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A Short Review of the Current and Future Prospects of Herbal Medicine and Natural Products

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ABSTRACT

Background: Plants produce a diverse array of natural compounds including primary and secondary metabolites. Primary metabolites, such as those involved in photosynthesis, contribute to plant growth development. Secondary metabolites, on the other hand, play crucial roles in plant defense, signaling, and the production of medically important compounds. These secondary metabolites not only contribute to the aromatic properties of plants but also possess therapeutic potential. Furthermore, they play a multifaceted role in the plant's adaptation to various environmental stresses. This study aims to provide a comprehensive review to guide future clinical research on the medicinal applications of plant-derived compounds.
Methods: We conducted a detailed review of 38 articles and provided a thorough summary of our findings in this section.
Results: The utilization of medicinal plants has evolved over time. Initially, they were used solely for their medicinal properties, but subsequently, they have become the subject of extensive clinical research for the treatment of various diseases using their extracted compounds.
Conclusion: We suggest that researchers conduct clinical studies on the synergistic effect of natural plant compounds and explore the development of recombinant drugs for the treatment of a wide range of diseases.

1. Introduction

The use of plants as medicine has a long history. For thousands of years, ancient people have used various herbal products to treat medical ailments. This practice has varying levels of cultural significance, with some civilizations ascribing magical or religious properties to certain plant-based remedies. Dating back over 3,000 years, many plant species have been used in traditional health practices, such as traditional Chinese medicine, Indian Ayurvedic medicine, and traditional African medicine. While many of these plants have medicinal value according to Western standards, some herbs that have been used for centuries by different cultures have not been scientifically proven to be effective (Talapatra et al., 2015; Akinyemi et al., 2018). Of all the vascular plant species discovered to date, approximately ten percent have been used as medicinal plants. Quantitatively speaking, about 350,000 to 500,000 plant species have been used for their medicinal properties (Alinia-Ahanani, 2017). This practice has a long history, dating back to ancient times when people relied on trial and error to identify beneficial herbs. Over time, this knowledge was passed down through generations and became what is known today as traditional medicine. Traditional medicine is defined as "the body of knowledge, skills, and practices based on theories, beliefs, and experiences native to various cultures, whether

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explicable or inexplicable, used in health maintenance as well as prevention. "diagnosis, improvement, or treatment of physical and mental diseases". Traditional medicine is based on the types of plants found in that particular habitat and accepted by the respective civilizations. Some scholars have claimed that this transfer of traditional knowledge led to the emergence of the pharmaceutical industry. Currently, medicinal plants are cultivated worldwide to extract biologically active products for potential therapeutic applications (Alinia et al., 2020). The activity of the active structure of these biologically active compounds and their toxic effects on humans remained unknown until the 18th century, after which the healing nature of plants and their effects on humans were investigated to produce newer drugs Today, medicinal plants are widely studied for the development of new medicines in the field of traditional as well as modern medicine (Alinia Ahnani, 2018; Alinia Ahnani et al., 2020; Alinia Ahnani et al., 2023) (Figure 2 and 3). A notable milestone in the history of medical plant research was observed during the Renaissance period when an Iranian physician and scientist wrote a book on medical law that remained influential in the 18th century. This era also witnessed the emergence of main advances, such as the development of chemical analysis techniques and the invention of the microscope. These advances facilitated the extraction and isolation of active compounds from medicinal plants, which were subsequently synthesized in laboratories to produce pharmaceutical drugs. The use of such drugs gradually accelerated and led to a reduced reliance on the direct use of medicinal plants in modern medicine. Today, the medical industry is heavily dependent on the production of pharmaceutical drugs derived from the active ingredients found in plants, which serve as vital raw materials. However, in less developed regions, traditional medicine that directly uses medicinal plants remains due to its cost-effectiveness, as access to modern synthetic drugs is limited (Hartmann, 2008; Salamoglu et al., 2023; Khoo et al., 2018; Alinia-Ahandani et al., 2021; Ahandani et al., 2022). It is necessary to note that the use of traditional medicine may have two important forms. First, there is a risk of using medicinal plants without proper health regulations, regardless of the potential adverse effects on one's health. While many commonly used herbs, such as chamomile, rosemary, mint, or thyme, are generally safe with minimal side effects, other herbs may contain harmful active ingredients. For example, the green seeds of bitter melon (Momordica charantia L.), which is used to treat fever and malaria, can be highly toxic and lead to a serious drop in blood sugar, eventually causing a hypoglycemic coma. This toxicity results from the structural similarities between the interactions of natural products from animal insulin and bitter melon extract. Insufficient research has also led to misconceptions about many natural products. When reviewing the literature on medicinal plants, three main types of studies can be identified: surveys based on specific geographic areas, studies focused on specific plants or plant families, and research investigating specific medicinal activities of interest (Alinia-Ahandani, 2018). This study aims to provide a comprehensive review to guide future clinical research on the medicinal applications of plant-derived compounds.

