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Review Article

**Review of *Arnebia euchroma* as a Potential Medicinal Plant Based on Phytochemistry and Pharmacological Activity**

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**Abstract:** *Arnebia euchroma*, commonly known as "Pink Arnebia," is a plant from the Boraginaceae family found in Western and Central Asia. Traditionally, it has been used to treat respiratory, gastrointestinal, and dermatological ailments. Recent studies have highlighted its pharmacological properties and potential health advantages, resulting in increased interest in this plant. Pharmacognostic investigations have revealed the presence of various beneficial phytochemicals. Phytochemical studies have identified several bioactive compounds in *A. euchroma*, such as eugormoside A, eugormoside B, scopoletin, and  $\beta$ -sitosterol, which exhibit diverse biological activities like antioxidant, antimicrobial, anticancer, and anti-ulcer effects. The therapeutic potential of these bioactive compounds suggests that *A. euchroma* could be beneficial for a wide range of diseases. Pharmacological studies have validated the plant's healing properties, demonstrating its antimicrobial activity against various pathogens. Furthermore, *A. euchroma* extracts possess antioxidant and anti-inflammatory properties that can potentially mitigate oxidative stress and inflammation-related diseases. Other pharmacological actions of *A. euchroma* include wound healing, gastroprotective, hepatoprotective, and anti-diabetic effects. Overall, *A. euchroma* exhibits promise as a medicinal plant with significant health benefits. However, further research is required to identify the active compounds responsible for its pharmacological activity and elucidate their primary mechanisms of action. Additionally, clinical studies are necessary to assess its safety and efficacy when used therapeutically. The primary objective of this review is to showcase the phytochemical composition and traditional ethnopharmacological applications of *A. euchroma* worldwide. The study examines previous research concerning this plant, laying the foundation for a forward-looking perspective on the potential future of *A. euchroma*.

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## 1. Introduction

According to the fossil record, the relationship between humans and plants has lasted for centuries (Trüeb et al., 2020). Conventional medical systems are repositories of expertise in medicine, and their value is not limited to their historical aspects (Aldayarov et al., 2022). Plants play an indispensable role in these systems, and identifying their characteristics derived from old medical works could motivate us to develop innovative medicines (Fabricant et al., 2001; Kaya et al., 2019). *A. euchroma* is a perennial plant of the Boraginaceae group. It is widespread throughout the Mediterranean, Central Asia, and the Middle East (Shilov et al., 2022). For centuries, this herb has been used in conventional medicine to treat a variety of ailments, including respiratory issues, skin disorders, wounds, and inflammation (Jain et al., 2021). With the growing interest in natural products, *A. euchroma* is being explored by the scientific community as a prospective source of new drugs. The *A. euchroma* plant, or aerobic herb, has been demonstrated to treat burn wounds. According to surveys, naphthoquinone and additional substances are common in bivalve parents (Pirbalouti et al., 2014). These compounds, as well as their derivatives (alkanins and alkanes), exhibit a wide range of characteristics, such as moisturizing and antibacterial properties (Sasaki et al., 2002; Shen et al., 2002; Annan et al., 2008; Pirbalouti et al., 2014; Bali, 2015), antiviral (such as influenza and HIV), and anticancer (Nuorani et al., 2005; Zhang et al., 2017). Scientific studies have also shown that this plant possesses antibacterial and anti-inflammatory properties. Among the called naphthoquinones, shikonin serves as the primary active component (Papageorgiou et al., 1999; You et al., 2000; Singh et al., 2003; Malik et al., 2016). Shikonin and its derivatives exhibit substantial anticancer action, with the potential to inhibit cell growth and cause apoptosis in a variety of human cancers, including gastric cancer (Liang et al., 2016). In addition, it has antiviral, antioxidant, anti-inflammatory, and antifertility pharmacological properties and can be used in food supplements and cosmetics (Gao et al., 2011; Huang et al., 2018). The aforementioned dried roots of the plant are utilized in the pharmaceutical industry to extract natural chemicals. As a result of its medicinal properties, excessive consumption of this plant has led to a decline in its population and endangered status (Kala et al., 2000). Furthermore, it is not easy to cultivate such plants using conventional agricultural methods and thus cannot meet the increasing industrial demand (Gupta et al., 2014). Altogether, this article provides an up-to-date range of information on *A. euchroma* (taxonomy, plant characteristics, distribution, wide range of uses, bioactive composition, health effects, and technological potential) to enhance comprehension of the potential of this species across diverse domains. Biome and species conservation considerations will also be provided. This review aims to comprehensively describe and provide an up-to-date overview of *Arnebia euchroma* from multiple perspectives, including its taxonomy, plant characteristics, distribution, diverse uses, bioactive composition, health effects, and technological potential. Additionally, the review will address the conservation concerns related to the species and its habitat. The primary goal is to enhance understanding of the potential applications and significance of *A. euchroma* across various domains, spanning from traditional medicine to industrial applications.

