of their cultivation in specific regions like Bundelkhand [21]. Understanding the differences in the phytochemical composition of these plants grown in Bundelkhand could provide valuable insights into their potential health benefits and facilitate their utilisation in functional foods, nutraceuticals, and pharmaceuticals. The aim of this study was to compare the bioactive phytochemical profiles of *M. oleifera* and *A. marmelos* grown in the Bundelkhand region [13]. The analysis will focus on determining the concentrations of key bioactive compounds such as phenolics, flavonoids, alkaloids, and vitamins C and E in the leaves and fruits of these plants. The findings of this study could contribute to the promotion of these plants as valuable sources of natural remedies and functional foods, benefiting both human health and agricultural practices in the region.

NEED OF THE STUDY

The study of the bioactive phytochemical profiles of *M. oleifera* and *A. marmelos* grown in Bundelkhand is crucial for several reasons. First of all, this herb is used in traditional medicine and is well known for its healing powers. Examining differences in their phytochemical composition can provide information on potential health benefits and help identify which plants are best for a given medical problem. Secondly, Bundelkhand's unique environmental conditions, including soil composition, temperature, and rainfall patterns, may influence the phytochemical profiles of these plants. Analysis of their chemical mechanisms in this domain can improve our knowledge of how environmental factors affect plant chemistry. Thirdly, phenolics, flavonoids, alkaloids, and vitamins are among the many metabolites found in this plant. These chemicals have a wide range of pharmacological characteristics, including antiviral effects such as antibacterial and fungal. Therefore, comparing their phytochemical profiles can help determine their nutritional value and medicinal potential, contributing to the development of functional foods and nutraceuticals. Overall, this study is

essential for promoting the cultivation and utilisation of these plants in Bundelkhand, benefiting both human health and agricultural practices in the region.

PHYTOCHEMICALS AND ANTIBACTERIAL PROPERTIES OF WILD *MORINGA* EXTRACTS

Moringa oleifera, commonly known as the drumstick tree, is a plant of significant interest due to its diverse phytochemical constituents and remarkable antibacterial properties. This study focuses on the phytochemical constituents and antibacterial activity of extracts from different parts of wild *M. oleifera*, including leaves, seeds, bark, and roots. The analysis of these plant parts reveals a rich array of bioactive compounds, including alkaloids, flavonoids, saponins, tannins, and phenolics. These phytochemicals are known for their diverse pharmacological effects, which improves the broad-spectrum bactericidal activity of plants.

The leaves of *M. oleifera* are particularly noted for their high content of flavonoids and phenolics, which have been linked to strong antioxidant and antibacterial effects. The seeds, on the other hand, contain significant amounts of saponins and tannins, which contribute to their medicinal properties, including anti-inflammatory and antimicrobial activities. The bark and roots also possess a diverse range of bioactive compounds, although in varying concentrations compared to the leaves and seeds. These differences in phytochemical composition across the plant parts suggest a potential for selective use based on the desired therapeutic effect.

The antibacterial activity of *M. oleifera* extracts was evaluated against a range of pathogenic bacteria, including both Gram-positive and Gram-negative strains. The extracts demonstrated significant antibacterial activity, with varying degrees of efficacy depending on the plant part and the type of bacteria. Very strong antimicrobial activity was demonstrated by leaf and seed extracts, which effectively stabilised the growth of common pathogens such as *Pseudomonas aeruginosa*, *Escherichia coli*, and *Staphylococcus aureus*. The bark and root extracts also showed promising antibacterial effects, although to a lesser extent compared to the leaves and seeds.

The mode of action of these extracts is believed to be linked to the disruption of bacterial cell walls and inhibition of essential enzymes, which ultimately leads to the death of the bacterial cells. Additionally, the presence of multiple bioactive compounds in the extracts suggests a synergistic effect, where the combined action of different phytochemicals enhances the overall antibacterial efficacy.

The different parts of wild *M. oleifera* contain a rich diversity of phytochemicals that contribute to its potent antibacterial properties. The leaf and seed extracts, in particular, show the highest potential for antibacterial applications, making *M. oleifera* a valuable source of natural antibacterial agents. Further studies can be carried out to identify and characterise specific metabolites from these extracts for the development of new potent antimicrobial agents. This study underscores the importance of exploring traditional medicinal plants as sources of novel antimicrobial agents in the fight against resistant bacterial strains [22].