1.1 Medicinal Plants in Traditional Knowledge

The use of natural products (NPs) as therapy and medicine can be traced through various cultural practices, including traditional potions, oils, and medicines. Of these, many methods involve the use of natural bioactive compounds that are not yet fully understood. The primary source of knowledge about the use of natural products derived from medicinal plants has come through centuries of human experimentation, often through trial and error, which involved the search for edibles with therapeutic properties. For example, the genus sage, which grows in northwestern Mexico and the southwestern United States, was used by Indian tribes in southern California to aid in childbirth. A unique method involved cooking baby boys in hot sage ash, as this process was believed to increase their strength and vitality and protect them from lifelong respiratory diseases (Heider et al., 2010). Another example is *Alhagi maurorum Medik*, commonly known as camel's thorn, which secretes a sweet, gummy substance from its stem and leaves on hot days. Manna, a gummy sap, consists mainly of inverted sugar, sucrose, and malicose. Ayurvedic doctors claim that it is useful in the treatment of fever, anorexia, dermatosis, constipation, obesity, epistaxis, leprosy, and more. Historical documents show that the Israelites boiled the root of this plant and used its extract to cure dysentery. In Konkani culture, smoking this herb was believed to be a cure for asthma, while the Romans used it to treat nasal polyps (Mayer et al., 2010). In Europe and North America regions, the herb *Ligusticum scoticum Linn.* was consumed raw in the morning, as it was believed to protect against infections. Furthermore, the root of this plant was used in the Faroe Islands as a sedative, pain reliever, and treatment for flatulence. On the other hand, nightingale (*Atropa belladonna Linn.*), a native plant found in North America, New Zealand, North Africa, Western Asia, and Central and Southern Europe, was considered too hazardous for use in folk medicine practices due to its highly toxic nature, where even the consumption of three berries could potentially prove fatal to a child. As a result, this plant was typically avoided for experimental purposes (Mayer et al., 2010; Alinia-Ahandani, 2018; Simanjuntak et al., 2016).

1.2 Historically significant natural products

Traditional medicine has served as the foundation for numerous early medicinal practices, which have subsequently been subject to further clinical, pharmacological, and chemical investigations. One of the most renowned examples to date is the extraction and purification of an anti-inflammatory agent, acetylsalicylic acid (aspirin) which was derived from another natural compound salicin isolated from willow tree (*Salix alba* L) bark. Another significant discovery was reported in 1803 when *Papaver somniferum* L. (poppy) was studied to identify various alkaloids like morphine (a commercially important

drug). During the 1870s, morphine in crude form was derived from the aforementioned plant which was subjected to a reaction with acetic anhydride, resulting in the production of diacetylmorphine (heroin), which could be easily converted to codeine, a pain reliever (Kim et al., 2010). Historical records indicate that ancient Iranians and Greeks as well as Sumerians were in practice of using poppy extract as a traditional medicine, however, the addictive properties of this extract were reported by the Arabs. In the 10th century, *Digitalis purpurea* L. (foxglove) was grown in Europe, but its property to improve cardiac contractile strength as well as improvement in cardiac conduction was reported due to the discovery of digitoxin, a cardiotonic glycoside in the 18th century. In the current times, digitoxin and its analogs are the subject of extensive research because of its ability to manage congestive heart failure despite its long-lasting side effects. Quinine (5), an antimalarial drug derived from *Cinchona succirubra* bark, has been utilized for centuries to treat malaria, fever, indigestion, oral and throat ailments, as well as cancer. Historical records have elaborated that the formal use of cinchona bark for treating malaria was initiated in the 19th century after which the British initiated its cultivation worldwide. Pilocarpine (6), obtained from *Pilocarpus jaborandi* (Rutaceae), is an alkaloid derived from L-histidine that has been employed as a clinical drug for over a century in the treatment of chronic open-angle glaucoma and acute angle-closure glaucoma. In 1994, an oral formulation of pilocarpine (6) received FDA approval for managing dry mouth (xerostomia), a side effect of radiation therapy for head and neck cancers. In the following sections, we will explore additional natural compounds found in plants and discuss recent scientific studies that have examined their clinical applications (Xu et al., 2018; Deyrup et al., 2011).