## 2. Morphological Structure

Morphologically, *A. euchroma* has glabrous shoots, funnel-shaped corollas, terminal, subglobose inflorescences, and purple roots (Kumar et al., 2021). The roots of *A. euchroma* are thick and devoid of violet coloring. The stems of *Euchroma* are typically erect or spreading, having one or more branches. They have delicate hairs and are light yellow or white in hue. Leaves are linear, with long bristles, spiny to prevent the plant from being eaten. The flowers are multifloral, in rounded, racemose inflorescences with pinkish-purple tips that eventually become blackish-purple and have few stems. Blooms are heterogamous, bisexual, and insect-pollinated (Singh, 2010). Figure 1 shows the visual structure of the parts of the plant of *A. euchroma*. The calyx is thick and light golden in color, with both sides pubescent. The corolla is dark purple, bell-shaped, and often tinted with light yellow or red. Fruiting is infrequent due to self-sterility. The majority of seeds land around the plant's base and

germinate there, resulting in a thick clump of plants. Throughout June to August, flowers bloom, while seeds ripen from July to September.

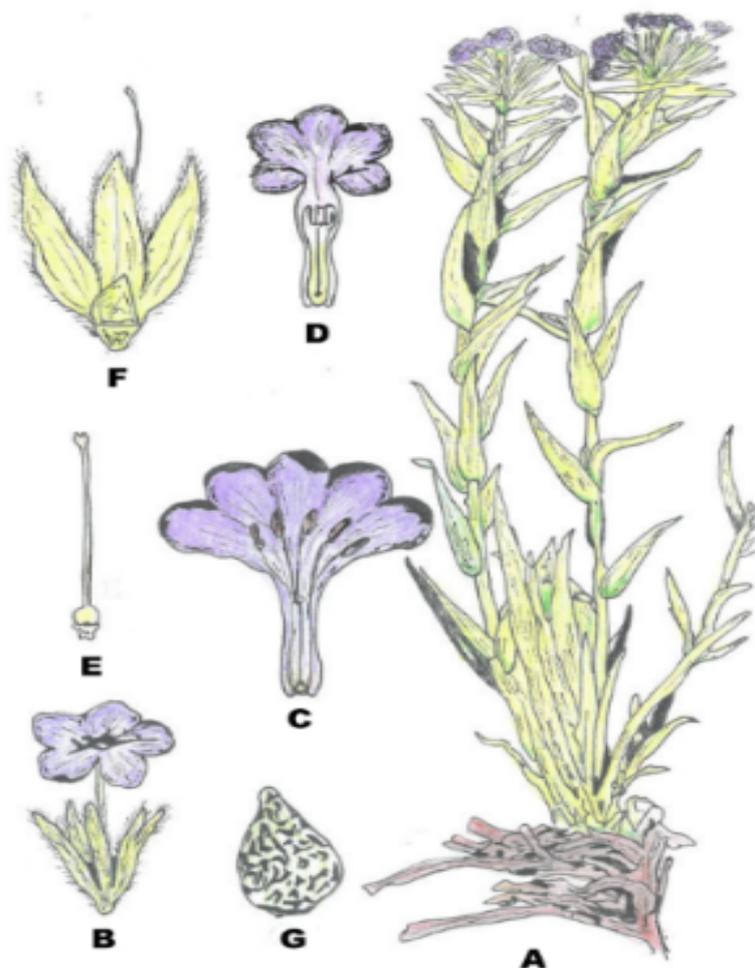


Figure 1. Illustration of the morphological description of *Arnebia euchroma*: (A. habit x 1/2, B. flower x 3, C. short styled flower 1.s x 3, D. long styled flower x 3, E. carpel x 6; F. fruit x 8, G. seed x 10).

### 3. Geographical Distribution of *A. euchroma*

*A. euchroma*, also known as "Red Root" or "Sappan Tree," is a plant species commonly found in the Himalayas and Naryn region, Kyrgyzstan. Its habitat preferences and distribution have been documented in several studies. According to a study published in the International Journal of Agriculture and Biology, *A. euchroma* grows in all regions of Kyrgyzstan, as well as in Naryn and Issyk-Kul oblasts on rocky slopes between 3 000 and 4 500 meters above sea level. It is also widespread in mountainous areas, including the Tien Shan and Pamir-Alai mountain ranges. It prefers well-drained soils with good sunlight exposure. The study also reports that this plant species is usually found in rocky and stony habitats, including slopes and grasslands (Li, 2015). Janibekov, (2017) reported that the plant is one of the medicinal plant species found in the flora of Kyrgyzstan. The study states that the plant species are found in different regions of Kyrgyzstan, including the Tien Shan and Alai mountain ranges. It is used in folk medicine for its anti-inflammatory and wound-healing properties (Janibekov, 2017). Akram, (2019) reported that it is commonly found in the subalpine and alpine regions of the Himalayas at an altitude of 2 000-4 500 meters above sea level. It prefers well-drained soils with good exposure to sunlight and is often found in rocky and rocky habitats, including slopes and grasslands. Another study published in the Journal of Ethnopharmacology reports that *A. euchroma* occurs wild in the northwestern region of Pakistan, where it grows on dry and rocky slopes in mountainous areas. The study also reports

that this plant species is commonly associated with other species of the same genus, such as *A. benthamii* and *A. hispidissima* (Bali, 2015).

