



Plantago major as a Beneficial Medicinal Plant

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Abstract

Medicinal plants have always obtained a high interest in the management of diseases and conditions. In this regard, *Plantago major* is a perennial plant, and is native to most of Europe, Northern, and Central Asia. *Plantago* is a genus widely distributed all over the world; *P. major* is spread in temperate regions of Asia, South Australia, North America, and North Africa and the leaves of *P. major* have been used for centuries to treat diseases relating to skin, digestive organs and blood circulation like wounds, inflammation, and hypertension. Greek physicians described the traditional use of *P. major* in wound healing already in the first century A.D. *P. major* contains biologically active compounds, such as polysaccharides, lipids, caffeic acid derivatives, flavonoids, iridoid glycosides, alkaloids, and terpenoids, and also the presence of different vitamins, such as ascorbic acid and carotenoids. In this paper, pharmacological properties, adverse events, toxicity, and applications of *Plantago major* are evaluated, and beneficial approaches might be provided for future clinical trials, and new pharmaceutical compounds of plantain are made.

Introduction

Herbal medicine has improved in developing countries as an alternative solution to health problems and the costs of pharmaceutical products. The development of drug resistance in human pathogens against commonly used antibiotics has necessitated a search for new antimicrobial substances from other sources, including plants [1]. Plants used for traditional medicine contain a wide range of substances that are used to treat chronic as well as infectious diseases [2]. The use of plants has been a widespread practice in folk medicine, both in urban and rural areas, as an alternative or complementary treatment to conventional medicine [3]. Under the plant kingdom, medicinal plants have been mainly used by local peoples found in developing countries, especially in resource-limited areas. Many people in this region directly or indirectly use medicinal plants to satisfy their primary healthcare needs [4]. Consumers' interest in using herbal products for personal and health care has grown worldwide [5]. Phytomedicines, derived from medicinal plant seeds, roots, leaves, fruits, and flowers, can treat diseases [6]. Many researchers have given more attention to medicinal plants because they can generate many uses and applications in medicine

and pharmacy [7]. It is estimated that half of the pharmaceutical drugs are derived from medicinal plants due to their capacity as chemical constituents that bring therapeutic effects [8]. *Plantago* is a genus of medicinal plants belonging to the Plantaginaceae which is a family of medical plant that is widely used, it has about 275 species that grow annually and permanently. They are found in temperate regions and in tropical zones and the most famous species are *P. major*, *P. ovate*, *P. media*, *P. lanceolata*, *P. indica*, and *P. asiatica*. They have been developed as medicines for thousands of years due to their considerable bioactivity and contain beneficial phytochemicals [9]. Its name comes from the Latin "planta" meaning "sole" to represent the broad leaves lying touching the ground [10]. It is known for its pharmaceutical activities [11]. *Plantago* has a wide range of uses, including raw materials for salads, soups, baking, and animal feed to improve health and reduce antibiotic use [12]. In traditional medicine, this plant has been extensively used in a number of diseases related to ophthalmology, reproduction, pulmonology, gastrointestinal system, and dermatology [6]. In recent years, researchers have found several bioactive compounds and mechanisms responsible for

More Information

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this plant's wide range of medical benefits. Flavonoid compounds that are isolated from the whole plant contain antidiabetic, antidiarrheal, anti-inflammatory, and wound-healing capacities. Polyphenols and polysaccharides are also responsible for their healing effects. Phenols and flavonoids are also antioxidative agents of *P. major* that contribute to wound healing by protecting the cells from destruction by inflammatory agents [6].



Figure 1: *Plantago major* Plant

Characteristics of *Plantago major*

Plantago major (Figure 1) consists of a short stem, broad leaves, roots, flowers, and seeds. There are about five to nine prominent veins on the leaves. The flowers are greenish-brown in color with purple

stamens and are small in size. The plant has small oval-shaped seeds which have a slightly unpleasant bitter taste [13].

Stems and Leaves

The herbaceous stem of *P. major* is short, sturdy, and erect. The leaves grow up to 30 cm long and form a basal rosette, and the leaves have parallel venation (5-9) and are oblong to elliptic in form. The leaf blade is whole or irregularly serrated, and the petiole is narrow. The leaf petiole is nearly as long as the blade. The leaves are glabrous or hairy and are usually green with purple coloring [14] (Figure 2).

Roots

Plantago major produces a large number of whitish adventitious roots [15] (Figure 2). The roots can reach a length of one meter [14].

Flowers

In the temperate zone, *P. major* flowers from May to September, but this can vary depending on where the plants are planted. The average time for a plant to flower for the first time is 13 weeks, but plants can flower and start setting seeds as soon as 6 weeks following germination [14] (Figure 2).