1.3 History of medicinal plants

It is estimated that 10% of all vascular plants are used for medicinal purposes, with between 350,000 to almost 500,000 species employed. The use of plants as medicines dates back to ancient times and has been gradually refined over generations, forming the foundations of traditional medical systems. The initial discovery of the therapeutic properties of plants largely occurred through trial-and-error experimentation, as populations sought to treat diseases and improve health using the flora available in their local environments The official definition of traditional medicine can be considered as the sum of knowledge, skills, and practices based on theories, beliefs, and experiences native to different cultures, whether explicable or inexplicable, used in the maintenance of health. "Also in the prevention, diagnosis, improvement, or treatment of physical and mental diseases. It is a fact that all civilizations have developed plant-based remedies for the plants found in their habitat. There are even authors who claim that this transmitted knowledge is the origin of medicine and pharmacy. Even today, hundreds of potential plants are cultivated around the world to achieve useful substances in medicine and pharmaceuticals. The healing properties of plants led to the creation of medicinal drugs made from specific plants with these benefits. Until the 18th century, the therapeutic properties of many plants, their effects on the human organism and their method of treatment were known, but the active compound was unknown. As an example, the Canon of Medicine written by the Persian physician and scientist Avicenna (Ibn Sina) was used until the 18th century. The origin of modern science, especially in the Renaissance, in particular chemical analysis, and the associated instrumentation such as the microscope, was what made it possible to isolate the active principles of medical plants. Since then, these active principles have been obtained synthetically in the laboratory to produce the medicines later. The use of medicines was gradually expanded. Until today, the direct use of medicinal plants is displaced in modern medicine. Today′s medicine needs the industry to produce pharmaceutical medicines, which are largely based on the active principles of plants, and therefore, these are used as raw materials in many cases. Recently, the underdeveloped world does not have access to this modern medicine of synthetic origin, and therefore, large areas of the world continue to use traditional medicine based on the direct use of medicinal plants due to their low cost (Salmerón-Manzano et al., 2020).

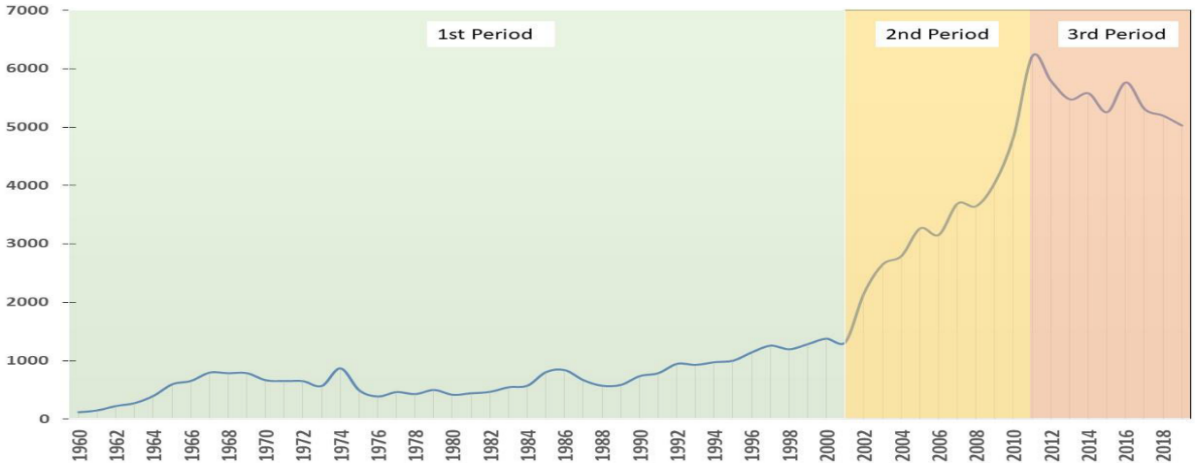

Figure 1. Worldwide temporal evolution of medical Plant publications (Salmerón-Manzano et al., 2020)

2. Materials and Methods

The research team consisted of pharmacists, biochemists, and botanists. In the initial phase of the literature review, each group searched for articles related to their fields, yielding a total of 120 articles. After specialized evaluations, only 38 articles were selected for further review. To ensure a comprehensive understanding of the subject matter and enable a more detailed investigation, we used a variety of keywords as well as more up-to-date and detailed content available The selected articles were sourced from reliable and reputable journals, and the review process incorporated evaluation of diverse perspectives and potentially contentious concepts.

3. Results and Discussion

3.1 Natural ingredients of plants

Biological reactions encompass a range of processes occurring within living organisms, including the absorption, synthesis, transformation, and interconversions of organic molecules in cells. These reactions involve both simple and complex organic molecules, occurring simultaneously and repeatedly. The three main biological processes are: (1) anabolism, the synthesis of small molecules and their ultimate conversion into complex ones, (2) self-replication, ensuring the continuation of life through generations, and (3) catabolism, the breakdown of molecules into smaller components (Talapatra et al., 2015; Hajipuor et al., 2022). Plants excel in carbon fixation and photosynthesis, the process through which green plants utilize sunlight energy to produce organic compounds. Photosynthesis involves the uptake of carbon dioxide and water, resulting in the synthesis of carbohydrates as the primary products. Through subsequent metabolic changes, these carbohydrates are transformed into simple organic compounds with low molecular weight, such as simple sugars. These small molecules are essential for the sustainability of all life forms and, hence regarded as primary metabolites. In plants, they serve similar metabolic functions, and their formation and transformation during anabolism and catabolism occur through primary metabolic pathways, constituting the primary metabolism of plants (Hartmann, 2008; Akinyemi et al., 2018). In the next step of metabolism, primary metabolites pass through a series of further reactions, leading to the formation of complex molecules known as secondary metabolites. The whole metabolic process is genetically regulated under the action of complex enzymes and the resultant products are distributed in nature in the whole fauna and flora of this world. These compounds are referred to as secondary metabolites. Figure 1 provides an overview of the production of these compounds (Alinia-Ahandani, 2018; Hartmann, 2008). Chemists refer to secondary metabolites as "natural products" to distinguish them from compounds traditionally studied by biochemists. These natural products exhibit unique characteristics, limited distribution, and often possess complex structures with various biological activities. Many of these compounds find applications in the field of pharmacy, insecticides, pesticides, and plant growth hormones (Talapatra, 2015; Birringer et al., 2018). The chemical composition of plants, particularly their natural products, can be influenced by environmental factors, such as location, season, and ecological parameters, which can lead to differences in the quantity, variety, and medicinal properties of extracted compounds. Additionally, different stages of a plant's life cycle, especially in the case of higher plants, can result in Variations in natural product content. Quite a small number of compounds may be present in certain stages but not reported, while previously isolated compounds may no longer be present. A considerable variation in the alkaloid contents of the plants grown in different areas of the world was noticed such as India, Madagascar, and elsewhere, due to the change in the ecological parameters (BASTIAN et al., 2016; Birringer et al., 2018). Likewise, the alterations among the various parts of plants were noticed especially the variations in the type and concentration of compounds among various parts of trees was also noticed. For smaller plants like creepers and herbs, as well as small shrubs, the amount of these compounds can vary in different parts of plants (Alinia-Ahandani et al., 2022).