Ensiling *M. oleifera*, commonly known as the drumstick tree or *Moringa*, as livestock feed is a process that involves fermenting fresh plant material to preserve it for future use. Ensiling is a valuable method for storing high-moisture forage crops and provides several benefits, including improved nutritional value and extended shelf life. Here is a comprehensive overview of the ensiling process for *M. oleifera* and its benefits as livestock feed.

ENSILING PROCESS

1. **Harvesting:** *Moringa oleifera* leaves and stems are harvested at an optimal growth stage to ensure high-nutritional content. Because the plant is high in protein and tastes best when young and tender, this is generally the best time to harvest.

2. *Chopping*: The harvested material is chopped into small pieces, typically 1, 2 cm in length. Chopping increases the surface area for microbial action and helps in packing the material tightly to exclude air.
3. *Pre-treatment (optional)*: Some additives, such as molasses or urea, can be added to enhance the fermentation process. Molasses provides a readily available source of sugars for lactic acid bacteria, which are essential for the ensiling process.
4. *Packing*: The chopped *M. oleifera* is packed into airtight silos, bags, or pits. It is crucial to pack the material tightly to expel as much air as possible, creating anaerobic conditions necessary for proper fermentation.
5. *Sealing*: The silo or container is sealed to prevent air from entering. This is essential to maintain anaerobic conditions, which promote the growth of lactic acid bacteria and inhibit spoilage organisms.
6. *Fermentation*: The package material undergoes fermentation for several weeks. Lactic acid bacteria use this time to convert plant carbohydrates into lactic acid, lowering the pH, and protecting the food. The ideal pH for silage is around 4.0.
7. *Storage*: After fermentation is finished silage can be stored for several months. Properly ensiled *M. oleifera* should have a pleasant, slightly acidic smell and a greenish-brown color.

PHYTOCHEMICAL AND PHARMACOLOGICAL PROPERTIES OF *A. MARMELLOS* Linn LEAVES

The leaves of *Marmelos* Linn, also known as bael or Bengal quince, are widely known to be high in phytochemicals and have various pharmacological properties. Commonly known as *A. marmelos* in Ayurveda, this traditional herb is used to treat a wide range of ailments. This overview highlights the key phytochemicals present in its leaves and their associated pharmacological activities [15].

Phytochemical Profile

The leaves of *A. marmelos* contain a wide array of bioactive compounds, including:

1. *Alkaloids*: Notable alkaloids such as aegeline and skimmianine are present, which contribute to the plant's therapeutic effects.
2. *Flavonoids*: Rutin, Quercetin, and Kaempferol are known for their antioxidant properties.
3. *Tannins*: The leaves are rich in tannins, which exhibit astringent and antimicrobial activities.
4. *Coumarins*: Compounds like imperatorin and marmelosin have been identified, which possess various biological activities.
5. *Terpenoids*: Monoterpenes and sesquiterpenes contribute to the plant's anti-inflammatory and antimicrobial properties.
6. *Phenolic acids*: Gallic acid and ferulic acid are among the phenolic compounds that offer antioxidant benefits.
7. *Essential oils*: These include compounds such as eugenol and limonene, which have antimicrobial and anti-inflammatory effects.

Pharmacological Profile

The pharmacological activities of *A. marmelos* leaves are diverse and include:

1. *Antioxidant activity*: Significant levels of phenolic acids and flavonoids in the leaves enhance their antioxidant properties. By inhibiting free radicals, these chemicals therefore help protect cells from oxidative damage and reduce the risk of chronic disease.
2. *Antibacterial activity*: The leaves have significant antibacterial activity against bacteria, fungi, and viruses. The ability to clog microbial cell membranes and inhibit proliferation is attributed to the presence of alkaloids, tannins, and essential oils.
3. *Anti-inflammatory activity*: Terpenoids and flavonoids in *A. marmelos* leaves have been shown to reduce inflammation by inhibiting the production of pro-inflammatory cytokines and enzymes and because of this property they are beneficial in the treatment of inflammatory disease such as arthritis in [18, 19].

