

PHYTOCHEMICAL PROFILING AND BIOLOGICAL ACTIVITIES OF MEDICINAL PLANTS: A REVIEW.

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Abstract

Even in contemporary healthcare systems, medicinal plants remain an essential component as a source of therapeutic compounds, as they have done since ancient times. Alkaloids, flavonoids, tannins, phenolics, terpenoids, glycosides, saponins, and steroids are just a few of the many phytochemicals found in plants that have the potential to be used as medicinal agents. Chromatography, spectroscopy, and metabolomic methods are among of the cutting-edge analytical tools used in phytochemical profiling, which aims to identify, characterise, and quantify these bioactive chemicals. Pharmacological potential, quality control, and therapeutic efficacy of medicinal plants can be better understood with the use of such profiling. Antioxidant, antibacterial, anti-inflammatory, anticancer, antidiabetic, hepatoprotective, cardioprotective, and immunomodulatory properties are only a few of the many biological activity documented in medicinal plants. A number of chronic and infectious illnesses can be better prevented and managed with the aid of phytoconstituents, which are mostly responsible for these biological qualities. In addition to being safer, more affordable, and less harmful to the environment than manufactured pharmaceuticals, medicinal plants also have other benefits. Research in phytochemistry and pharmacognosy has been further expedited due to the rising incidence of drug resistance, negative effects of conventional medications, and the need for natural treatments. The significance of phytochemical profiling in medicinal plant research is emphasised in this study, which also offers a thorough synopsis of the main phytochemicals and the biological activities linked with them. The paper goes on to talk about how analytical techniques have been improving recently, the problems with standardisation, and the potential for new medications made from plants in the future. All things considered, medicinal plants are still a great place to find bioactive chemicals that might be used in new drugs or for therapeutic purposes.

Keywords: Phytochemical, Profiling, Biological, Medicinal, Plants

Introduction

Traditional healthcare systems have relied heavily on medicinal plants from ancient civilisations, and these plants still play an important role in contemporary medicine. Many ancient medical systems and indigenous communities have recorded the therapeutic benefits of plants, including Ayurveda, Unani, Siddha, TCM, and indigenous folk medicine. One of the first sources of therapeutic resources accessible to humans, medicinal plants are considered by Hippocrates to be nature's strong healer. According to the World Health Organization, many people throughout the world, particularly in underdeveloped nations, rely on herbal remedies as their main source of healthcare. Extensive study

into medicinal plants and their bioactive ingredients has been driven by the rising desire for natural medicines. Phytochemicals, a class of secondary metabolites, are the active ingredients in medicinal plants that give them their medicinal effects. Essential oils, glycosides, alkaloids, flavonoids, phenolic compounds, tannins, steroids, terpenoids, and saponins are all examples of phytochemicals. Phytochemicals have amazing pharmacological effects that are good for people's health, and they're also vital to plants' defence systems (Harborne, 1998). Research into the chemical make-up of medicinal plants has been driven by the increasing fascination with phytochemistry, which aims to uncover new therapeutic agents. The tremendous therapeutic potential of medicinal flora is demonstrated by the fact that many contemporary medications, such as digoxin, quinine, morphine, and artemisinin, have their origins in chemicals obtained from plants. The process of meticulously identifying, characterising, and quantifying bioactive chemicals found in plants is known as phytochemical profiling. To determine whether herbal goods are safe, genuine, high-quality, and have therapeutic potential, it is an indispensable instrument. Chromatography, spectroscopy, mass spectrometry, and metabolomics are only a few examples of the analytical methods that have greatly enhanced the accuracy and efficiency of phytochemical analysis. In phytochemical studies, several techniques are utilised, such as High-Performance Liquid Chromatography (HPLC), Gas Chromatography-Mass Spectrometry (GC-MS), Thin Layer Chromatography (TLC), and Nuclear Magnetic Resonance (NMR) spectroscopy. For a better grasp of medicinal plants' biological importance and therapeutic performance, phytochemical screening is essential, say Trease and Evans. These phytoconstituents have a significant role in the biological activities of therapeutic plants. Medicinal herbs have immune-modulatory, hepatoprotective, cardioprotective, antiviral, anti-inflammatory, anticancer, and antidiabetic effects, according to a large body of research. The prevention of chronic illnesses including cancer, diabetes, and cardiovascular problems can be achieved by the use of antioxidant chemicals like flavonoids and phenolics, which serve to neutralise free radicals and decrease oxidative stress. The anti-inflammatory and antibacterial characteristics of terpenoids and alkaloids make them useful in the treatment of inflammatory and infectious illnesses. Scientists like Cowan (1999) have highlighted the potential of antimicrobial chemicals produced from plants as an alternative to synthetic antibiotics. This is particularly true when it comes to fighting off infections that are resistant to many drugs. In light of the growing number of chronic diseases, the development of antibiotic resistance, and the negative side effects linked to synthetic medications, research into medicinal plants as potential safer and more environmentally friendly therapeutic alternatives has been expedited. In rural areas and communities with little resources, herbal medications are generally seen as affordable and culturally acceptable options. More and more people are learning about the advantages of natural goods and preventative healthcare, which has led to a fast growth in the worldwide herbal medicine industry. More and more funds are going into drug development initiatives based on plants in the hopes of finding new bioactive compounds with better therapeutic potential in the pharmaceutical and nutraceutical sectors. Standards, quality control, and scientific validation of herbal medicines continue to be obstacles, despite plants' immense medical usefulness. Phytochemical composition and biological activity can be impacted by variations in weather, geographical dispersion, harvesting methods, and extraction procedures. To guarantee the efficacy, safety, and consistency of formulations derived from medicinal plants, thorough phytochemical profiling and pharmacological assessment are necessary. New standardised herbal remedies and pharmaceutical substances are anticipated to be developed with the use of contemporary