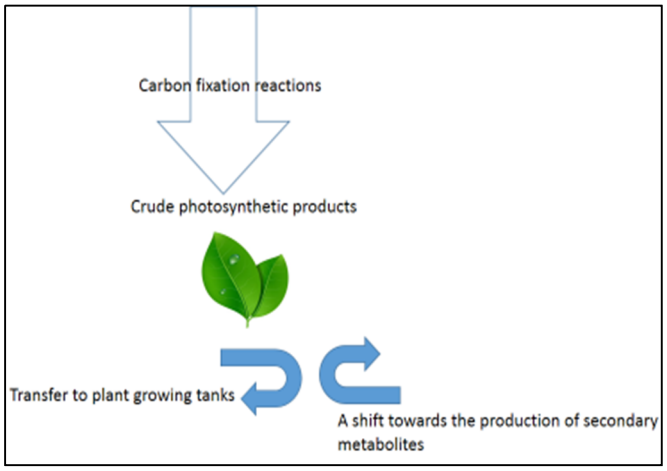

Figure 2. Overview of the production of natural compounds in plants

3.2 Definition of secondary metabolites as natural compounds

Plant bioactive compounds, also known as secondary metabolites, are small organic molecules that originate from primary plant metabolites. These compounds typically have a molecular mass of less than 3000 daltons. Primary metabolites are produced during photosynthesis and ultimately lead to the production of secondary metabolites. These primary metabolites are not directly involved in growth and development. The biosynthesis of secondary metabolites involves changes such as methylation, glycosylation, and hydroxylation (Tahmasebi et al., 2018; Alinia-Ahandani et al., 2023; Isah et al., 2018). Based on biosynthetic pathways, plant metabolites can be classified

into three main categories namely phenolic compounds, terpenes, steroids, and nitrogen-containing compounds. Secondary metabolites play their obligate role in carrying out certain physiological and biochemical roles which further ensures the survival and ecological interactions while coping with the biotic as well as abiotic stresses (Yang et al., 2022). Plants possess versatile spectra of pharmacological potential due to the presence of complex moieties along with the varying structure-activity relationships between them (Andrade et al., 2016; Chetri et al., 2016). Every year, newer cytotoxic drug candidates are channelized into the drug discovery process mainly isolated from plants. Some of these compounds are ruled out because of the limitations in the factors like bioavailability and toxicity. However, plant secondary metabolites can serve as promising leads for drug development. The cytotoxic potential of plant secondary metabolites may be enhanced by modifications in the chemical structure of these compounds while considering their ADMET (absorption, distribution, metabolism, elimination, toxicity) properties (Alinia-Ahandani et al., 2022; Cusido et al., 2014).