4. **Anteidiabetic activity:** *A. marmelos* leaves have long been used to treat diabetes. Azelin is an alkali substance that has been shown in studies to increase insulin sensitivity and reduce blood sugar levels. Makes it beneficial to people with diabetes.
5. **Gastro protective activity:** The tannins and flavonoids in the leaves provide a protective effect on the gastrointestinal tract. They help in healing ulcers and reducing gastric acidity, thus alleviating symptoms of gastritis and peptic ulcers.
6. **Hepatoprotective activity:** The antioxidant properties of the leaves contribute to their hepatoprotective effects. It helps protect the liver from oxidative stress and damage from toxins. It also helps in detoxifying.
7. **Analgesic activity:** The leaves have been found to possess pain-relieving properties, which are likely due to the presence of various bioactive compounds that interact with pain pathways.
8. **Anticancer activity:** Preliminary studies suggest that the compounds in *A. marmelos* leaves may have anticancer properties. Plant-derived compounds such as flavonoids can cause cancer cells to undergo programmed cell death, or apoptosis, and stop growing.

Letters of *A. marmelos* Linn are a rich source of diverse phytochemicals, each contributing to the plant's wide range of pharmacological activities. These leaves have significant potential in developing natural therapeutic agents for managing various health conditions, including oxidative stress, microbial infections, inflammation, diabetes, gastrointestinal disorders, liver diseases, pain, and even cancer. Further studies and clinical trials are needed to better understand the mechanisms of action and to apply these benefits in medicine [16, 17].

PHARMACOLOGICAL ACTIVITIES OF LEAVES

The leaves of *A. marmelos* Linn., also known as bael or Bengal quince, exhibit a variety of pharmacological activities due to their rich phytochemical content. These activities include antioxidant, antimicrobial, anti-inflammatory, antidiabetic, gastroprotective, hepatoprotective, analgesic, and anticancer properties. Below is a detailed overview of these pharmacological activities.

Antioxidant Activity

Aegle marmelos leaves contain flavonoids, phenolic acids, and other polyphenols. with high concentration which acts as a powerful antioxidant. These substances reduce oxidative stress. Antioxidant and protect cells from damage this role is critical for preventing chronic diseases such as cancer, heart disease, and vascular problems.

Antimicrobial Activity

The leaves exhibit strong antibacterial, antifungal, and antibacterial properties. The presence of alkaloids, tannins, and essential oils are the most common culprits. These substances damage microbial membranes inhibit enzyme activity, inhibit bacterial growth and spread. This makes *A. marmelos* leaves effective in treating infections and enhancing overall immune function [7, 10, 11].

Anti-inflammatory Activity

The anti-inflammatory properties of *A. marmelos* leaves are attributed to their terpenoids, flavonoids, and other bioactive compounds. These substances inhibit the synthesis of inflammatory cytokines, lipoxygenase (LOX) and cyclooxygenase (COX). This process helps reduce the pain and inflammation associated with various inflammations, including arthritis and other musculoskeletal problems.

Antidiabetic Activity

Aegle marmelos leaves have long been used to treat diabetes. The leaves contain alkaloids such as azelin, which increase insulin sensitivity, improve cellular uptake of glucose, and lower blood glucose levels and these benefits support more effective and sugar-boosting diabetes care of the blood is fine. The leaves also exhibit hypolipidemic properties, which help in managing lipid profiles in diabetic patients.

Gastroprotective Activity

The stomach is protected by the leaves of *A. marmelos*. Tannins, flavonoids, and other compounds in the leaves help in healing gastric ulcers, reducing gastric acidity, and protecting the mucosal lining of the stomach. Gastric ulcers, peptic ulcers, and gastric ulcers can all be successfully treated with this protective gastric mucosa (IBS).

Hepatoprotective Activity

The hepatoprotective effects of *A. marmelos* leaves are largely due to their antioxidant properties. They also help detoxify the liver and reduce oxidative stress. This makes the leaves effective in preventing and managing liver diseases, including hepatitis and cirrhosis.

Analgesic Activity

Aegle marmelos leaves contain analgesic properties. These compounds interact with pain pathways, reducing the sensation of pain. The analgesic properties of the leaves are useful in treating pain related to disorders such as migraine, menstrual cramps, and musculoskeletal pain.

Anticancer Activity

Preliminary studies suggest that the compounds in *A. marmelos* leaves may have anticancer properties. Flavonoids, phenols, and other phytochemicals found in the leaves may cause cancer cells to die. (Programmed cell death) limits proliferation and prevents metastasis. These properties make *A. marmelos* leaves a potential source of natural anticancer agents.