Seeds

The seeds of *P. major* are formed in capsules with 4-15 seeds per capsule. Seeds set rapidly within three weeks after flowering. *P. major* plants produce a large number of seeds, up to 20,000 per plant. The seeds are quite small ($0.4-0.8 \times 0.8-1.5$ mm) with an ovate to elliptic shape, which varies according to the number of seeds in the capsule. The seeds become thick when moistened because of the polysaccharides present in the seed coat, and can become attached to animals and humans, and thus spread over large distances [14] (Figure 2).

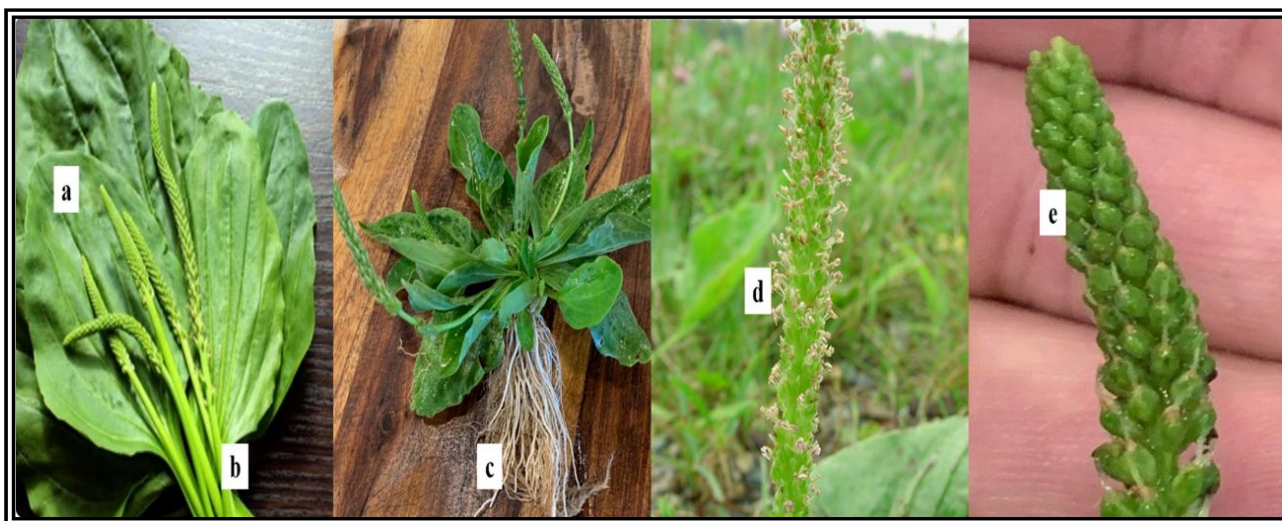


Figure 2: *Plantago major* Structures; (a) leaf, (b) stem, (c) root, (d) flower, and (e) seeds



Distribution of *Plantago major*

Plantago major was once found primarily in Europe, Northern and Central Asia and now is widely dispersed throughout the world where it is known as a common weed [8]. A study on air pollen content was conducted and found that this species has been present in Denmark, Finland, Iceland, Norway, and Sweden as well as their autonomous regions (the Aland Islands, the Faroe Islands, and Greenland) thousands of years ago. It was also identified in England in 1672 and has been known in Canada since 1821 [8]. Interestingly, *P. major* was nicknamed 'white man's footprint' by the Indians because it was found in every place Europeans had been [13]. *P. major* is readily found in areas with compacted soil, such as roadsides and beside paths. Besides, it is fertilized by the wind and propagates

primarily by seeds, which are held on the spikes located above the leaves [8].

Plantago major Chemical Constituents

Plantago major is an important therapeutic plant that contains a variety of bioactive compounds including flavonoids, alkaloids, terpenoids, phenolic compounds (caffeic acid derivatives), iridoid glycosides, fatty acids, polysaccharides, and vitamins. These compounds can be found in nearly all parts of the plant, such as the seeds, leaves, and roots. The bioactivities of *P. major* are attributed to these chemical constituents [16].

Terpenoids

Terpenoids (Figure 3) were isolated from the leaves of *P. major*; Pailer and Haschke-Hofmeister isolated loliolid from the leaves and also ursolic acid, oleanolic acid, sitosterol acid [17].

