JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

A Review on Phytochemical Evaluation of *Aegle marmelos*

Correspondence Authors: Aashish Vishwakarma, Syed Shahab Ahmad, Deepak Bakoriya
Department of UTD, Biotechnology,Sri Satya Sai University of Technology & Medical Sciences, Sehore

Abstract:

Natural medicinal plants have existed for many years—possibly even before the dawn of time. Over the past 20 years, there has been a noticeable increase in public interest in medicinal plants due to their biological properties. This has led to the use of herbal items as natural products and widespread self-medication. Apart from the medicinal application of plants, there is a growing tendency to utilize herbal items mainly as dietary supplements to enhance overall well-being (Pardon, 2003). An ethno-pharmacological study of 236 traditional medicines used in Jordan found that they are made from plants and are used to cure a variety of illnesses (Lev and Amar, 2002). Many plant extracts have been tested for their antibacterial (Mahasneh and Al-Oklah, 1999), anti-diabetic (Hamdan and Eiffy, 2004), anti-cancer (Abuharfil et al., 2000), and anti-seizure (alcofi and eta, 1999) properties. For phytochemical examination, a variety of analytical methods are used, including as mass spectrometry, spectroscopy, and chromatography. The woody, hard-shelled capsule that contains several seeds and a yellowish scent is the fruit of the *Aegle marmelos* plant. These phytochemicals are made up of phenolic acids (galic, ellagic, and protocatechuic acid), alkaloids, and flavonoids. The pharmacological characteristics of bael fruit extract, such as its antidiarrheal, antioxidant, antidiabetic, hepatoprotective, radioprotective, anticancer, and antiulcer qualities, have also been the subject of much research.

Keywords: Phytochemical analysis, antioxidant, antibacterial, antifungal, alkaloids, flavonoids, terpenoids, and polyphenols.

1. Introduction

Aegle marmelos (L.) Correa (Bael), a fruit plant belonging to the Rutaceae family, is often cultivated in tropical and subtropical regions of Southeast Asian nations. Bael fruit has been the subject of a great deal of research recently due to its high nutritional content (carbohydrates, proteins, minerals, and vitamins) and the presence of various phytochemicals that add to its high medicinal potential. These phytochemicals consist of several components such as alkaloids, flavonoids, and phenolic acids (galic, ellagic, and protocatechuic acid). Considerable study has also been done on the pharmacological properties of bael fruit extract, including its

antidiarrheal, antioxidant, antidiabetic, hepatoprotective, radioprotective, anticancer, and antiulcer properties [1].

Fig. 1; *Aegle marmelos* (L.) Correa (Bael)

A. marmelos is a fruit with several medicinal uses. The medicinal herb is a lifesaver for the impoverished all over the world. These conventional treatments, which typically involve plant extracts, are practiced in about 80% of the nations on Earth [2]. Aegle marmelos fruits have nutritional and nutraceutical value and are used to create jam, squash, toffee, slab, and wine. Fruit, leaf, stem, root, stem bark, and specific chemical extracts from Aegle marmelos have been demonstrated to provide several useful medicinal advantages [3].

It is used to treat a wide range of ailments in the Ayurvedic system of traditional Indian medicine. Many ethnic civilizations on the Indian subcontinent have used it in similar ways for over 5000 years. Its leaves, bark, stem, fruits, and seeds have all been proven to have numerous medical use. Bael fruits are beneficial in treating peptic ulcers, persistent diarrhea, and dysentery; they are also useful as a laxative and in treating respiratory infections. Scientific research has validated many ethnomedical uses of A. marmelos, including its antibacterial, antiviral, antidiarrheal, gastroprotective, anti-ulcerative colitis, hepatoprotective, antidiabetic, cardioprotective, and radioprotective qualities. Due to its possible application as an anticancer agent in the treatment of many cancer types, this plant has recently attracted attention [4].