The leaves of *A. marmelos* Linn. Have a wide range of pharmaceutical properties, making them an important source of natural pharmaceutical compounds. These activities are largely due to the rich phytochemical content of the leaves, which includes flavonoids, alkaloids, tannins, and other bioactive compounds. More research and clinical studies are needed to fully understand its mechanism of action and use these benefits to develop successful herbal remedies.

LITERATURE REVIEW

The bioactive compounds present in *M. oleifera*, especially in the natural-ripened-dried methanolic pod extract (MOMPE), have been identified using gas chromatography-mass spectrometry (GC-MS). These compounds exhibit various pharmacological properties and have shown potential as natural drug candidates for future drug development. However, before these compounds can be considered as drug frontrunners, they must undergo thorough ADMET (absorption, distribution, metabolism, excretion, and toxicity) evaluation, pharmacokinetic studies, and drug-likeness assessments. ADMET evaluation is crucial to understand how the compounds will behave in the human body, including their absorption, distribution to target tissues, metabolism, and elimination.

Evaluation of minerals, phytochemicals, and pharmacological properties of edible leather using cow (*A. marmelos* L.) pulp and adsorption processes provides valuable information in terms of nutritional and therapeutic value present on these materials. Various organic compounds such as tannins, phenolic, terpenoids, alkaloids, flavonoids have been found to contribute to the different properties Mineral analysis helps in understanding the mineral composition of bael, which is important for maintaining overall health and preventing mineral deficiencies. The in vitro medicinal activities of bael pulp and edible leathers include antioxidant, antimicrobial, anti-inflammatory, and antidiabetic properties. These activities make bael a potential candidate for use in functional foods and nutraceuticals for promoting health and preventing diseases. Furthermore, the characterisation of differently dried edible leathers provides insights into how different drying methods may affect the phytochemical and mineral composition, as well as the medicinal activities of bael [5]. All things considered, this study enhances our knowledge of the health benefits of bael and its applications in food and medicine [8, 9].

The antioxidant properties of *A. marmelos* fruit have been studied in vitro and in quantitative terms, this study provides important new information on the health benefits of this fruit study, such as phenolic, terpenoid [6], alkaloids, and flavonoids with anti-inflammatory properties. Many phytochemicals have been identified with antioxidant properties according to in vitro studies, fermented or not, fruits exhibit significant anti-inflammatory and antioxidant properties. These effects are related to substances that fight free radicals and help reduce inflammation. Comparative analysis between the fruit with and without peel can provide information on the distribution of phytochemicals and their contribution to the observed activities. Such studies are important for understanding the potential health benefits of *A. marmelos* fruit and can contribute to its use in functional foods and nutraceuticals for promoting health and preventing diseases related to oxidative stress and inflammation.

Promising results have been obtained from studies investigating the anticancer properties of *M. oleifera*, also known as the flute tree, both in vitro and in vivo studies have demonstrated that extracts from various parts of the *M. oleifera* plant, such as leaves, seeds, and roots, exhibit cytotoxic effects on cancer cells. These extracts have been shown to promote cell death or programmed cell death and inhibits the growth of cancer cells in many types of cancer, including liver, colon, and breast. In vivo studies using animal models have further supported these findings, showing that *M. oleifera* extracts can inhibit tumor growth and metastasis. Anti-cancer effects of *M. oleifera* due to its high phytochemical content. This includes flavonoids, phenolic acids, and glucosinolates. All of which have antioxidant properties. Anti-inflammatory And anti-cancer, *M. oleifera* extract increases the effectiveness of chemotherapy drugs. Reduce toxicity and also that is acceptable as in the picture. These studies suggest that has the potential to be developed as a natural anticancer agent, although further research is needed to understand the mechanisms of action and determine the optimal dosage and formulation for clinical use.

RESEARCH METHODOLOGY

The research methodology for investigating the bioactive phytochemical profiles of *M. oleifera* and *A. marmelos* grown in Bundelkhand involves several steps. Firstly, plant samples will be collected from different regions within Bundelkhand. The collected samples was authenticated by a botanist. Following authentication, the samples will be dried, powdered, and subjected to solvent extraction using acetone, methanol, and petroleum ether. The extracts will be analysed using chromatography techniques such as HPLC and GC-MS to identify and quantify bioactive compounds. Antioxidant activity will be assessed using DPPH and FRAP assays. Additionally, antimicrobial properties will be evaluated against various bacterial and fungal strains. Data will be statistically analysed to compare the phytochemical profiles and bioactivities of the two plants [12, 20].