3.3 Herbal medicine

Medicinal plants play a crucial role in providing health benefits and treating a wide range of diseases, as well as serving as a source of food for communities. The healing properties of many plants were known before the 18th century, despite the biological mechanisms underlying their efficacy remaining largely unknown at the time. Plant-derived metabolites have been utilized for medicinal and nutritional purposes since as early as 2600 BC, and over the next 4000 years, secondary metabolites of plant origin were predominantly used for such applications (Alinia-Ahandani et al., 2022; Daglia et al., 2023). Numerous drugs used in modern medicine have a historical background as herbal remedies, including opium, aspirin, digitalis, and quinine. The use of medicinal plants is growing worldwide due to the expanding interest in herbal treatments and traditional medicine. Plants are used in medical practices to enhance physical, mental, and spiritual well-being, as well as to address specific conditions and diseases. Traditional medicine, referred to as "complementary" or "alternative" medicine in industrialized countries, continues to be popular in developing regions and is rapidly expanding in industrialized nations. The global herbal medicine market exceeds 80 billion dollars annually and continues to grow. For example, in countries such as Nigeria, Ghana, Mali, and Zambia, traditional medicine is the primary healthcare choice for up to 60% of children with high fever caused by malaria (Akinyemi et al., 2018; Selamoglu et al., 2023). Plants store valuable metabolites in specialized tissues and structures like vacuoles, specialized glands, and trichrome (Isah et al., 2018; Ruiz & Hernández, 2016). Traditional medicine relies on the beneficial properties of various herbs for the treatment of diverse diseases and disorders over an extended period. Phytochemicals and medicinal herbs are now recognized as powerful therapeutic tools in modern medicine. Increasing evidence suggests that medicinal herb extracts can positively influence cellular behavior both in vitro and in vivo. Natural medicinal compounds are being investigated for their potential in treating cancer and promoting tissue repair and regeneration. Since angiogenesis plays a crucial role in physiological and pathological conditions, therapeutic approaches have been developed to regulate neovascularization by promoting or inhibiting it. While most phytochemicals and medicinal herbs have been utilized in an antiangiogenic context, specific plant compounds can induce neo-vessel formation, making them valuable for accelerating wound healing (Andrade et al., 2016). While recent studies indicate a decrease in the use of traditional medicines, even in middle-income countries, the utilization of herbal medicines remains common worldwide, particularly in oncology treatment. Over the past two decades, the acceptance of herbal medicines as complementary and alternative treatments has grown significantly in many developed countries, albeit under strict and controlled regulations. Natural products have gained attention in cancer chemotherapy due to their biological compatibility with target sites and lower toxicity to normal cells. Moreover, anticancer drugs derived from natural products have shown alternative modes of promoting cell death. As a result, researchers are increasingly exploring the potential of plants to provide natural products that can be valuable for the pharmaceutical industry. The use of natural products as a basis for discovering and developing medicinal entities remains an active area of research. Approximately 49% of tiny molecules approved for cancer chemotherapy between 1940 and 2014 are derived from natural products (Mujib et al., 2014). In this section, we present a range of natural compounds derived from plants, which serve as the primary components in the production of various drugs. Curcumin, a bioactive compound belonging to the curcuminoid group, is responsible for the yellow color of turmeric. Studies have demonstrated that curcumin, which constitutes 2-5% of turmeric, suppresses tumorigenesis induced by reactive oxygen species (ROS) and provides protection against ROS-induced DNA damage in normal tissues. Notably, curcumin exhibits minimal toxicity to healthy tissue, even at doses exceeding 8 grams per day, making it a valuable anti-cancer agent (Deyrup et al., 2011). Clinical studies have indicated that curcumin is safe for consumption and exhibits therapeutic potential against cancer. For instance, increased curcumin dosage (500-8000 mg per day) over three months led to improved histology of precancerous lesions in patients with bladder cancer (Ruiz & Hernández, 2016). Epidemiological studies have reported the presence of an effective compound in green tea (*Camellia sinensis L*) that reduces the risk of various cancers. Consumption of green tea has been found to significantly decrease smoking-induced micronuclei, a marker of DNA damage, in peripheral white blood cells among smokers (Deyrup et al., 2011). Through a review of research, it has been observed that supplementing smokers with four cups of decaffeinated green tea (73.5 mg of catechin per cup) over four months resulted in a 31% reduction in urinary 8-OHdG

levels. Furthermore, regular consumption of ≥150 grams of tea per month (equivalent to 2-3 cups per day) has been associated with a protective effect against esophageal cancer in women. Green tea consumption has also shown a small protective role against breast, colon, and prostate cancer (Alinia-Ahandani et al., 2018).