The oxidation that leads to human illness states is started by free radicals (FR). Moreover, activated oxygen promotes the body's production of reactive oxygen species (ROS), which harms cells and results in a number of health issues. Because of their hazardous or cancer-causing qualities, the use of the synthetic antioxidants BHA (butylated hydroxy anisole), BHT (butylated hydroxytoluene), and TBHQ (tertiary butylhydroquinone) has been limited. The antioxidant properties of essential oils may help to keep oral health issues in check. Dental caries and periodontal disease can be brought on by free radicals generated in the mouth cavity. The plant's essential oils contain antioxidant components that are neither harmful nor cancer-causing, and they may be an important source of defense against a variety of oral illnesses [5].

In this study, the primary compounds derived from crude ethanolic extracts of Bael tree leaves were screened, and their effects on non-target aquatic predators and Aedes aegypti (L.) mosquito larvae and adults carrying dengue fever were assessed. The GC-MS data revealed that oleic acid (OA) had the second-highest peak area, at 11.43%, and N-methyl-1-adamantaneacetamide (N-M 1a), at 63.08, respectively. The highest dosage of 100 ppm demonstrated a notable death rate of 93.60% in the larvicidal action against fourth instar larvae and crude Ex-Am. 10 ppm (97.73%) and 12 ppm (95.4%) were the death rates for N-M 1a and OA, respectively. When comparing the repellent action to the pure compounds (N-m 1a and OA), it was discovered that crude Ex-Am (50 ppm) exhibited the most, with a maximum protection duration of 210 minutes [6].

According to studies conducted in 2017 by Choudhary et al., A. marmelos leaves are used to treat blood sugar problems, backaches, abscesses, stomach disorders, vomiting, cuts and wounds, ulcers, dropsy, beriberi, heart weakness, hair loss, cholera, and diarrhea. A. marmelos leaf fresh juice has laxative properties and can be used to treat asthma symptoms and eye infections. The anticancer potential of A. marmelos plant extracts was assessed for cytotoxic activity utilizing tumor cell lines, brine shrimp lethality assay, and sea urchin eggs assay, taking into account the use in traditional medicine of Bangladesh [7].

A significant dietary supplement is also made from the fruit (Barthakur and Arnold, 1989). According to reports, this plant's root bark extract can treat mental illnesses, pericarditis, angina pectoris, and intermittent fever (Nadkarni, 1976). The components of bael are used to treat heart conditions (Kakiuchi et al., 1991). Additionally, it has been observed that bael leaves have a hypoglycemic impact (Santhoshkumari and Devi, 1990). Plant essential oils are widely utilized in the food, beverage, and perfume industries. Research has shown that these oils have antimicrobial properties against a range of bacteria and fungi (Rao and Joseph, 1971; Jain, 1977; Singh et al., 1980; Dikshit and Husain, 1984; Onawunmi et al., 1984; Onawunmi and Ogunlana, 1986; Onawunmi, 1989; Begum et al., 1993; Apisariyakul et al., 1995; Pattnaik et al., 1996) [8].

2. Extraction of Sample

The success of Soxhlet extraction, a separation process, depends critically on the solubility qualities of the particular species involved. The grinding stage in this method helps dissolve secondary metabolites and increase extraction yields by facilitating the solvent's access into the cellular structure of the plant tissues. Smaller particle sizes of the plant material generally result in a more successful extraction process (Silva et al., 1996).

As a popular extraction solvent, ether has a low boiling point, is highly non-polar, and is generally non-toxic (compared to methanol or chloroform) (Bergeron and Benning, 2010). Diethyl ether is not often used in plant extractions because of its volatility, flammability, toxicity, and tendency to produce explosive peroxide. Petroleum ether is less costly, more non-polar, and less flammable than diethyl ether. Petroleum ether's stronger non-polarity compared to diethyl ether will result in a more concentrated extract (Bergeron and Benning, 2010). Solvents' capacity for extraction vary depending on the molecular structures of the solute as well as their own chemical properties. Other factors that affect the choice of solvent include boiling point, density, surface

tension, viscosity, flammability, toxicity, stability, compatibility with the product, availability, and cost (Cowan, 1999). Plant components can be extracted using a variety of solvents, including acetone, petroleum ether, hexane, ethanol, and dimethyl sulfoxide. Ethanol and water are the two most often utilized solvents.