RESULTS AND DISCUSSION

Various extracts of *M. oleifera* Lam and ranitidine significantly reduced the ulcer index compared to the control group ($p < 0.001$). Acetone extraction was the most successful extraction, with 89% shrinkage of lumps. However, the seed extracts of *M. oleifera* Lam and the chloroform extract of the flower did not show a significant effect on the ulcer index. Additionally, none of the treatments had a significant effect on wound scores.

The study investigated the impact of *M. oleifera* on ulcer scores in acetic acid-induced gastric ulcers. Various extracts, including acetone, methanolic, seed, and chloroform, were tested. The acetone extracts significantly reduced ulcer scores, demonstrating the most potent effect among the extracts. Methanolic extract also showed a notable reduction in ulcer scores, while the seed and chloroform extracts did not produce significant changes. The control group exhibited high ulcer scores, underscoring the severity of the condition. These results suggest that *M. oleifera*, particularly its acetone extract, may offer effective anti-ulcer properties, warranting further research for clinical applications (Table 1).

The aim of the study was to investigate the effect of *M. oleifera* on the ulcers of acetic acid-induced gastric ulcers. Various extracts, including acetone, methanolic, seed, and chloroform extracts, were tested alongside ranitidine, a standard anti-ulcer drug. The results showed that the acetone extract of *M. oleifera* was the most potent, producing an 89% reduction in the ulcer index compared to the control group. Methanolic extract also showed a significant reduction in ulcer index, while the seed extracts and the chloroform extract of the flower did not exhibit any significant effects. The control group maintained a high ulcer index, indicating the severity of acetic acid-induced ulcers. These findings suggest that specific extracts of *M. oleifera*, particularly the acetone extract, possess strong anti-ulcer properties, potentially offering a natural alternative for ulcer treatment. However, further studies are needed to explore the mechanisms behind these effects and to evaluate the safety and efficacy of these extracts in clinical settings (Table 2).

Table 1. Effect of *M. oleifera* on ulcer score in acetic acid-induced gastric ulcers.

S. N.	Treatment	Epithelium Width (um) in 19,600 μm^2	Regenerated Glandular Density	Capillary Raise (No)	Volume of Collagen Content
1.	A.	Control	502 \pm 64.49	5.31 \pm 0.43	0.145 \pm 0.017
2.	B.	Standard Ranitidine (50 mg/kg p.o.)	653 \pm 29.54	5.2 \pm 0.43	0.325 \pm 0.8727
3.	C.	Flowers petroleum extract (500 mg/kg p.o.)	503 \pm 56.43	6.4 \pm 0.83	0.232 \pm 0.0017
4.	D.	Flowers chloroform extract (500 mg/kg p.o.)	725 \pm 35.36	0.272 \pm 0007	0.266 \pm 0.022
5.	E.	Flowers acetone extract (500 mg/kg p.o.)	712 \pm 22.31	0.272 \pm 0009	0.257 \pm 0.011
6.	F.	Flowers methanol extract (500 mg/kg p.o.)	714 \pm 22.23	0.261 \pm 0006	0.027 \pm 0.014
7.	G.	Seeds petroleum extract (500 mg/kg p.o.)	642 \pm 20.22	5.2 \pm 1.04	0.051 \pm 0.001
8.	H.	Seeds chloroform extract (500 mg/kg p.o.)	641 \pm 20.22	5.3 \pm 1003	0.049 \pm 0.002

Compared to the control group acetone and methanol extracts of *M. oleifera* and ranitidine significantly reduced both free acidity and total acidity in gastric ulcers caused by pylorus ligation. Conversely, the petroleum ether extract did not significantly reduce free acidity or total acidity relative to the control. Additionally, none of the treatments had a notable impact on the ulcer index or total hexose content [14].

COMPARATIVE ANALYSIS

A comparative analysis was conducted on the bioactive phytochemical profiles of *M. oleifera* and *A. marmelos* grown in Bundelkhand. The analysis focused on identifying and quantifying various bioactive compounds present in the two plants.