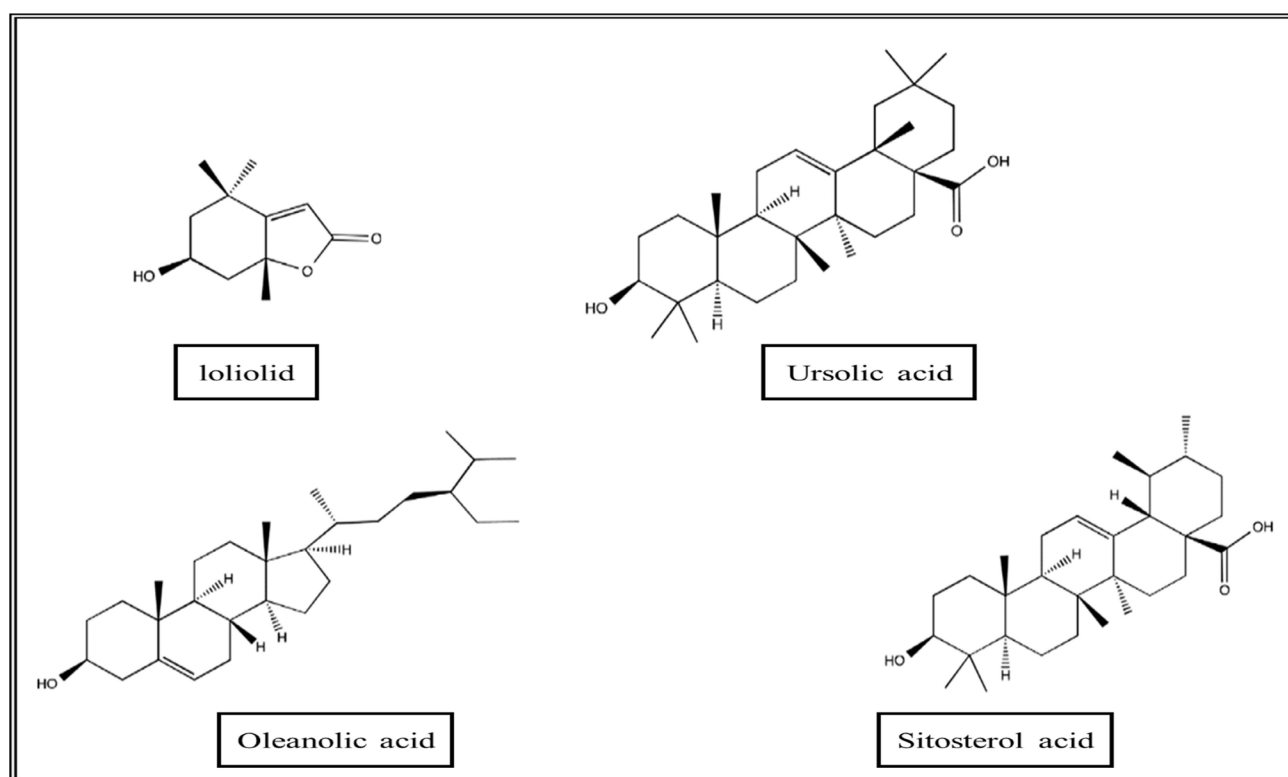


Figure 3: Terpenoids in *P. major*

Flavonoids

The presence of flavonoids (Figure 4) in *P. major* has been widely reported. The main flavonoids present are flavones, including luteolin, and apigenin [16]. A number of scholars have isolated flavonoids from this plant, including Yuting *et al.*, who isolated baicalein,

hispidulin, and plantaginin and Sanz *et al.*, who isolated scutellarein [18]. Kawashty *et al.* isolated a broad number of flavonoids from *P. major* in Egypt: luteolin 7-glucoside, hispidulin 7-glucuronide, luteolin 7-diglucoside, apigenin 7-glucoside [19]. Skari *et al.*, found homoplantagin [20].