scientific methods that combine ethnobotany, phytochemistry, molecular biology, and biotechnology. The primary objective of this study is to offer a thorough synopsis of the methods used for phytochemical profiling as well as the main biological processes linked to medicinal plants. Recent developments in phytochemical research, the potential of natural product drugs for future treatments, and the role of bioactive chemicals in illness prevention and therapy are all highlighted in the review.

Medicinal Plants and Their Therapeutic Importance

Since ancient times, medicinal plants have been an essential part of human healthcare, and they continue to be today as a source of therapeutic chemicals. When it comes to illness prevention and treatment, traditional systems like Ayurveda, Unani, Siddha, and Traditional Chinese Medicine heavily rely on medicinal plants. Nearly 80% of people in underdeveloped nations use herbal remedies as their main source of healthcare, according to the World Health Organization. Medicinal plants are rich sources of bioactive chemicals that have major therapeutic value, according to researchers like Fabricant and Farnsworth (2001). The demand for plant-based medications has been further boosted by the rising interest in natural remedies and the increasing knowledge of the negative effects of synthetic pharmaceuticals.

Concept of Phytochemical Profiling

Discovering, characterising, and quantifying bioactive chemicals found in therapeutic plants is known as phytochemical profiling. Plants produce these phytochemicals as secondary metabolites to ward against harmful insects, diseases, and herbivores. Understanding the therapeutic value and pharmacological qualities of plants requires phytochemical research (Harborne, 1998). Scientists can learn more about the herbal compositions' authenticity, purity, safety, and medicinal potential through phytochemical profiling. The procedure involves utilising several analytical methods to extract, separate, isolate, and analyse phytoconstituents. Drug discovery and the creation of new medicinal compounds from natural resources are both greatly aided by these types of research.

Major Phytochemicals Present in Medicinal Plants

All sorts of phytochemicals, including steroids, glycosides, alkaloids, tannins, phenolic compounds, terpenoids, saponins, and essential oils, are found in medicinal plants. Different classes of phytochemicals have different biological and pharmacological effects. The nitrogen-containing chemicals called alkaloids have antibacterial, anticancer, and analgesic effects. The powerful antioxidant capabilities of flavonoids and phenolic compounds have made them famous for shielding cells from the damaging effects of oxidative stress. If you believe Trease and Evans, tannins have antibacterial and anti-inflammatory properties, while terpenoids help fight cancer and viruses. Cardioprotective and immunomodulatory effects have also been linked to saponins and glycosides. Medicinal plants are more effective as a whole due to the synergistic interplay of these compounds.