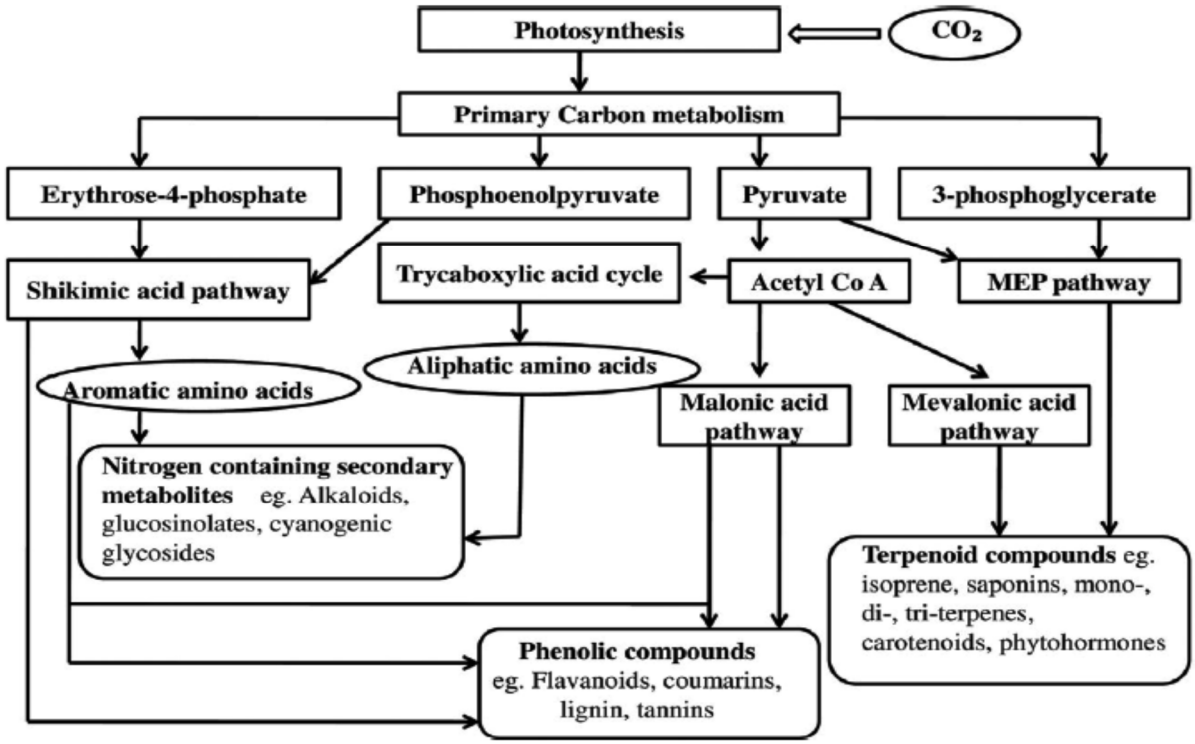

Figure 3. Production pathways of natural compounds in plants (Verma & Sukla, 2015)

Researchers have discovered that resveratrol, a natural polyphenol found in blueberries, cranberries, nuts, red grapes, and wine, exhibits chemopreventive activity against all three stages of carcinogenesis. Resveratrol exerts its anti-cancer effects through its antioxidant and anti-inflammatory properties. Numerous studies have indicated a 50% or greater reduction in breast cancer risk among women who consumed resveratrol-rich grapes. Laboratory studies exploring the chemotherapy effects of resveratrol on breast, pancreas, and prostate cancer have yielded promising results due to its antioxidant potential (Andrade et al., 2016). *Citrus* flavonoids, including hesperidin, nobilitin, 2'-hydroxyflavanone (2HF), and quercetin, are valuable compounds with anticancer effects. These flavonoids, abundantly found in citrus fruits and peels, regulate oxidative stress pathways and contribute to cancer prevention and treatment (Chikara et al., 2018). Genistein, a potent anti-cancer compound, is commonly isolated from soybeans, lentils, peas, and beans. It demonstrates a pro-apoptotic effect in colon cancer and exhibits diverse functions (Khan et al., 2022). Lycopene, a vibrant red pigment present in tomatoes, red carrots, watermelon, and red papaya, acts as a potent antioxidant. By activating antioxidant enzymes such as GSH, GPx, and GST, lycopene effectively reduces oxidative damage. It inhibits the growth of cancer cells and induces apoptosis by suppressing the ERK signaling pathway (Khan et al., 2022; Chikara et al., 2018). Chrysin, a phytochemical widely found in *Matricaria chamomilla* L., *Oroxylum Indicum* (L.) Kurz, *Passiflora edulis* Sims, *P. caerulea* L., as well as in honey, passion fruit, and mushrooms, exhibits inhibitory effects on proliferation and induces apoptosis in various cancer cells, potentially surpassing other flavonoids in leukemia cells (Naz et al., 2019).

4. Conclusion

We reviewed many studies in the field of natural compounds of plants, the results of the studies show that the natural compounds of plants include two parts, primary metabolites and secondary metabolites. Primary metabolites are the result of photosynthetic reactions that produce sugars, a part of the primary metabolites goes to the growing reservoirs of plants and reaches the consumption of growing fruits and seeds, but another part goes to the production of compounds considered these compounds do not play a role in growth and development, but they are effective in creating aroma, color, taste, and most importantly in creating the

medicinal role of plants. In contrast, secondary metabolites have a multi-dimensional role in the life of plants, conferring resistance to various environmental stresses in addition to their medicinal properties. The use of medicinal plants has evolved over time, transitioning from their empirical application as traditional remedies to the inception of clinical research investigating the therapeutic potential of their constituent compounds. This progression has involved an initial phase of medicinal use, followed by the commencement of clinical studies exploring the application of these plant-derived compounds in the treatment of various diseases, including their extraction and purification. We should also pay attention to the fact that the use of healthy and safe medicinal plants and the examination of nutritional contaminating factors can be very important, which has been widely mentioned in various articles (Alinia-Ahandani et al., 2019; Daglia et al., 2023). The findings from these studies suggest that natural plant-derived compounds hold promise as alternatives to synthetic pharmaceuticals, potentially offering reduced side effects. Accordingly, researchers are encouraged to conduct further clinical investigations exploring the synergistic effects of these natural compounds, to develop more efficacious treatments for a broader range of diseases.