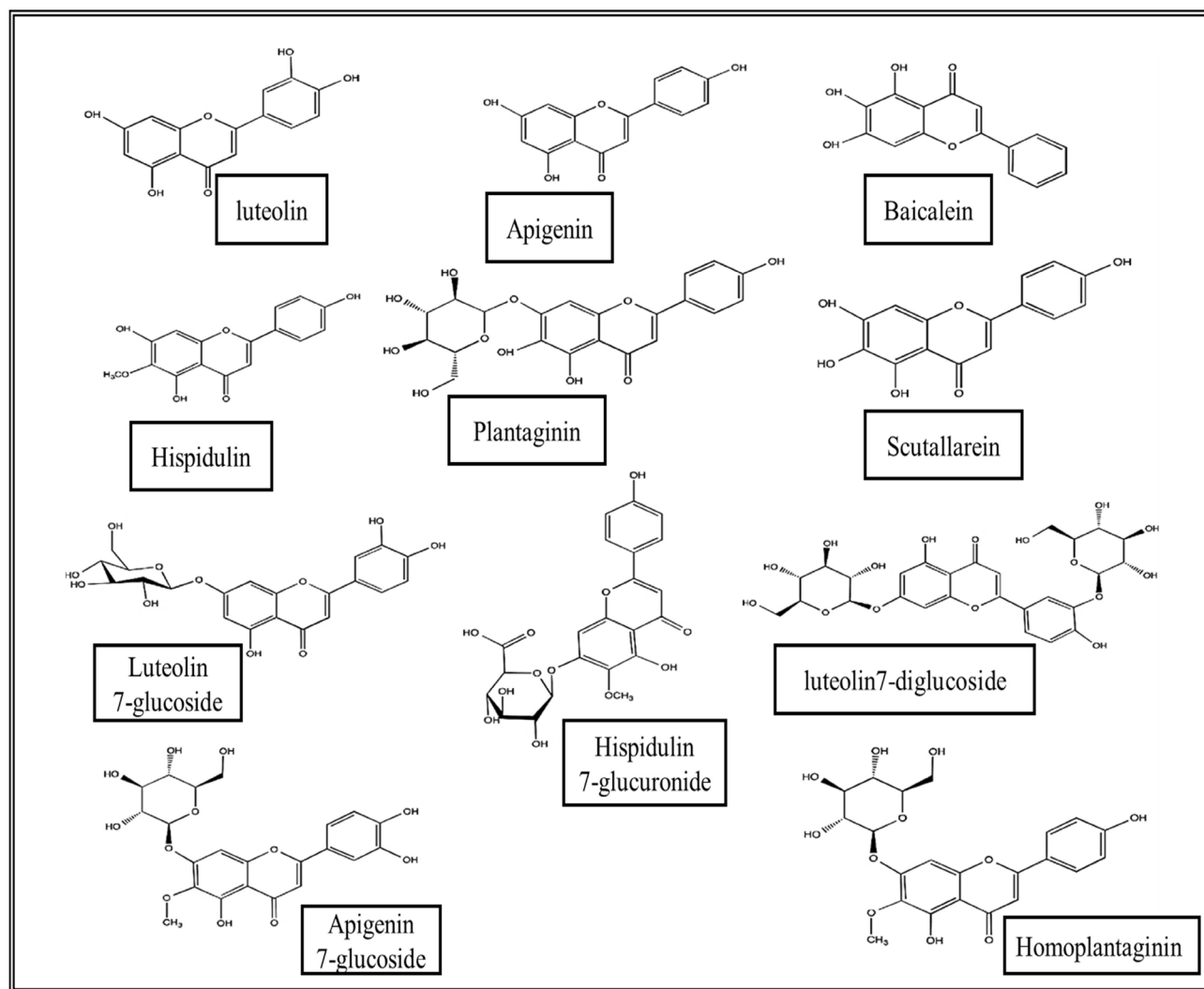


Figure 4: Flavonoids in *P. major*

Alkaloids

Schneider isolated the alkaloids indicain, and plantagonin from *P. major* [21] (Figure 5).

Caffeic acid Derivatives

Noro, found caffeic acid derivatives (Figure 6), namely plantamajoside, and acteoside [22] and these findings were also proven by Skari and his colleagues [20].

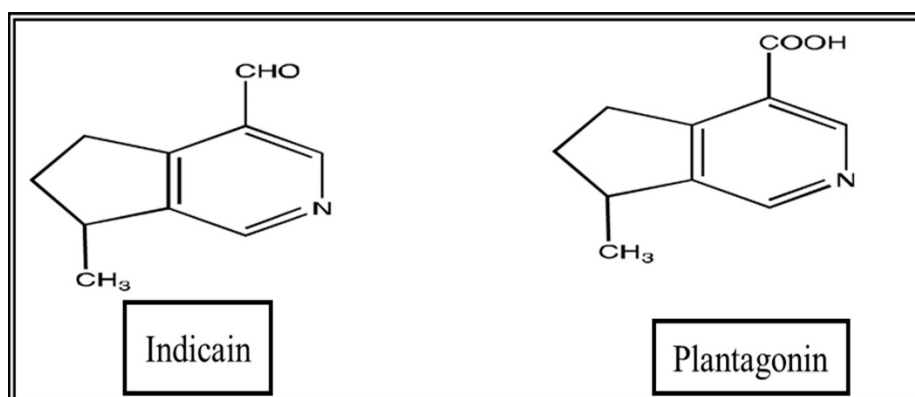
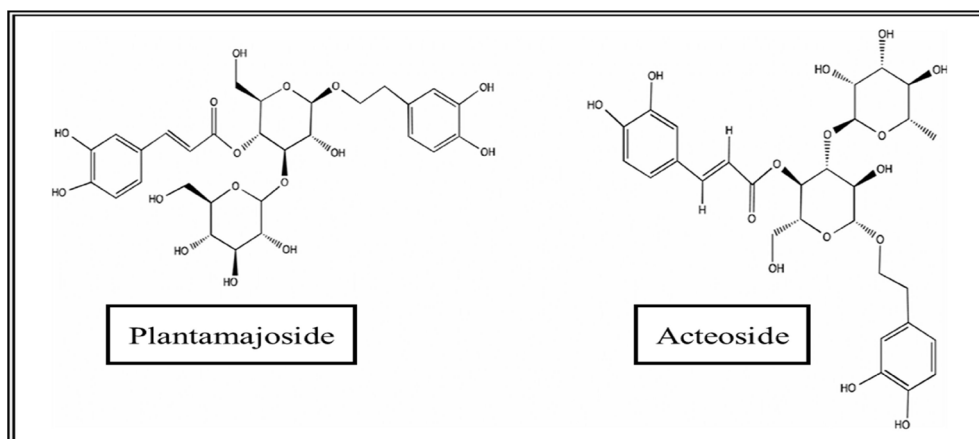