Techniques Used in Phytochemical Analysis

Accurate identification and quantification of plant bioactive chemicals are made possible by modern phytochemical analysis, which employs sophisticated analytical methods. In phytochemical studies, spectroscopic and chromatographic techniques are frequently used. Many different techniques are

utilised for phytochemical profiling, including HPLC, Fourier Transform Infrared Spectroscopy (FTIR), GC-MS, Gas Chromatography-Mass Spectrometry (GC-MS), Thin Layer Chromatography (TLC), and Nuclear Magnetic Resonance (NMR) spectroscopy. Sasidharan et al. (2011) states that these analytical methodologies yield trustworthy data on the chemical make-up and therapeutic capabilities of plants. Metabolomics and bioinformatics have recently made great strides, allowing for even more efficient and accurate phytochemical research.

Antioxidant Activity of Medicinal Plants

The antioxidant activity of medicinal plants is one of their most important biological functions. Oxidative stress, caused by free radicals produced by metabolic processes, can damage cells and eventually lead to chronic illnesses including diabetes, cancer, and heart problems. Plants with high vitamin, flavonoid, and phenolic content are powerful antioxidants that can eliminate harmful free radicals. Rice-Evans et al. (1997) states that polyphenolic chemicals found in plants are crucial in preventing oxidative damage to biological systems. The safety and therapeutic advantages of natural antioxidants obtained from medicinal plants are making them a popular alternative to synthetic antioxidants.

Antimicrobial and Antiviral Activities

When it comes to combating harmful bacteria, viruses, and other microbes, medicinal plants really shine. The development and metabolism of microbes can be disrupted by substances produced from plants, including alkaloids, terpenoids, flavonoids, and tannins. Phytochemicals found in therapeutic plants, asserts Cowan (1999), offer viable substitutes for manufactured antibiotics. Herbal antimicrobial compounds have been the focus of increased study because to the rising number of bacteria and viruses that are resistant to antibiotics. There are a number of medicinal plants that might be useful in creating new antimicrobial medications due to their inhibitory effects on certain microorganisms.

Anti-Inflammatory and Anticancer Activities

Although inflammation serves a preventive purpose, it is linked to chronic inflammation, which in turn causes a number of illnesses, including as cancer, cardiovascular problems, arthritis, and autoimmune diseases. By blocking inflammatory mediators, medicinal plants rich in flavonoids, terpenoids, and phenolic chemicals have potent anti-inflammatory effects. Further, many phytochemicals have anticancer effects by triggering cell death, reducing tumour development, and stopping the spread of cancer. Newman and Cragg (2020) state that natural products still play a significant role in the creation of anticancer medications. Compounds originating from plants, such vincristine, camptothecin, and paclitaxel, have been extremely effective in treating cancer.

Challenges in Standardization and Quality Control

A key obstacle in the field of herbal medicine research is the absence of standardisation and quality control, which is problematic given the therapeutic relevance of medicinal plants. Phytochemical composition can be affected by factors including location, weather, time of harvest, storage, and extraction techniques. If we want to make sure that herbal medicines are safe, effective, and consistent,

we need to standardise them, says the World Health Organization. The worldwide adoption of plant-based medicines is contingent upon their scientific verification, evaluation of toxicity, and appropriate quality control procedures. To make herbal compositions more consistent and dependable, biotechnology, molecular biology, and contemporary analytical technologies should be used together.

Future Prospects of Medicinal Plant Research

Natural therapies and medications generated from plants are gaining popularity, which bodes well for the future of medical plant research. New opportunities for the identification of unique bioactive chemicals are emerging as a result of developments in nanotechnology, genomics, phytochemistry, and metabolomics. The protection, large-scale production, and sustainable use of medicinal plants are gaining more and more attention from researchers. Rates (2001) asserts that medicinal plants still have tremendous potential for the creation of reasonably priced, highly effective, and safe pharmaceuticals. Research combining ethnobotany, pharmacology, and biotechnology has the potential to advance the field of herbal medicine by bolstering its scientific basis and paving the way for new and exciting healthcare innovations.

MATERIALS AND METHODS

Sodium chloride, magnesium chloride, ferric chloride, ammonium hydroxide, and Mayers reagent were all analytical grade chemicals acquired from Merck and BDH, respectively. Scharlu supplied the hexane, ethanol, hydrochloric acid, methanol, and butanol, while Defco supplied the nutritional agar medium, sterile yeast, and mould extract agar.