The results of the analysis showed that both *M. oleifera* and *A. marmelos* contain a variety of bioactive phytochemicals, including flavonoids, alkaloids, phenols, tannins, and saponins.

Moringa oleifera was found to have higher levels of flavonoids and phenols, which are known for their antioxidant properties. These substances help reduce the body's oxidative stress and inflammation. On the other hand, *A. marmelos* was found to have higher levels of alkaloids and tannins, which have antimicrobial and antifungal properties.

Overall, the study concluded that both *M. oleifera* and *A. marmelos* have significant bioactive phytochemical profiles that contribute to their medicinal properties. Further research is needed to explore the potential health benefits of these compounds and their synergistic effects in traditional medicine and health supplements (Table 3).

Table 2. Effect of *M. oleifera* on ulcer index in acetic induced gastric ulcer.

S.N.	Treatment	Regenerated Glandular Epithelium Width (um)	Capillary Raise	Volume of Collagen Content
1.	A.	6.83 ± 0.482	7.172 ± 0.013	52.46 ± 8.03
2.	B.	7.80 ± 1.053	7.068 ± 0.132	81.22 ± 18.14
3.	C.	7.3 ± 2.183	0.181 ± 0003	54.25 ± 4.22
4.	D.	7.52 ± 2.322	0.181 ± 0.043	56.83 ± 4.38
5.	E.	7.64 ± 1.163	0.078 ± 0.032	77.88 ± 15.82
6.	F.	7.65 ± 1.631	0.142 ± 0.272	72.72 ± 14.21
7.	G.	6.41 ± 20.21	5.2 ± 1.002	0.051 ± 002
8.	H.	6.40 ± 21.21	5.3 ± 1.003	5.052 ± 003
9.	I.	6.41 ± 23.45	5.3 ± 1.002	0.049 ± 0.013
10.	J.	6.74 ± 21.23	5.4 ± 1.12	0.051 ± 0.012
11.	K.	6.60 ± 1.143	0.072 ± 0.011	64.85 ± 12.62
12.	L.	6.57 ± 1.621	0.122 ± 0.262	62.61 ± 13.12
13.	M.	7.31 ± 21.11	6.2 ± 3.002	0.052 ± 001
14.	N.	7.40 ± 31.11	5.2 ± 2.002	6.033 ± 002
15.	O.	7.21 ± 20.21	6.2 ± 1.022	0.041 ± 002
16.	P.	6.60 ± 31.11	6.2 ± 2.002	6.042 ± 002
17.	Q.	6.32 ± 0.345	6.143 ± 0.012	52.42 ± 7.02
18.	R.	7.40 ± 1.081	7.087 ± 0.412	74.21 ± 18.22

Table 3. *Moringa oleifera* exhibits higher levels of flavonoids, polyphenols, alkaloids, tannins, and saponins compared to *Aegle marmelos*.

Phytochemical	<i>M. oleifera</i>	<i>A. marmelos</i>
Flavonoids	12.5 mg/g	8.2 mg/g
Polyphenols	18.3 mg/g	15.7 mg/g
Alkaloids	5.6 mg/g	3.9 mg/g
Tannins	9.7 mg/g	6.5 mg/g
Saponins	7.2 mg/g	4.8 mg/g

SCOPE OF THE RESEARCH

The scope of this research encompasses a detailed comparative analysis of the bioactive phytochemical profiles of *M. oleifera* and *A. marmelos* grown in the Bundelkhand region. The study will focus on collecting samples of leaves and fruits from these plants at different locations in Bundelkhand to analyse their phytochemical composition. The analysis will include the quantification of key bioactive compounds such as phenolics, flavonoids, alkaloids, and vitamins C and E using standard analytical methods. The research will also explore any variations in phytochemical composition based on factors such as plant part (leaves vs. fruits) and geographical location within Bundelkhand. Studies investigating the potential health benefits of these metabolites will look at their anti-inflammatory, anti-inflammatory, anti-inflammatory, and other properties. These findings are important for improving our understanding of the healing characteristics of these plants and explore the potential applications of these plants in health foods, nutrients, and medicine. The study will provide insights into the cultivation and utilisation of these plants in Bundelkhand, contributing to agricultural practices and promoting sustainable development in the region.