3. Material and Methods

3.1. Phytochemical Analysis

3.1.1. Qualitative Phytochemical Analysis

Qualitative phytochemical study serves as the foundation for investigating the therapeutic potential of plants. Different chemical tests that target different groups of phytoconstituents can be employed to distinguish between the different classes of bioactive compounds. Sources such as Harborne (1998), Trease and Evans (1989), and Kokate (1994) state that these methods are fundamental to understanding the pharmacological potential of plants and have a significant impact on the field of phytochemistry, which aims to identify various bioactive compounds present in plant extracts. These compounds reinforce the therapeutic properties of plants and are essential to understanding their potential uses. Finding specific chemical components is essential to qualitative analysis; these components are often classified into classes such as glycosides, phenols, alkaloids, flavonoids, terpenoids, saponins, and tannins.

3.1.1.1. CARBOHHYDRATE TEST

a. MOLISH TEST:

To a 2-3 ml aqueous solution of the sample extract, add a few drops of α-naphthol and give it a good shake. Apply four to five drops of sulfuric acid to the test tube's side. Carbohydrates (reducing sugars) are indicated by the formation of a violet ring during interphase.

b. COBALT-CHLORIDE TEST:

Add two milliliters of cobalt chloride to three milliliters of test solution; bring to a boil and allow to cool. Add a few drops of the NaOH solution once it has cooled. When reducing sugars—also referred to as carbohydrates—are present, a solution will appear greenish-blue in color.

c. IODINE TEST:

Two milliliters of an iodine solution were used to test the solution. Carbohydrates (non-reducing sugars) are indicated by a dark blue or purple hue.

d. TANNIC ACID TEST:

One to two milliliters of a 20% tannic acid solution should be added to the test solution. A precipitate indicates the presence of non-reducing carbohydrates.

3.1.1.2. PROTEIN TEST

a. BIURET TEST:

To a 3 ml test solution, add a few drops of 1% $CuSO_4$ and 4% NaOH. The color violet indicates the presence of protein.

b. MILLION'S TEST:

Add a few drops of Million's reagent to a test solution that has two milliliters.

Warming causes the coloring to turn stained red.

c. XANTHOPROTEIN TEST:

3 ml of the extract were combined with 1 ml of pure nitric acid. A white precipitate was produced. Tap water was used to chill the solution after it had heated for one minute. It became alkaline when 40% more NaOH was added. Orange precipitate indicates the presence of protein.

d. TEST FOR PROTEIN CONTAINING SULFUR:

To a 5 ml test solution, add 2 ml of 40% NaOH and a few drops of 10% CH_3COOPb. Mix thoroughly and bring to a boil. Protein that contains sulfur is indicated by a dark brown solution.

3.1.1.3. TERPENOID TEST

a. SALKOWSKI TEST:

Three milliliters of concentrated H2SO4 were cautiously added to two milliliters of chloroform after the required amount of extract had been added to produce a layer. A reddish-brown hue appeared on the interface, suggesting the presence of terpenoids.

b. LIBERMANN - BURCHARD TEST:

A few drops of acetic anhydride were added to the test solution's chloroform extract and thoroughly mixed in. The concentrated H_2SO_4 was then added along the test tube's side. Triterpenes are shown by a reddish-purple layer.

3.1.1.4. FLAVONOID TEST

Concentrated sulfuric acid is added to the extract, causing the color of the extract to change from yellow to orange, which indicates the presence of anthocyanins, to yellow to orange, which indicates the presence of flavones, and orange to red, which indicates the presence of flavanones.

3.1.1.5. TEST FOR PHENOLS

A small quantity of sample was mixed with a few drops of 5% $FeCl_3$. The presence of phenols and tannins is indicated by a brownish green or bluish-black tint.

3.1.1.6. TEST FOR ALKALOIDS

a. MAYER'S TEST:

To 2-3 ml of filtrate, add a few drops of Mayer's reagent (K_2HgI_4). yields a yellow-white precipitate in an alkaline or acidic solution.

b. WAGNER'S TEST:

To the 2-3 milliliters of filtrate, add 1 milliliter of diluted hydrochloric acid and Wagner's reagent. Shake well. An appearance of a reddish-brown precipitate indicates the presence of alkaloids.