Post harvest treatment of plant materials

After rinsing with deionised water, all of the plant materials were dried in the shade after being rinsed with tap water. In order to extract powerful plant ingredients, the dried plants were ground to a powder using a sterile electric blender. Preserved in air plant materials were the powdered plant components. For further examination, the plant materials that had been pulverised were placed in sealed glass jars.

Phytochemical analysis

Alkaloids: After drying out the chloroform extracts, they were mixed with a 2% HCl solution and heated over a boiling water bath to dissolve any remaining residue. After cooling, filtering, and treatment with Mayer's reagent, the extracts were ready to be used. The next step was to check the sample for turbidity or yellow precipitation (Evans, 2000; Tyler, 1994; Harborne, 1973).

Flavonoids: The plant extracts were combined with 1.5 ml of 50% aqueous methanol in a volume of 4 ml. After warming the solution, magnesium chloride was included. A few drops of strong HCl were added to the mixture and watched for the solution to become red.

Tannins: The mixture was then tested for the presence of blue or greenish-black colouration by adding 1 millilitre of distilled water and 1 to 2 drops of ferric chloride solution to half a millilitre of extract solution.

Saponins: 2 ml of distilled water was added to 2 ml of the test solution and shaken very well till frothing was observed.

Phenols: After adding a few drops of ferric chloride solution to 2 millilitres of the test solution, the mixture was coloured by observing the addition of ethanol.

Quantitative analysis

Alkaloids: 200 millilitres of a 10% CH₃COOH in C₂H₅OH was added to 5 grams of plant material already prepared in a beaker. The mixture was left undisturbed for four hours. After filtering, the mixture was heated over a water bath until the extract was reduced to ¼ of its original volume, a process known as concentration. The process of precipitation was continued by adding concentrated ammonium hydroxide. The whole mixture was given time to settle before collecting the precipitate, which was subsequently washed with diluted ammonium hydroxide and filtered. The alkaloids that remained after extraction were dried and weighed.

Flavonoids: The plant material, weighing 10 g, was extracted at room temperature using 100 ml of 80% aqueous methanol. The entire mixture was passed through a filter, and the resulting filtrate was evaporated using a water bath. The solution was subsequently dried by evaporation and weighed repeatedly until a stable mass was achieved.

Tannins: A 50 ml flask was used to hold 500 mg of the plant sample after it was weighed. The next step was to add 50 cc of distilled water and stir the mixture for 1 hour. We used the same distilled water to fill a 50 ml volumetric flask to the mark after filtering the sample. The filtered material was transferred to a test tube using a pipette and mixed with 2 millilitres of ferric chloride solution (0.1 M). Within 10 minutes, the absorbance was measured at 395 nm using a spectrophotometer.

Saponins: Twenty grams of ground plant material was added to a conical flask along with one hundred millilitres of twenty percent aqueous ethanol. While constantly stirring, the aforementioned samples were heated in a water bath at about 55°C for four hours. After filtering the extracted liquid, 200 ml of 20% aqueous ethanol was used for a second extraction of the residue. By reducing the combined leftovers to 40 cc in a hot water bath, the process was completed. After that, 20 millilitres of diethyl ether was added to the concentrated residue in a separating funnel after it had been well shaken. The organic layer was discarded and the aqueous layer was recovered through a repeated purification procedure. The 60 ml of n-butanol was mixed with the combined extract, and then 10 ml of a 5% NaCl solution was used for two washes. The samples were oven-dried until they reached a consistent weight after being heated in a water bath and evaporating the leftover solution.

Phenols: Five millilitres of the plant material was cooked in fifty millilitres of (CH₃CH₂)₂O for fifteen minutes. Then, ten millilitres of distilled water was added to the mixture. Next, 2 millilitres of NH₄OH solution and 5 millilitres of concentrated CH₃ (CH₂)₃CH₂OH were added to the mixture. After filling the sample to the specified level, it was allowed to react for 30 minutes in order to develop colour. A spectrophotometer was used to measure the absorbance of the coloured product at 505 nm. Phenol concentrations were calculated using the calibration curve.