RESEARCH PROBLEM

The focus of the study was on the incomplete knowledge on the bioactive phytochemical profiles of *A. Marmelos* and *M. oleifera*, two plants cultivated in Bundelkhand region. While both plants are known for their medicinal benefits and are used in Ayurveda and other ancient medical systems, yet little scientific investigation has been done to evaluate their phytochemical structure. Especially in the context of their cultivation in Bundelkhand. This research problem is significant because it hinders the development of new therapeutic agents, dietary supplements, and functional foods based on these plants' bioactive compounds. The lack of understanding of the phytochemical profiles of these plants in Bundelkhand limits our knowledge of how environmental factors influence their composition. Addressing this research problem is essential for advancing scientific knowledge, validating traditional medicine, promoting agricultural practices, and stimulating economic development in the region.

CONCLUSION

The comparative analysis of the bioactive phytochemical profiles of *M. oleifera* and *A. marmelos* grown in Bundelkhand holds immense promise for various fields, including health, agriculture, and traditional medicine. By gaining new insights into the therapeutic properties of these plants, this research can advance scientific understanding. Additionally, the research can validate the traditional uses of *M. oleifera* and *A. marmelos* in Ayurveda and other traditional medicinal systems. The study's findings can have practical implications for agriculture in the Bundelkhand region, as understanding the phytochemical profiles of these plants can help optimise cultivation practices and improve crop yields. Furthermore, the identification of bioactive compounds in *M. oleifera* and *A. marmelos* has the potential to stimulate the development of new medicines, dietary supplements, and functional foods, which helps human health and the pharmaceutical and nutritional industries? The comparative analysis of the bioactive phytochemical profiles of *M. oleifera* and *A. marmelos* grown in Bundelkhand is a significant step towards harnessing the medicinal potential of these plants and promoting sustainable agricultural practices and economic development in the region.

Future Work

Future research in this area could focus on several key aspects to further enhance our understanding and utilisation of *M. oleifera* and *A. marmelos*. More in-depth research can be done to identify the exact bioactive chemicals responsible for the plant's healing properties. and explain their mode of action. This may require the use of state-of-the-art analytical techniques such as atomic magnetic resonance spectroscopy and MS. Research could explore the cultivation practices and environmental factors that influence the phytochemical composition of these plants, with the aim of optimising their growth conditions and increasing their bioactive compound content. This could involve field trials and controlled environment studies. Further research may consider possible synergistic effects of mixing extracts or chemicals from *M. oleifera* and *A. marmelos*, as well as interactions with traditional medicine and may pave the way for new combination therapy for various medical diseases.

REFERENCES

1. Yadav NP, Chanotia CS. Phytochemical and pharmacological profile of leaves of *Aegle marmelos* Linn. Pharmaceut Rev. 2009;11:144–50.
2. Amalraj S, Krupa J, Prabhu S, Murugan R, Raj MS, Gurav SS, Ayyanar M. Exploring the phytochemical profile and therapeutic investigations on *Moringa concanensis* Nimmo pod husk extracts: An integrated in vitro and in silico approach. Biocatal Agricul Biotechnol. 2024;58:103234.
3. Kandeepan C, Sukanandam K, Jeevalatha A, Kavitha N, Senthilkumar N, Sutha S, Seyed MA, Gandhi S, Ramya S, Pushpalatha GG, Abraham GC. ADMET-evaluation, pharmacokinetics, drug-likeness and medicinal chemistry of GCMS identified bioactive compounds of *Moringa oleifera* natural-ripened-dried methanolic pod extract (MOMPE) as a potential source of natural drug frontrunner for next generation. J Drug Deliv Therap. 2022;12(6):65–85.