3.1.2. Quantitative Phytochemical Analysis

Quantitative phytochemical analysis is necessary to assess the amount of bioactive compounds present in plants. These substances include tannins, phenolic compounds, alkaloids, flavonoids, and terpenoids. Plant species, sections, and growth periods exhibit variability in the concentration of these phytochemicals. To precisely ascertain these levels, researchers employ a range of analytical techniques, such as spectrophotometry, chromatography, and titration procedures.

A popular quantitative analysis method for measuring how much light phytochemicals absorb is called spectrophotometry. This method is widely used for compounds like flavonoids and phenolics. Following the extraction of phytochemicals from plant samples, researchers prepare solutions and measure the absorbance at specific wavelengths. Correlating the absorbance findings with standard calibration curves allows one to determine the concentration of the desired phytochemicals.

3.1.2.1. Total Flavonoid Content

Chang et al. (2017) reported that a colorimetric approach was used to evaluate total flavonoids with some minor adjustments. The calibration curve was made with quercetin [9]. One milliliter of distilled water was mixed with about one milligram of quercetin, and the mixture was diluted one test tube at a time. Each test tube was then filled with 150µl of 10% aluminum chloride, which was left undisturbed for five minutes at room temperature. Next, 1 ml of 1M NaOH was added, and the mixture was incubated for thirty minutes at room temperature. At 510 nm, the absorbance was measured using a UV-Vis spectrophotometer against a blank that did not contain quercetin, and the graph was plotted.

3.1.2.2. Total Alkaloids Content

The Bromo-Cresol Green Reagent method was applied with various modifications to ascertain the amount of alkaloid contained in the aqueous extract. Colchicine was the usual medication. A milliliter of distilled water was used to dissolve one milligram of colchicine, and the extract solution was then diluted in test tubes by 200, 400, 600, 800, and 1000 µl increments until it reached one milliliter. Prepare an extract solution in a different test tube by diluting 600 µl of extract with 400 µl of distilled water. Each sample solution received 500 µl of 2N HCl added to it. A few minutes later, fill each test tube with 2.5 milliliters of the Bromo cresol green reagent. To each test tube, add 2.5 milliliters of phosphate buffer and 2 milliliters of chloroform. After a few minutes of incubation at room temperature, measure the absorbance at 470 nm using a UV-Vis spectrophotometer against a blank. Draw a graph with the outcomes.

3.1.2.3. Total Phenolic Content

The phenolic content of the aqueous extract was determined by utilizing tannic acid as a standard and the Folin-Ciocalteu reagent method with certain modifications. The reagent Folin-Ciocalteu is diluted 1:9 with distilled water. Ten milliliters of distilled water are used to dilute one milliliter of tannic acid serially. Distilled water was used to dilute the extract in a separate test tube. Each sample solution should be mixed with 5 milliliters of 35% Na2CO3 and kept undisturbed at room temperature. After that, add 1 milliliter of Folin-Ciocalteu reagent and let the mixture sit at room temperature for 90 minutes. Following the incubation period, the absorbance at

760 nm was measured and plotted in a UV-Vis spectrophotometer against a blank that did not contain tannic acid.

3.2. Antimicrobial Assay

The Kirby-Bauer Method, a modified agar-Disc Diffusion Method, was employed to carry out the in vitro anti-fungal and anti-bacterial tests.

Principle:

The industry standard for measuring antibiotic susceptibility for many years has been the disc diffusion test, also referred to as the Kirby-Bauer test. The World Health Organization standardized it in 1961 after W. Kirby and A. Bauer made improvements to it after it was first developed in the 1950s. Clinical laboratories now use automated testing instead of manual ones.

By determining whether aerobes or facultative anaerobes are sensitive (clear zone of inhibition) or resistant (less or no zone of inhibition) to specific medications, a doctor can use this test to treat patients with bacterial infections.