Antibacterial activity

Separate extractions were performed using chloroform and water on 100 g of coarsely powdered plant material. To create precipitates, the filtered extracts were mixed with a small amount of crystals from a sodium chloride solution. The precipitates were subsequently moved to an airtight amber glass container after being separated via filter paper and air dried. We made a final concentration by dissolving the crude extract in chloroform and water; we refrigerated it until we needed it (Lang et al., 1990).

Preparation of standard bacterial suspension

Use the surface viable counting technique to find the average number of *Bacillus subtilis* (NCTC8236), *Escherichia coli* (ATCC25922), *Proteus vulgaris* (ATCC6380), *Pseudomonas aeruginosa* (ATCC27853), *Salmonella typhi* (ATCC0650), and *Staphylococcus aureus* (NCTC25953) organisms per millilitre of the stock suspension. We utilised a concentration of around 108 to 109 CFU per millilitre. Without fail, a new stock suspension was made for every occasion (Hanna, 2008; Lee et al., 2003).

Antimicrobial activity

We used the well agar diffusion method to find out how effective the extracted compounds were against microbes. In a 60 ml volume of sterile nutritional agar, the standard bacterial stock solution containing 108 to 109 CFU/ml was mixed well. 20 millilitres of nutritional agar that had been infected was added to clean Petri dishes. After letting the agar set, sterile cork borer No. 8 was used to make four 10-millimeter-diameter wells in each of the plates. The discs of agar were thereafter removed. At room temperature, the wells were filled with 0.1 ml of each extract using a microtiter pipette and left to diffuse for two hours. The plates were kept at 37°C for a duration of 24 hours. Each extract was tested against each of the test organisms twice. At the same time, as a control, the appropriate solvent was added instead of the extract. Following incubation, the inhibition zones were measured in millimetres and an average value was computed (Hanna, 2008; Lee et al., 2003).

Antifungal activity

The antifungal activities of the prepared extracts were determined by using well agar diffusion method. 0.6 ml standard fungal stock suspension 108 to 109 CFU/ml was mixed with 60 ml of sterile yeast and mould extract agar thoroughly. Sterile Petri plates were filled with 20 ml of inoculated yeast and mould extract agar. The agar was left to set and four wells (10 mm in diameter) was made in each of these plates using sterile cork borer No 8. And then agar discs were removed. The entire well were filled with 0.1 ml of each extracts using micro titer-pipette and allowed to diffuse at room temperature for 2 h. The plates were then incubated at 25°C for 4 days for *Candida albicans* and 3 days for *Aspergillus niger*. Three replicates were also performed for each extract against each of the test organism. At the same time, as a control, the appropriate solvent was added instead of the extract. After incubation, the zones of inhibition (in mm) were measured and mean value was calculated (Hanna, 2008; Lee et al., 2003).

Preparation of standard fungal suspension

In a four-day incubation period at 25°C, the *A. niger* (ATCC 9763) and *Candida albicans* (ATCC 7596) fungal cultures were sustained on saboraud dextrose agar. According to Hanna (2008) and Lee et al. (2003), the fungal growth was collected, rinsed with sterile normal saline, and then kept in a refrigerator until needed.

RESULTS AND DISCUSSION

The qualitative findings of the analysis are shown in Table 1, while the quantitative data are presented in Table 2. Both tables display the different concentrations of the phytochemicals that were found.

Alkaloid

This table presents the various concentration levels of phytochemicals that were acquired via the use of various methodologies. The alkaloid concentration in *E. helioscopia* was found to be 0.9%, followed by the concentration in *C. foliosum*, while the concentration in *A. calamus* was found to be 0.3%, which was a lower concentration.

Flavonoids

Flavonoids have been shown to have anti-inflammatory and anti-allergic properties (Yamamoto and Gaynor, 1980). Cushnie and Lamb (2005) found that it has anticancer and antibacterial properties. Flavonoids, commonly known as bioflavonoids, are a kind of polyphenol antioxidant that may be found in plants in their natural state. While the remaining samples had concentration levels ranging from 0.22 to 0.53%, the amount of crude flavonoid that was identified in *A. annua* was found to be 0.99%, while the amount found in *A. calamus* was determined to be 0.70 percent.