Authors' Contributions

Sahebeh Hajipour: The main idea and text writing. Ali Ghonoudi: Search for articles. Ebrahim Alinia-Ahandani: Correcting the text and providing a solution. Ammara Riaz: Sorting sources.

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Conflicts of Interest

The authors have declared that no Conflict of Interest.

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Ethical considerations

Before collecting the articles, the researchers of the present study fully explained the purpose of the study to the participants and assured them that their participation in the study was completely voluntary. Privacy and confidentiality of the content were considered. Informed consent was obtained from the study participants.

References

1. Ahandani, E. A., Rafeie, F., Alizadeh-Tarpoei, Z., Hajipour, S., Selamoglu, Z., & Heidari-Bazardehy, S. S. (2022). An attitude towards the effects of heavy metals in medicinal plants. *Bioengineering Studies*, *3*(2), 1-7.

2. Akinyemi, O., Oyewole, S. O., & Jimoh, K. A. (2018). Medicinal plants and sustainable human health: A review. *Horticultural International Journal*, *2*(4), 194-195.

3. Alinia-Ahandani, E. (2018). Medicinal plants with disinfectant effects. *Journal Pharmacology Science Research*, *10*, 1.

4. Alinia-Ahandani, E., Nazem, H., Malekirad, A. A., & Fazilati, M. (2022). The safety evaluation of toxic elements in medicinal plants: A systematic review. *Journal of Human Environment and Health Promotion*, *8*(2), 62-68.

5. Alinia-Ahandani, E., Alizadeh-Terepoei, Z., Sheydaei, M., Selamoglu, Z., & Alinia-Ahandani, M. (2022). A new perspective on the introduction of some medicinal plants for oral health and teeth. *Advances Dentistry Oral Health*, *15*(2), 555909.

6. Alinia-Ahandani, E., Rafeie, F., Alizadeh-Tarpoei, Z., Hajipour, S., Selamoglu, Z., & Arici, E. C. (2023). Overview of raspberry leaves and cohosh (Caulophyllum thalictroides) as partus preparatory. *Central Asian Journal of Plant Science Innovation*, *2*(2), 54-61.

7. Alinia-Ahandani, E., Alizadeh-Terepoei, Z., & Boghozian, A. (2019). The positive role of green tea as an anti-cancer biomedical source in Iran northern. *American Journal of Biomedical Science & Research*, *5*(1), 15-18.

8. Alinia-Ahandani, E., Nazem, H., Boghozian, A., & Alizadeh, Z. (2019). Hepatitis and some effective herbs: A review. *EAS Journal Parasitology Infectious Diseases*, *1*(1), 20-27.

9. Alinia-Ahandani, E., Malekirad, A. A., Nazem, H., Fazilati, M., Salavati, H., & Rezaei, M. (2021). Assessment of some toxic metals in ziziphora (ziziphora persica) obtained from a local market in Lahijan, Northern Iran. *Annals of Military and Health Sciences Research*, *19*(4).

10. Alinia-Ahandani, E., Boghozian, A., & Alizadeh, Z. (2019). New approaches of some herbs used for reproductive issues in the world: Short review. *Journal Gynecology Women's Health*, *16*(1), 555927.

11. Alinia-Ahandani, E. (2018). Medicinal plants and their usages in cancer. *Journal Pharmacology Science Research*, *10*, 2.

12. Alinia-Ahandani, E. (2018). Medicinal plants are effective in pregnancy, infections during pregnancy, and fetal infections. *Journal Pharmacology Science Research, 10*(3).

13. Andrade, E. L., Bento, A. F., Cavalli, J., Oliveira, S. K., Schwanke, R. C., Siqueira, J. M., . . . & Calixto, J. B. (2016). Non-clinical studies in the process of new drug development II: Good laboratory practice, metabolism, pharmacokinetics, safety, and dose translation to clinical studies. *Brazilian Journal of Medical and Biological Research*, *49*, e5646.

14. Birringer, M., Siems, K., Maxones, A., Frank, J., & Lorkowski, S. (2018). Natural 6-hydroxy-chromanols and-chromenols: Structural diversity, biosynthetic pathways, and health implications. *RSC Advances*, *8*(9), 4803-4841.

15. Chetri, S. K., Kapoor, H., & Agrawal, V. (2016). Marked enhancement of sennoside bioactive compounds through precursor feeding in Cassia angustifolia Vahl and cloning of isochorismate synthase gene involved in its biosynthesis. *Plant Cell, Tissue and Organ Culture (PCTOC)*, *124*, 431-446.

16. Chikara, S., Nagaprashantha, L. D., Singhal, J., Horne, D., Awasthi, S., & Singhal, S. S. (2018). Oxidative stress and dietary phytochemicals: Role in cancer chemoprevention and treatment. *Cancer Letters*, *413*, 122-134.

17. Cusido, R. M., Onrubia, M., Sabater-Jara, A. B., Moyano, E., Bonfill, M., Goossens, A., . . . & Palazon, J. (2014). A rational approach to improving the biotechnological production of taxanes in plant cell cultures of Taxus spp. *Biotechnology Advances*, *32*(6), 1157-1167.