The presence or lack of an inhibitory zone (also called the inhibition zone) surrounding the disc and the resulting number, known as the minimal inhibitory concentration (MIC), define the bacterial susceptibility to the antimicrobial drug.

3.3. Total Antioxidant Activity

Using the thiocyanate method, the antioxidant properties of aqueous extracts from 20 medicinal plants (1 mg/mL) were assessed with respect to the peroxidation of linolic acid. Of these, 11 exhibited substantial antioxidant activity (> 70%). Compared to the other plants, Cornus officinalis, Acanthopanax sessiliflorus, and Epimedium koreanum had higher hydroxy radical scavenging capacity (> 60%). Compared to other plant extracts, Epimedium koreanum had the best superoxide radical scavenging activity (42%) [10].

One aliquot of the leaf extract (10 µL) was incubated for 10 min at 30 °C with 200 µL of ABTS (2,20-azinobis(3-ethylbenzothiazoline-6-sulphonic acid)) in order to evaluate the total antioxidant activity (TAA), which was determined by the ABTS+• free cation radical scavenging activity technique, as reported by Re et al. Next, a calibration curve for gallic acid was used to determine the total antioxidant activity after the supernatant's absorbance at 734 nm was measured. The total antioxidant activity is measured in milligrams of dry extract (µM Gallic Acid Equivalents) [11].

4. Result

4.1. Qualitative Phytochemical Analysis Test Result

The qualitative phytochemical analysis conducted on *Aegle marmelos*, *Stevia rebaudiana*, and *Murraya koenigii* showed that the plants under study contained substances such as carbohydrates, protein, amino acids, steroids, flavonoids, phenolic compounds, etc; with potential medical applications.

4.2. Quantitative Phytochemical Analysis

Flavonoids are considered to be among the most abundant classes of naturally occurring substances present in plants. The flavonoid content values for *Aegle marmelos*, *Stevia rebaudiana*, and *Murraya koenigii* were 0.359334183 µg per ml, 0.3593799 µg per ml, and -0.05152174 µg per ml, respectively. Extracts of *Aegle marmelos* at varying concentrations (in µl) have the highest total phenolic content when compared to standard; these extracts have 0.026740829 µg.

The extract of *Aegle marmelos* (L.) Correa showed 0.449197738 mg/g of ascorbic acid's total antioxidant activity, respectively.

4.3. Antimicrobial Assay

The antibacterial activity of *Aegle marmelos* leaf extracts in vitro was examined against bacterial and fungal species using petroleum ether, chloroform, and methanol extracts. With zones of inhibition ranging from 10 to 22 mm against bacteria (*Staphlococcus au*reus, beta *Streptococcus haemolyticus* group A, *Proteus mimrabilis*, *Klebsiella pneumoniae*, *Pseudomonas aenrginosa*, *Escherichia coli*, *Salmonella typhi*) and fungi (*Candida albicans*, *Candida tropicalis*, and *Aspergillus flavus*), all of the extracts demonstrated broad spectrum antimicrobial activity. The extracts had minimal inhibitory concentrations (MIC) of 1.25 to 10 mg/mL and minimal microbicidal concentrations (MMC) of 2.5 to 20 mg/mL, respectively. *Pseudomonas aeruginosa*, beta *Streptococcus haemolyticus* group A, *Escherichia coli*, and *Staphylococcus aureus* demonstrated a high susceptibility to petroleum ether extract, according to an assessment of the antibacterial activity of several extracts. Salmonella typhi, Proteus mimrabilis, and *Klebsiella pneumoniae* all displayed strong susceptibilities to methanol extract and chloroform extract, respectively [12].