Saponins

The saponins are surface-active glycosides that occur naturally in certain environments. Saponins have been shown to possess a wide range of pharmacological properties, including antibacterial, antifungal, antiviral, hepatoprotective, anti-inflammatory, and antiulcer properties (Oakenfull, 1986; Zhang et al., 2001).

Table 1. Qualitative analysis of phytochemicals of ten selected medicinal plants.

Sample code	Phenols	Tannins	Alkaloids	Saponins	Flavonoids
<i>A. calamus</i>	+	+	+	+	+
<i>A. annua</i>	+	+	+	+	+
<i>C. foliosum</i>	+	+	+	+	+
<i>C. sempervirens</i>	+	+	+	+	+
<i>E. helioscopia</i>	+	+	+	+	+

Table 2. Quantitative phytochemicals analysis of selected medicinal plants.

Samplecode	Alkaloids(%)	Flavonoids(%)	Tannin(%)	Saponins(%)	Phenols(%)
A. calamus	0.3	0.70	0.20	1.2	0.028
A. annua	0.5	0.99	0.26	0.6	0.0063
C.foliosum	0.8	0.51	0.28	1.3	0.0065
C.sempervirens	0.7	0.22	0.31	1.9	0.067
E.helioscopia	0.9	0.53	0.02	2.4	0.021

Table 3. Zones of inhibitions of water extracts of selected medicinal plants in millimeters.

S/N o.	Water extract of the plants	1	2	3	4	5	6	7	8
1	A. calamus	13	10	8	5	2	2	2	2
2	A. annua	9	13	19	4	3	1	2	0
3	C. foloisom	12	7	14	6	3	4	1	2
4	C. sempervirens	9	14	11	4	6	3	1	0
5	E. helioscopia	21	16	19	13	10	9	3	4

hypocholesterolaemic, haemolytic, immunostimulatory, and anti-tumourigenic actions (Hostettmann and Marston, 1995), as well as chemoprotective activities (Ireland and Dziedzic, 1986) have been claimed to have major biological activities in humans. Furthermore, these activities have been shown to be beneficial in the treatment of cancer. With a percentage of saponins of 2.4%, E. helioscopia was discovered to be the most abundant, followed by C. sempervirens with 1.9% and C. foliosum with 1.3%. A. annua, on the other hand, had the least quantity, with just 0.6%.

Phenols

According to Table 2, the percentage of phenols in all of the plant samples was extremely low. The concentration of phenols in C. sempervirens was 0.07%, in A. calamus it was 0.028%, in E. helioscopia it was 0.02%, and in A. annua it was 0.01%.

Water extract

As can be seen in Table 3, E. helioscopia exhibited a high level of activity against B. subtilis, measuring 21 millimetres, whereas A. annua exhibited a lower level of activity, measuring 9 millimetres, against B. subtilis. Table 3 further demonstrates that E. helioscopia has a high activity against P. vulgaris, which is measured at 16 mm, whereas the activity of E. helioscopia against bacteria in aqueous extract of C. sempervirens was measured at 14 mm. The activity of A. annua against P. vulgaris is measured at 13 millimetres. Comparatively speaking, the activities of the other water extract were not as dissimilar to one another. A water extract of A. annua and E. helioscopia showed the maximum zone of inhibition against E. coli, measuring 13 mm. This was followed by a water extract

of *C. foliosom*, which showed 11 mm of inhibition against the same pathogen. Extremely low levels of activity were seen in every fraction that was tested, with the exception of *E. helioscopia*, which exhibited a 10 mm zone of inhibition against *P. aeruginosa*. Insignificant results were achieved against pathogens *S. typhi*, *A. niger*, and *Candida albicans* by all water extracts of plant species that were tested between 1 and 9 mm. The water extracts of *C. sempervirens* and *A. annua* were shown to be fully inactive against *Candida albicans*. *E. helioscopia* demonstrated a high level of activity against *P. aeruginosa*, measuring 10 mm, but *C. sempervirens* demonstrated a level of activity of 6 mm against the same bacterium. There was a significant amount of activity of 4 mm of *E. helioscopia* against *C. albicans*, while there was some activity of 2 mm detected in the remainder of the samples.