4. Srivastava R, Parambil JV. Evolution of extraction technique for the separation of bioactive compounds from *Aegle marmelos*. *Separat Sci Tech*. 2023;58(4):667–81.
5. Hazra SK, Sarkar T, Salauddin M, Sheikh HI, Pati S, Chakraborty R. Characterization of phytochemicals, minerals and in vitro medicinal activities of bael (*Aegle marmelos* L.) pulp and differently dried edible leathers. *Heliyon*. 2020;6(10).
6. Ganpat SP, Jagdish SD, Onkarappa GR. Quantitative phytochemical analysis and in vitro study of antioxidant and anti-inflammatory activities of *Aegle marmelos* fruit with peel and without peel: a comparative evaluation. *Int J Pharm Investigation*. 2022;12(1):15–19.
7. Maqsood M, Qureshi R, Arshad M, Ahmed MS, Ikram M. Preliminary phytochemical screening, antifungal and cytotoxic activities of leaves extract of *Moringa oleifera* Lam. from Salt range, Pakistan. *Pak J Bot*. 2017;49(1):353–9.
8. Khor KZ, Lim V, Moses EJ, Abdul Samad N. The in vitro and in vivo anticancer properties of *Moringa oleifera*. *Evidence-Based Complement Alternat Med*. 2018;2018(1):1071243.
9. Devaraj VC. Activity guided isolation of phytoconstituents of *Moringa oleifera* Lam leaves to study their in-vitro free radical scavenging activity. *Asian J Immunol*. 2023;6(1):252–9.
10. Randika SW, Nilushi NR, Pathmalal M, Lanka U, Dhanushka U, Nilmini LR, Prasanna G. Effects of extraction solvents on phytochemical screening, cytotoxicity and anti-obesity activities of selected Sri Lankan medicinal plants. *Pharmacog Res*. 2021;13(4):246–56.
11. Kumar V, Srivastav AK. Phytochemical screening and quantitative analysis of extract from *Aegele marmelos*, *Catharanthus roseus*, *Garcinia pedunculata*, *Musa paradisiaca* and *Ocimum sanctum*. *European J Mol Clin Med*. 2021;8(3):3268–85.
12. Reddy VP, Urooj A. Proximate, phytochemical profile and antioxidant activity (in vitro and ex vivo) of *Morus indica* varieties. *Int J Pharmaceut Sci Res*. 2013;4(4):1626.
13. Modi D, Patel J, Shah B, Nayak B. Phytopharmacology of *Moringa oleifera*—an edible plant. *Pharmacology*. 2010;2:692–705.
14. Agarwal A. Cholesterol lowering potentials of a blend of standardized methanol extracts of *Moringa oleifera* leaves and fruits in albino wistar rats. *Int J Pharma Pharmaceut Sci*. 2016;8(11):262–68.
15. Yousaf MA, Anwer SA, Basheera S, Sivanandan S. Computational investigation of *Moringa oleifera* phytochemicals targeting EGFR: molecular docking, molecular dynamics simulation and density functional theory studies. *J Biomol Struc Dynam*. 2024;42(4):1901–23.
16. Prabhavathi H, Dasegowda KR, Renukananda KH, Karunakar P, Lingaraju K, Raja Naika H. Molecular docking and dynamic simulation to identify potential phytochemical inhibitors for EGFR and HER2 as anti-breast cancer agents. *J Biomol Struc Dynam*. 2022;40(10):4713–24.
17. Osagie EA, Osayemwenre E, Udogadi NS, Olalekan SH. Action of fractionated *Moringa oleifera* Lam leaf extracts on multidrug resistant *Pseudomonas aeruginosa* strains. *Int J Clin Exper Med Res*. 2021;5(3):316–29.
18. Jhahharia A, Kumar K. Chapter-3 Antidiabetic and biochemical properties of ethanolic leaf extract of *Aegle marmelos* and seeds extract of fenugreek in alloxan-induced diabetic mice. *ADVANCES IN*. 2020;75:31.
19. Khairulmazmi A, Tijjani A. Natural compounds extracted from *Moringa oleifera* and their agricultural applications. *Nat Bio-active Comp Vol 1 Prod Applic*. 2019:449–75.
20. Donga S, Chanda S. Evaluation of phytochemical profile and antioxidant activity of some medicinal plants seed extracts obtained by traditional and modern (green) extraction methods. *Int J Chem Stud*. 2020;8(4):3295–309.
21. Singh S, Bhadoria BK, Koli P, Singh A. Nutritional evaluation of top foliages for livestock feeding in semi-arid region of India. *Indian J Anim Sci*. 2019;89(12):1389–98.
22. Neupane NP, Yadav E, Verma A. Cultural, Practical, and Socio-Economic Importance of Edible Medicinal Plants Native to Central India. In: *Edible Plants in Health and Diseases: Volume 1: Cultural, Practical and Economic Value* (pp. 181–207). Singapore: Springer Nature Singapore; 2022.