Figure 5: Alkaloids in *P. major*

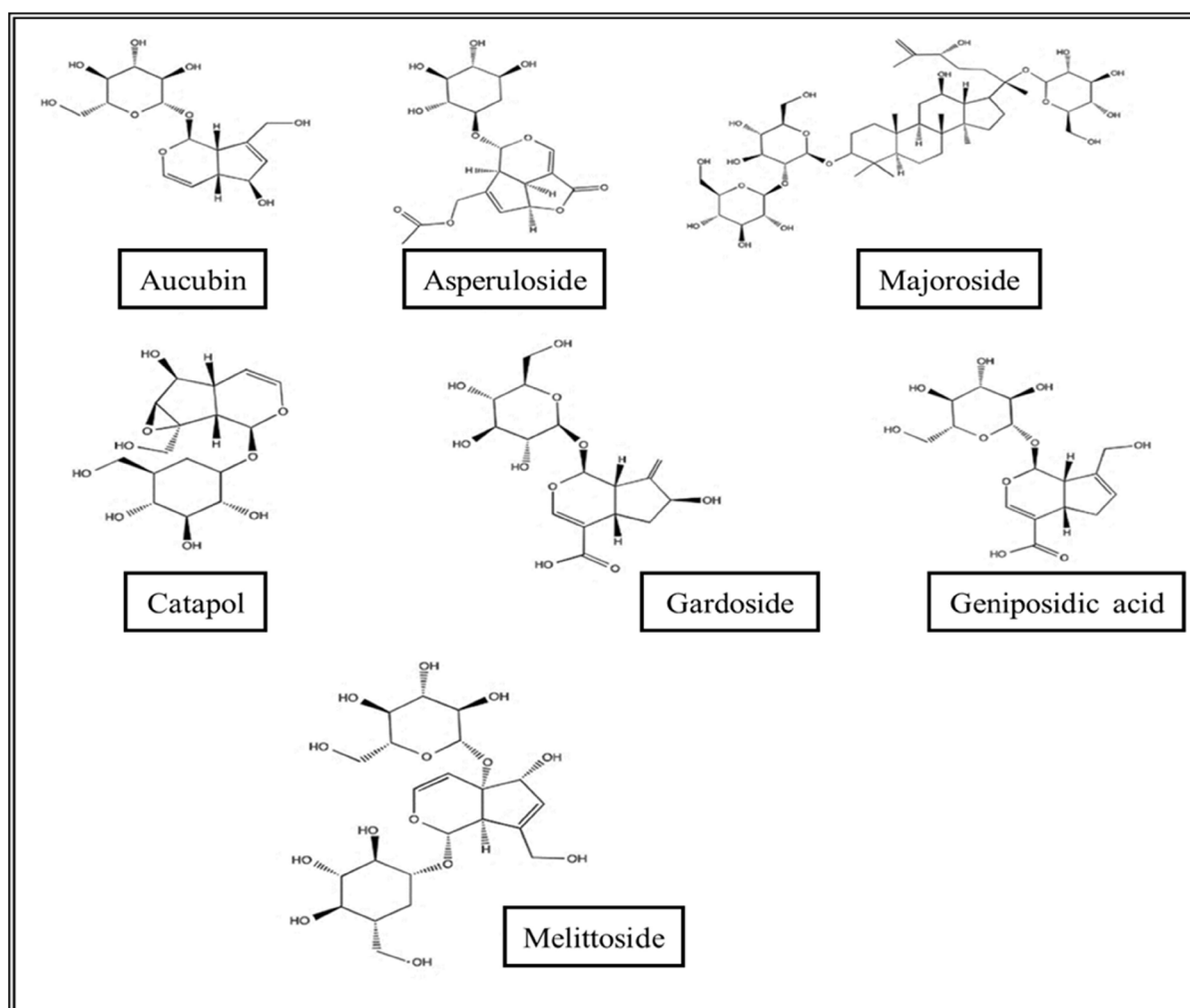


Figure 6: Caffeic Acid Derivatives in *P. major*

Iridoid Glycosides

The main iridoid glycosides present in *P. major* are aucubin, which Long *et al.*, isolated them from the leaves [16]. A number of other iridoid glycosides (Figure 7) were isolated from other parts of the plant. While Bianco *et al.*, isolated asperuloside from the flowers [16], a number of studies have shown the presence of

iridoid glycosides in the aerial parts of *P. major*. These include the study by Handjieva *et al.*, which found majoroside in the aerial part of *P. major*, and the study by Murani *et al.*, in 1995 that added catapol, gardoside, geniposidic acid, and melittoside to the substances extracted from the aerial part.