Gas chromatography mass spectrometric (GC-MS) study was performed on the essential oil of *A. marmelos* LBD to ascertain its chemical makeup. Out of the six solvents, the extracts of n-hexane and petroleum ether demonstrated significant potential for antibacterial action against all bacteria, exhibiting inhibition zones of 13.3±0.58 to 10±1.0 mm. In contrast, the essential oil exhibited an inhibition zone of 12.33±1.53 mm to 9.33±0.58 mm. For the extracts of petroleum ether, dichloromethane, and n-hexane, the MIC value was 32 µgD ml, and for the essential oil of *A. marmelos* LBD, it was 16 µlD ml. The essential oil of A. marmelos LBD was analyzed using GC-MS, and eighteen chemical components were discovered. Ledene oxide-(II)(18.16%), menthol, 12-(butyn-3-one-1-yl), (1R, 2S, 5R)(7.04%), (-)-caryophyllene oxide(7.10%), and himachalol (6.15%) are the main ingredients of the essential oil. Because *A. marmelos* LBDis an effective antibacterial agent against a variety of infectious disorders, it is likely because to its strong antibacterial action, which was previously well-known [13].

4.4. Total Antioxidant Activity

For many years, A. marmelos has been utilized as food and medicine (Kirtikar & Basu, Citation 1993). A. marmelosin, marmesin, psoralen, and umbelliferone are a few of the main chemical components that fall under the coumarin category (Kokate et al., Citation1990). The phenolic compounds known as coumarins have strong metal chelating and free radical scavenging properties. They are potent antioxidants that break down chains.

According to a study (Kamalakkannan & Stanely, Citation2004; Wohaieb & Godin, Citation1987), umbelliferone shows a promising preventive impact against oxidative stress in the heart and brain as well as a protective effect against the risk of complications from diabetes [14]. The extract of *Aegle marmelos* (L.) Correa showed 0.449197738 mg/g of ascorbic acid's total antioxidant activity.

5. Discussion

The notion that plants have therapeutic properties is not new (Cowan, 1999). One of the key components of peoples' cultures and traditions is their use of medicinal plants. Nowadays, the vast majority of people on the planet receive their medical care from medicinal herbs (Manandhar, 1995).

India is renowned among the ancient civilizations for having a plentiful supply of therapeutic plants. India's woods are a significant source of aromatic and medicinal plants, which are mostly harvested as raw materials for the production of pharmaceuticals and colognes. In Ayurveda, about 8,000 herbal medicines are encoded. 290 species in the Atharvaveda (4500–2500 BC), 67 species of medicinal plants in the Rigveda (5000 BC), 81 species in the Yajurveda, and characteristics of 1100 and 1270 species in the Charaka Samhita (700 BC) and Sushruta Samhita (200 BC), respectively.

Since the dawn of time, medicinal plants have been found in nature for thousands of years. Over the past two decades, there has been a significant surge in the public's interest in medicinal plants due to their biological properties, which has led to the use of herbal goods as natural products and widespread self-medication. Beyond this medicinal approach to plants, there is a growing trend of using herbal products mainly as dietary supplements to enhance overall well-being (Pardon, 2003).

Following scientific validation of traditional herbal medicines' efficacy in treating ailments for which they were traditionally prescribed, India has recently stepped up research into the field of traditional herbal medicines. According to the current study, the plant *Aegle marmelos* (L.) Correa is rich in naturally occurring phytochemicals that have great therapeutic value and are beneficial to human health.

Worldwide use of bael has increased as more study is done on its advantageous properties in hopes of creating novel treatments. Therefore, more clinical and preclinical research on *A. marmelos* is justified by the need for novel therapeutic medicines with focused actions and minimal side effects. This review can be related to the biological activities of isolated chemicals from *A. marmelos* that are being studied utilizing extracts. According to the findings of this study, *A. marmelos* holds great promise for the treatment and prevention of a variety of illnesses, such as cancer, infectious diseases, and diabetic problems.

Because stevia has no calories and may be used as a natural sugar substitute, its popularity is growing. Because it could be a useful addition to the current arsenal of anti-diabetic medications and could aid in reducing complications from diabetes. The presence of alkaloids, flavonoids, tannin, saponins, phenols, steroids, and cardiac glycosides was identified by the main phytochemical study. Due to the plant's high concentration of these bioactive substances, it is likely to provide a wide range of therapeutic benefits, including antibacterial, antifungal, antioxidant, laxative, and anticancer properties.