18. Daglia, M., Pasdaran, A., Ahandani, E. A., & Selamoglu, Z. (2023). Medicinal plants as a hopeful therapeutic approach against COVID-19 infection. *Central Asian Journal of Medical and Pharmaceutical Sciences Innovation*, *1*(3), 1.

19. Deyrup, S. T., Eckman, L. E., McCarthy, P. H., Smedley, S. R., Meinwald, J., & Schroeder, F. C. (2011). 2D NMR-spectroscopic screening reveals

polyketides in ladybugs. *Proceedings of the National Academy of Sciences*, *108*(24), 9753-9758.

20. Hajipuor, S., Alinia-Ahandani, E., & Selamoglu, Z. (2022). A closer look at some medical use of green Persian walnut shell. *Eurasian Journal of Medical and Biological Sciences*, *17*.

21. Hartmann, T. (2008). The lost origin of chemical ecology in the late 19th century. *Proceedings of the National Academy of Sciences*, *105*(12), 4541-4546.

22. Heider, D., Verheyen, J., & Hoffmann, D. (2010). Predicting Bevirimat resistance of HIV-1 from genotype. *BMC Bioinformatics*, *11*, 1-9.

23. Isah, T., Umar, S., Mujib, A., Sharma, M. P., Rajasekharan, P. E., Zafar, N., & Frukh, A. (2018). Secondary metabolism of pharmaceuticals in the plant in vitro cultures: strategies, approaches, and limitations to achieving higher yield. *Plant Cell, Tissue and Organ Culture (PCTOC)*, *132*, 239-265.

24. Khan, A. W., Farooq, M., Haseeb, M., & Choi, S. (2022). Role of plant-derived active constituents in cancer treatment and their mechanisms of action. *Cells*, *11*(8), 1326.

25. Kim, H. K., Choi, Y. H., & Verpoorte, R. (2010). NMR-based metabolomic analysis of plants. *Nature Protocols*, *5*(3), 536-549.

26. Mayer, A. M., Glaser, K. B., Cuevas, C., Jacobs, R. S., Kem, W., Little, R. D., & Shuster, D. E. (2010). The odyssey of marine pharmaceuticals: A current pipeline perspective. *Trends in Pharmacological Sciences*, *31*(6), 255-265.

27. Mujib, A., Ali, M., & Isah, T. (2014). Somatic embryo mediated mass production of Catharanthus roseus in culture vessel (bioreactor)-A comparative study. *Saudi Journal of Biological Sciences*, *21*(5), 442-449.

28. Naz, S., Imran, M., Rauf, A., Orhan, I. E., Shariati, M. A., Shahbaz, M., & Heydari, M. (2019). Chrysin: Pharmacological and therapeutic properties. *Life Sciences*, *235*, 116797.

29. Ruiz, R. B., & Hernández, P. S. (2016). Cancer chemoprevention by dietary phytochemicals: Epidemiological evidence. *Maturitas*, *94*, 13-19.

30. Salmerón-Manzano, E., Garrido-Cardenas, J. A., & Manzano-Agugliaro, F. (2020). Worldwide research trends on medicinal plants. *International Journal of Environmental Research and Public Health*, *17*(10), 3376.

31. Selamoglu, Z., Alinia-Ahandani, E., Alizadeh-Tarpoei, Z., Hajipour, S., & Rafeie, F. (2023). A mini-review of the medicinal properties of the lavender plant and ways to increase its effective compounds. *Journal of Human Environment and Health Promotion (JHEHP)*, *9*(1).

32. Simanjuntak, D. H., Herpandi, H., & Lestari, S. D. (2016). Karakteristik kimia dan aktivitas antioksidan kombucha dari tumbuhan apu-apu (Pistia stratiotes) selama fermentasi. *Jurnal FishtecH*, *5*(2), 123-133.

33. Tahmasebi, A., Aram, F., Pakniyat, H., Niazi, A., Tavakol, E., & Ebrahimie, E. (2018). Global analysis of gene expression and identification of modules in Echinacea purpurea using a systems biology approach. *Journal of Cell and Molecular Research*, *10*(1), 18-26.

34. Talapatra, S. K., & Talapatra, B. (2015). *Chemistry of plant natural products* (pp. 855-874). Berlin, Germany, Springer.

35. Verma, N., & Shukla, S. (2015). Impact of various factors responsible for fluctuation in plant secondary metabolites. *Journal of Applied Research on Medicinal and Aromatic Plants*, *2*(4), 105-113.

36. Xu, W., Zou, Z., Pei, J., & Huang, L. (2018). Longitudinal trend of global artemisinin research in chemistry subject areas (1983-2017). *Bioorganic & Medicinal Chemistry*, *26*(20), 5379-5387.

37. Yang, M., Wu, C., Zhang, T., Shi, L., Li, J., Liang, H., . . . & Li, F. (2022). Chicoric acid: Natural occurrence, chemical synthesis, biosynthesis, and their bioactive effects. *Frontiers in Chemistry*, *10*, 888673.