Figure 7: Iridoid Glycosides in *P. major*

Fatty Acids

Fatty acids (Figure 8) were also isolated from the seeds and leaves of *P. major*. Pailer and Haschke-Hofmeister isolated lignoceric acid from the seeds [17]. Besides, the presence of palmitic acid, stearic acid, oleic acid,

and linoleic acid was confirmed in *P. major* by using gas-liquid chromatography spectrophotometric techniques [16]. Likewise, myristic acid was isolated from the seeds [16]. In addition, arachidic acid, and behenic acid isolated from the leaves [16].

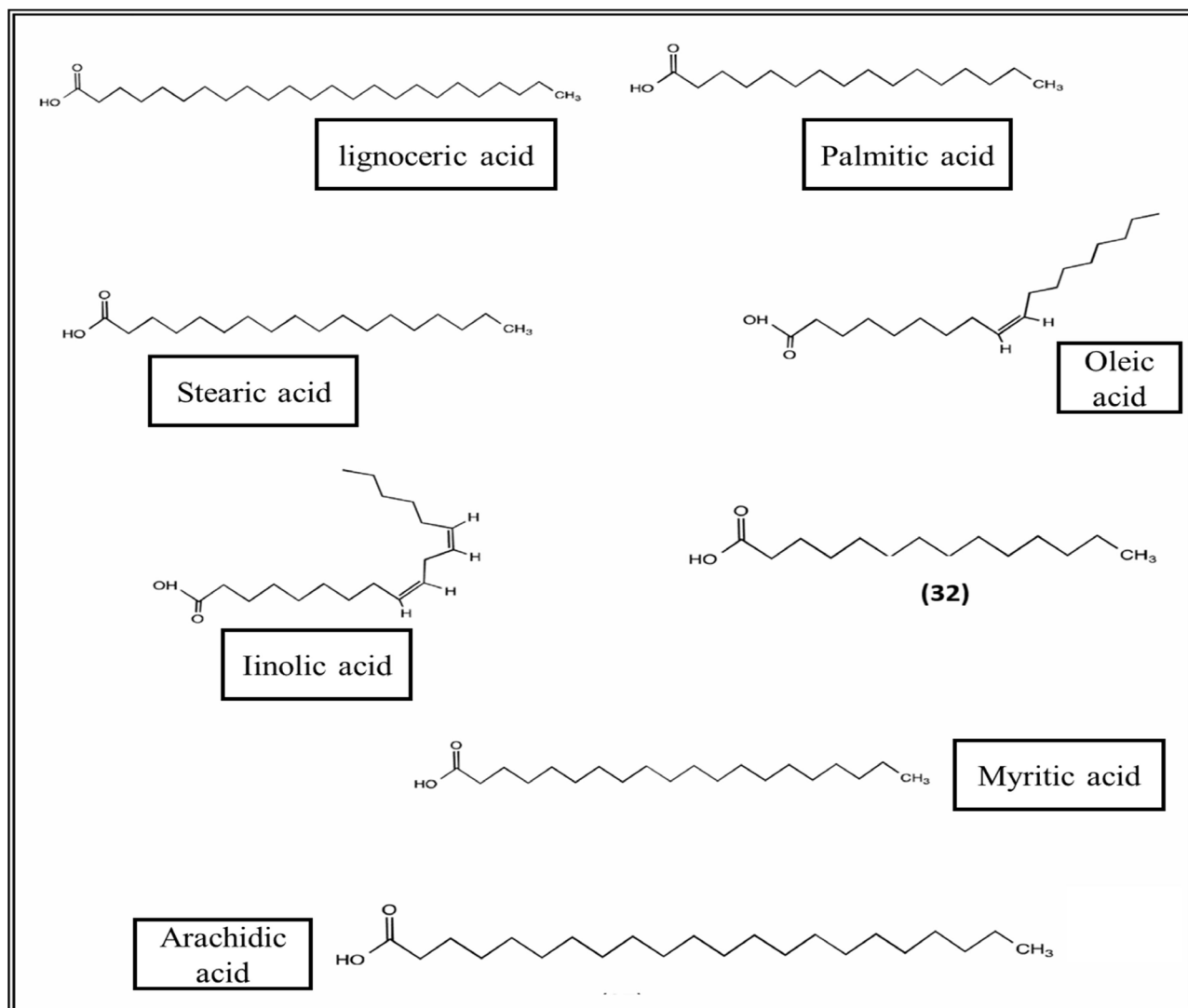


Figure 8: Fatty acids in *P. major*

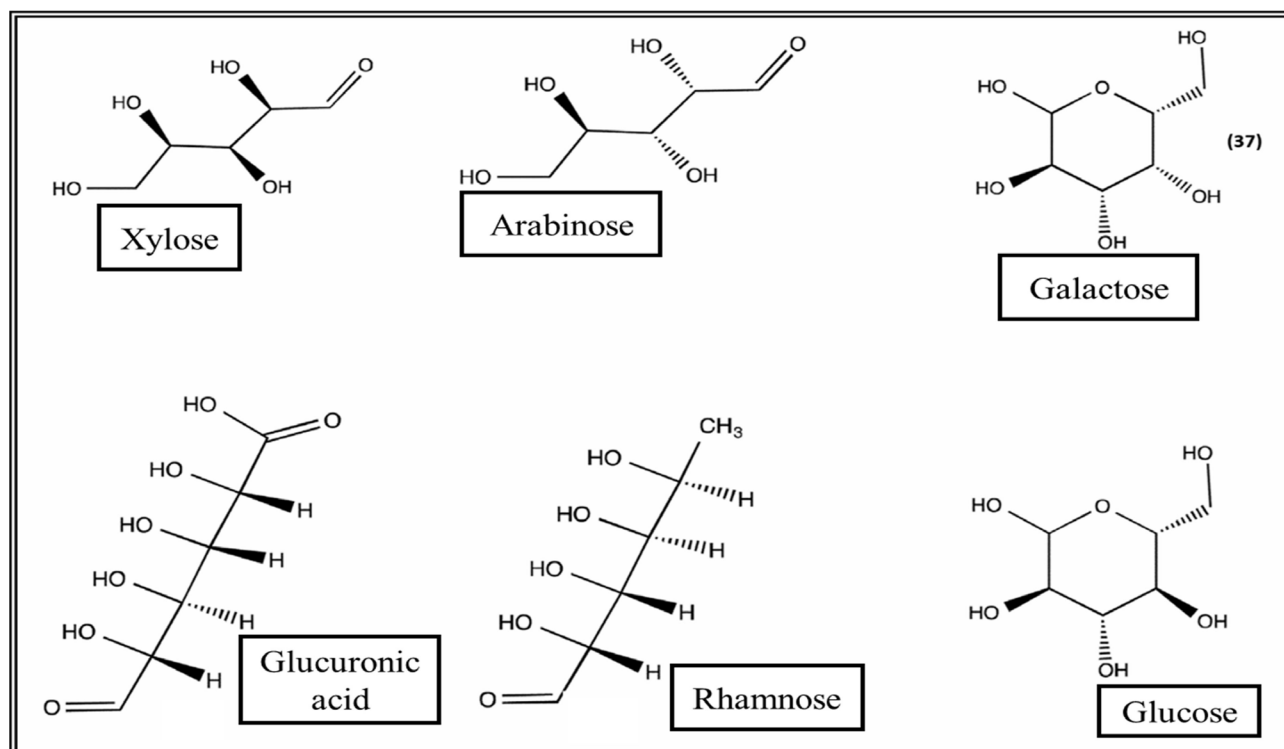
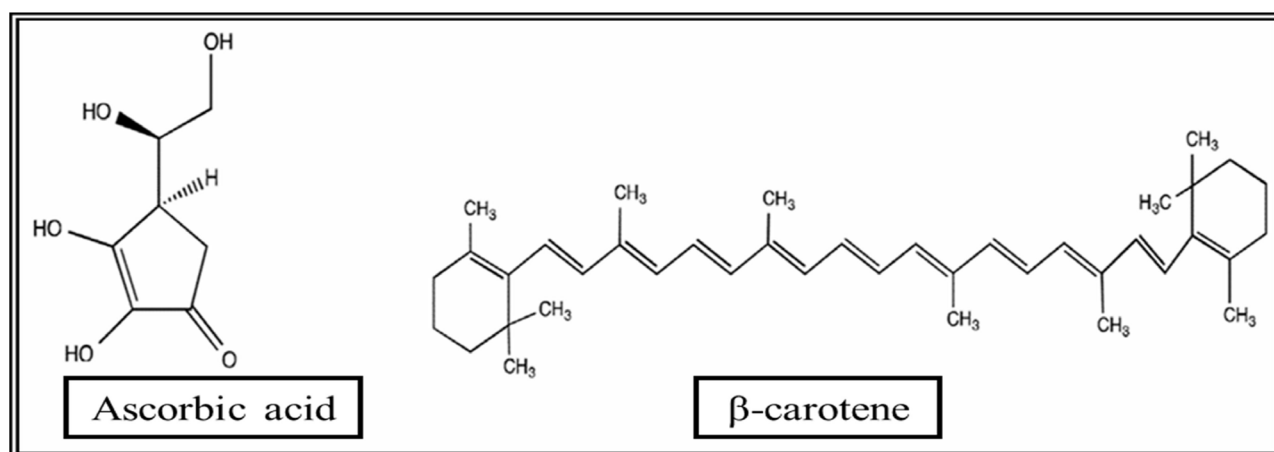
Polysaccharides

Ahmed *et al.*, in 1980 extracted polysaccharides from the seeds of *P. major*. They also isolated xylose, and arabinose in cold water extract and isolated galactose from hot water extract [23]. Additionally, Samuelsen isolated glucuronic acid, rhamnose, and glucose from 50°C water extract [13] (Figure 9).