Conclusion and Recommendation

In addition to significantly enhancing human health, plant-based medications have inspired the development of novel pharmacological compounds. Drawing from the above mentioned research, it is evident that this plant holds significant potential for use in pharmacology and as a possible source of costly pharmaceuticals. Because it has many elements that are essential to optimal health, it can also be used to improve the health of society as a whole. particular physiological effects on humans are attributed to particular organic components present in medicinal plants. These substances—which are also referred to as bioactive substances—include flavonoids, terpenoids, alkaloids, tannins, and carbohydrates. These compounds are produced by the primary, or more precisely the secondary, metabolism of living organisms. The chemistry and taxonomy of secondary metabolites are unknown, despite their extreme diversity. They are widely used in a wide range of industries, such as agriculture, human therapy, veterinary care, and scientific research.

Herbal compounds are safe and will overcome the resistance developed by pathogens since they are present in the protoplasm of plant cells in the joint or grouped form of many molecules (Sengupta et al., 2004). Certain herbs have antibacterial and antifungal properties that can be useful in clinical settings (Kalimba and Kunikeka, 2003). Plant and phytochemical extracts, with their proven antibacterial properties, have a major place in medicine.

Research on various compounds present in plant-based medicines across several countries has demonstrated that TM played a critical role in the development of unique, genuinely very effective drugs. Eighty percent of the 122 compounds that were the focus of that investigation were linked to the effects of medications used in traditional medicine. The compounds were discovered to have originated in 94 distinct plant species (Fabricant and Farnsworth 2001).

When comparing the total alkaloid content of the three species—a crucial parameter for assessing the medicinal potential of plants—there were noticeable variations. *Aegle marmelos* has a high concentration of alkaloids, which suggests that the plant may be used to produce bioactive compounds of medicinal use. Alkaloids are present in medicinal plants and are often associated with a range of health advantages, including antibacterial, anti-inflammatory, and analgesic effects.

Total phenolics are a significant class of secondary metabolites that enhance the antioxidant capacity of plants. The investigation's findings demonstrated that the total phenolic content of *Aegle marmelos*. The high phenolic content of these plants raises the possibility that they can combat oxidative stress and related diseases. The well-known ability of phenolics to scavenge free radicals and lessen cellular damage makes them essential for maintaining overall health.

This investigation showed that there are significant amounts of total phenol, flavonoids, tannin, and other phytochemicals in the powdered fruit pulp of Bael (*Aegle marmelos* L.). Antioxidants, which are particularly helpful in halting detrimental processes like oxidative stress-induced lipid oxidation, are also abundant in it.

The therapeutic potential of these plants is further supported by the association found between their strong antioxidant activity and the presence of phenolic and flavonoid components. In these conditions, efficiency

ought to be raised. Therefore, more experimental studies on enhancing bioavailability and efficiency in clinical trials are required for future research.

REFERENCES

1. Nortjie E, Basitere M, Moyo D, Nyamukamba P. Extraction Methods, Quantitative and Qualitative Phytochemical Screening of Medicinal Plants for Antimicrobial Textiles: A Review. *Plants*. 2022; 11(15):2011. https://doi.org/10.3390/plants11152011

2. Sharma N, Radha, Kumar M, Zhang B, Kumari N, Singh D, Chandran D, Sarkar T, Dhumal S, Sheri V, Dey A, Rajalingam S, Viswanathan S, Mohankumar P, Vishvanathan M, Sathyaseelan SK, Lorenzo JM. *Aegle marmelos* (L.) Correa: An Underutilized Fruit with High Nutraceutical Values: A Review. Int J Mol Sci. 2022 Sep 17;23(18):10889. doi: 10.3390/ijms231810889. PMID: 36142805; PMCID: PMC9504793.

3. Monika S, Thirumal M, Kumar PR. Phytochemical and biological review of *Aegle marmelos* Linn. Future Sci OA. 2023 Mar 23;9(3):FSO849. doi: 10.2144/fsoa-2022-0068. PMID: 37026028; PMCID: PMC10072075.