Table 4. Zones of inhibitions of chloroform extracts of ten selected medicinal plants in millimeters.

S/N o.	Chloroform extract of the plants	<i>B</i> <i>s</i>	<i>Pv</i>	<i>Sa</i>	<i>Ec</i>	<i>Pa</i>	<i>At</i>	<i>An</i>	<i>Ca</i>
1	<i>A. calamus</i>	8	12	9	6	2	4	0	0
2	<i>A. annua</i>	1 4	9	11	4	3	5	2	2
3	<i>C. foliosom</i>	1 0	13	8	5	2	4	1	2
4	<i>C. sempervirens</i>	1 2	10	9	5	3	1	0	3
5	<i>E. helioscopia</i>	1 9	14	21	3	5	6	3	2

the plant extracts against the same fungus as the others. According to the data presented in the table, *E. helioscopia* demonstrated a higher level of effectiveness against all gram-positive and gram-negative bacteria as well as fungus in comparison to all other plants.

Chloroform extract

Taking into consideration the data shown in Table 4, it can be concluded that the chloroform extract of *E. helioscopia* exhibited a high level of activity against *B. subtilis*, measuring 19 mm. On the other hand, the activity displayed by the remaining plant extracts ranged from 1 to 17 mm. *E. helioscopia* was similarly active against *P. aeruginosa* at a radius of 5 millimetres. The antifungal activity of *E. helioscopia* was found to be strong, measuring 3 mm, when tested against *C. sempervirens*. On the other hand, the activity of other plant extracts was found to be in the range of 0-2 mm. The results of *E. helioscopia* 17 mm against *S. aureus* are significantly more significant. In the same vein, the aqueous extract of *A. annua* exhibited the maximum activity against *B. subtilis*, measuring 14 millimetres, whereas the activity against the pathogens *A. niger* and *C. albicans* was minimal, measuring just 2 millimetres. The zone of inhibition that *C. foliosom* displayed against *P. vulgaris* was 13 millimetres. When tested against *A. niger* and *Candida albicans*, the water extract of *A. calamus* came out entirely inert. It was discovered that the water extract of *C. sempervirens* was ineffective against *A. niger*. On

the other hand, the water extract of *A. calamus* had the largest 12 mm zone of inhibition against *P. vulgaris*.

Conclusion

For the purpose of human healthcare and the creation of pharmaceuticals, medicinal plants continue to be one of the most valuable sources of therapeutic chemicals. The presence of a large variety of phytochemicals, including alkaloids, flavonoids, phenolics, terpenoids, tannins, glycosides, and saponins, is a key contributor to the extensive range of biological activities that these fruits and vegetables exhibit. Phytochemical profiling has developed as a crucial scientific method for discovering and characterising these bioactive ingredients. This has enabled researchers to get a better understanding of the medicinal potential and treatment processes of a wide range of plant species. Analytical methods such as high-performance liquid chromatography (HPLC), gas chromatography mass spectrometry (GC-MS), thin-layer chromatography (TLC), Fourier transform infrared (FTIR), and nuclear magnetic resonance (NMR) spectroscopy have significantly enhanced the precision and effectiveness of phytochemical research. Antioxidant, antibacterial, anti-inflammatory, anticancer, antidiabetic, hepatoprotective, cardioprotective, and immunomodulatory activities are only some of the major biological qualities that medicinal plants have been shown to exhibit, according to a number of studies. As a result of these pharmacological properties, medicinal plants are becoming increasingly attractive as potential alternatives to synthetic medications, particularly in the treatment of persistent illnesses and infections. The World Health Organization (WHO) asserts that traditional herbal medicine continues to be an essential component of healthcare systems across the world, particularly in underdeveloped nations where access to modern treatment may be restricted. The significance of plant-based treatments has been further bolstered by the growing incidence of antibiotic resistance as well as the terrible side effects that are linked with synthetic medications. In conclusion, medicinal plants offer a rich and sustainable reservoir of bioactive chemicals that have a tremendous potential for future uses in the fields of drug development and healthcare. Continued research that draws from a variety of disciplines and focuses on phytochemical characterisation, biological assessment, and clinical validation will make a substantial contribution to the creation of innovative, safe, and effective medications derived from plants for the purpose of improving world health.

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