Vitamins

Additionally, *P. major* is a good source of vitamin (A, B, C, k) and carotenoids. This is confirmed in a study by Zenni and Ogzwewalla where ascorbic acid [24] and β -carotene (provitamin A) were isolated [25](Figure 10).



Figure 9: Polysaccharides in *P. major*Figure 10: Vitamins in *P. major*

Medicinal Benefits of *Plantago major*

For the past few decades, a growing number of people have turned to alternative forms of medicine. Many botanicals, especially herbal products, have gained popularity for the treatment of diseases, such as the common cold, wounds, hypertension, inflammation, viral infections, depression, and even cancer [26].

Wound Healing Effects

The leaves of the *P. major* have been used as a wound-healing remedy in almost all parts of the world in folk medicine. Either whole or crushed leaves are used to treat, for example, burns and other kinds of wounds to enhance the healing process, and to stop bleeding [16]. Herein, the compound responsible for wound healing is the polyphenols, polysaccharides, and the antioxidant

compounds present in *P. major* contribute to wound healing [15]. The possible mechanism responsible for this is that it protects cells against destruction by inflammatory mediators which contribute to wound healing [8].

Anti-inflammatory Effects

A study conducted by Samuelsen claimed that the anti-inflammatory activity of *P. major* is contributed by iridoid glycosides, such as aucubin, and flavonoids, baicalein, and hispidulin [13].

Antidiarrheal Effects

Plantago major is one of the traditional medicinal plants used in the management of diarrhea. However, there have been very few scientific studies to confirm the efficacy and activity of *P. major* as a treatment of



diarrhoea. The antidiarrheal effect of *P. major* could be attributed to its content of tannins, flavonoids, and alkaloids [16]. Mukherjee *et al.*, suggested that tannins showed antidiarrheal action by forming protein tannate which reduces intestinal secretion [27]. In 2017 a study reported that intraperitoneal injection of some alkaloids decreased the intraluminal accumulation of fluid [8].

Antibacterial and antifungal Effects

A study was conducted by Hetland *et al.* on mice to test the antibacterial activity of *P. major*, they found that the soluble pectin polysaccharide isolated from *P. major* leaves had defensive effects against systemic *Streptococcus pneumoniae* [28]. A study conducted by Sharifa *et al.* tested the whole plant aqueous, methanol, and ethanol extracts of *P. major* on *Bacillus subtilis*, *Staphylococcus aureus*, *Candida albicans*, and *Escherichia coli* [29]. Another study conducted by Metiner *et al.* examined the anti-bacterial activity of *P. major* leaves extracts on nine species of bacteria; *Escherichia coli*, *Bacillus cereus*, *Bacillus subtilis*, *Staphylococcus epidermidis*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Klebsiella pneumonia*, *Salmonella enteritidis* and *Proteus mirabilis*; their results showed that *P. major* leaves extracts have effect on all of the nine bacteria species with different concentrations [30].

Antiviral Effects

Certain pure compounds of *P. major* possess antiviral activity. Chemical compounds found in the extracts of *P. major* (mainly phenolic compounds) exhibit potent anti-herpes virus and anti-adeno virus activities [31]. *P. major* has been used by the Chinese as a traditional medicine to treat common cold, conjunctivitis, and viral hepatitis. A study conducted by Chianget *al.* examined the activity of antiviral of *P. major* extracts on herpes virus (HSV-1, HSV-2) and adenoviruses (ADV-3, ADV-8, and ADV-11) [31].

The polyphenolic compounds were claimed to have the strongest activities against human herpes viruses and adenoviruses infections; chlorogenic acid was active against HSV-1, HSV-2, ADV-3, ADV-8, and ADV-11, whereas caffeic acid was active against HSV-1, HSV-2 and ADV-3 [32].

Conclusion

Plantago major plays an important role in the management of certain ailments and diseases such as ulcers, bacterial and viral infections, diarrhoea, pain, inflammation and cancer. This plant has been shown to contain several classes of essential biologically active compounds; flavonoids, alkaloids, iridoid glycoside, fatty acids, vitamins, phenolic compounds (caffeic acid) and terpenoids. The biological activities and medicinal properties of *Plantago major* mainly depend on the activities of the responsible active chemical constituents. However, this field still needs more study

to determine the exact mechanisms and the main bioactive compound activity responsible for treating certain diseases.

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