4. Murthy, H.N., Bhat, M.A., Dalawai, D. (2019). Bioactive Compounds of Bael (*Aegle marmelos* (L.) Correa). In: Murthy, H., Bapat, V. (eds) Bioactive Compounds in Underutilized Fruits and Nuts. Reference Series in Phytochemistry. Springer, Cham. https://doi.org/10.1007/978-3-030-06120-3_35-1

5. Aodah AH, Balaha MF, Jawaid T, Khan MM, Ansari MJ, Alam A. *Aegle marvels* (L.) Correa Leaf Essential Oil and Its Phytoconstituents as an Anticancer and Anti-*Streptococcus mutans* Agent. Antibiotics (Basel). 2023 Apr 30;12(5):835. doi: 10.3390/antibiotics12050835. PMID: 37237738; PMCID: PMC10215268.

6. Chellappandian M, Senthil-Nathan S, Karthi S, Vasantha-Srinivasan P, Kalaivani K, Hunter WB, Ali AM, Veerabahu C, Elshikh MS, Al Farraj DA. Larvicidal and repellent activity of N-methyl-1-adamantylamine and oleic acid a major derivative of bael tree ethanol leaf extracts against dengue mosquito vector and their biosafety on natural predator. Environ Sci Pollut Res Int. 2022 Mar;29(11):15654-15663. doi: 10.1007/s11356-021-16219-w. Epub 2021 Oct 11. PMID: 34636011.

7. Pant P, Sut S, Castagliuolo I, Gandin V, Maggi F, Gyawali R, Dall'Acqua S. Sesquiterpene rich essential oil from Nepalese Bael tree (Aegle marmelos (L.) Correa) as potential antiproliferative agent. Fitoterapia. 2019 Oct;138:104266. doi: 10.1016/j.fitote.2019.104266. Epub 2019 Jul 11. PMID: 31302251.

8. Rana BK, Singh UP, Taneja V. Antifungal activity and kinetics of inhibition by essential oil isolated from leaves of Aegle marmelos. J Ethnopharmacol. 1997 Jun;57(1):29-34. doi: 10.1016/s0378-8741(97)00044-5. PMID: 9234162.

9. Kim, E. Y., Baik, I. H., Kim, J. H., Kim, S. R., & Rhyu, M. R. (2004). Screening of the antioxidant activity of some medicinal plants. *Korean Journal of Food Science and Technology*, *36*(2), 333-338.

10. Dias MC, Pinto DCGA, Costa M, Araújo M, Santos C, Silva AMS. Phytochemical and Antioxidant Profile of the Medicinal Plant *Melia azedarach* Subjected to Water Deficit Conditions. Int J Mol Sci. 2022 Nov 6;23(21):13611. doi: 10.3390/ijms232113611. PMID: 36362399; PMCID: PMC9656347.

11. Kothari S, Mishra V, Bharat S, Tonpay SD. Antimicrobial activity and phytochemical screening of serial extracts from leaves of Aegle marmelos (Linn.). Acta Pol Pharm. 2011 Sep-Oct;68(5):687-92. PMID: 21928713.

12. Pandiyan I, Arumugham MI, Doraikannan SS, Rathinavelu PK, Prabakar J, Rajeshkumar S. Antimicrobial and Cytotoxic Activity of *Ocimum tenuiflorum* and *Stevia rebaudiana*-Mediated Silver Nanoparticles - An *In vitro* Study. Contemp Clin Dent. 2023 Apr-Jun;14(2):109-114. doi: 10.4103/ccd.ccd_369_21. Epub 2022 Nov 11. PMID: 37547431; PMCID: PMC10399804.

13. Jamal, M. A. H. M., Rahman, M. S., Hossain, M. B., Sharma, S. P., Chung, H. J., Kim, H. J., & Hong, S. T. (2017). Antibacterial properties and chemical composition of essential oil from Aegle marmelos (L.) Corr. leaves growing in Bangladesh. *Journal of Essential Oil Bearing Plants*, *20*(1), 155-174.

14. K. Dhalwal, V. M. Shinde, A. G. Namdeo & K. R. Mahadik (2008) Antioxidant Profile and HPTLC-Densitometric Analysis of Umbelliferone and Psoralen in Aegle marmelos., Pharmaceutical Biology, 46:4, 266-272, DOI: 10.1080/13880200701741088