In addition, a study published in the Journal of Medicinal Plant Research reports that *A. euchroma* is commonly found in the western Himalayas, including Afghanistan, India, Nepal, Pakistan, and Tibetan regions. It is found in various habitats, including forest edges, thickets, and grasslands (Hussain et al., 2012). Thus, *A. euchroma* is a plant species well adapted to rocky and scree habitats in the Himalayas and often found at high altitudes. Its distribution range extends to several countries and habitats in the region. In China, it is found in Xinjiang (East Turkistan) and the Sijiang region (autonomous region of Tibet). In India, the plant grows in Jammu and Kashmir, Himachal Pradesh, and Uttarakhand in the Transgimalaya region. In Pakistan, *A. euchroma* is found in the Karakorum mountain range, in the Batura Valley (mountain-steppe area) at altitudes between 2 600 and 3 900 meters above sea level, and in the Hindu Kush in the Swat region. In Iran, *A. euchroma* grows in rocky areas in the Zagros Mountains and the Caspian Mountains between 3 600 and 4 000-meters altitude (El-Keblawy et al., 2017). *A. euchroma* is also found in the Pamir mountains in Tajikistan, Afghanistan, Siberia (Russia), Kazakhstan, Nepal, Tibet (China), East Turkestan (Xinjiang, China), and Uzbekistan (Lee et al., 2017).



Figure 2. Distribution areas of *Arnebia euchroma* in the world.

#### 4. Chemical Content

The most important and prevalent phytochemical components of *A. euchroma*, coumarins, shikonin, acetyl shikonin, iso-butyryl shikonin, -di-methyl acryl shikonin, isovaleryl shikonin, B-hydroxy isovaleryl shikonin, deoxy-shikonin, isobutyl-shikonin, arnebinone, arnebin-7, and stigma sterol are some examples, are recognized for their antibacterial properties, anticancer, and anti-immunodeficiency characteristics (Lin et al., 1980; Kashiwada et al., 1995; Jain et al., 2000; Samant et al., 2015). Additionally, *Arnebia benthamii*, a different species, is utilized in the treatment of cardiac and febrile illnesses (Dar et al., 2002; Ganie et al., 2012; Parray et al., 2015). Roots of *A. euchroma* contain various organic compounds such as naphthoquinone, arnebin-1, alkanin, ethyl-9-(2, 5-dihydroxyphenyl) nonanoate, iso-hexenyln-aphthazarin, octyl-ferulate, and butyryl-alkannin are anti-microbial, wound healing, and anti-tumor agents used in various medications (Liu et al., 2010; Ashkani-Esfahani et al., 2012; Hosseini et al., 2018; Cao et al., 2020).

**Shikonin:** The roots of the *A. euchroma* plant, which is extensively dispersed throughout South and Central Asia, are the primary source of the naphthoquinone chemical known as shikonin. Shikonin has been utilized in traditional medicine for millennia due to its wide range of medicinal characteristics, including its anti-inflammatory, antibacterial, and wound-healing capabilities. In-depth investigation of

shikonin and its derivatives' pharmacological properties has been done recently. By preventing the synthesis of cytokines that promote inflammation like TNF- and IL-6 and stimulating the production of nuclear factor-kappa B (NF- $\kappa$ B), it has anti-inflammatory characteristics (Zhao et al., 2018). Shikonin also displays antimicrobial activity against various types of organisms, among them bacteria, fungi, and viruses (Zhou et al., 2017). Additionally, shikonin has been shown to have antitumor effects against a wide variety of cancer cell types, from lung cancer to breast and prostate cancer (Zhang, 2019). Research has also been conducted to explore the therapeutic potential of shikonin in addressing various skin conditions. Shikonin has been found to have significant wound-healing properties, promoting the growth and movement of skin cells, and increasing the production of collagen and other extracellular matrix components (Yin, 2017). Moreover, shikonin has been shown to exhibit therapeutic potential in the treatment of psoriasis, a chronic autoimmune disease characterized by skin inflammation and hyperproliferation. Shikonin has been shown to suppress the differentiation and proliferation of keratinocytes, which play a key role in the pathogenesis of psoriasis (Liu, 2019). The potential of shikonin in conjunction with other medicinal drugs has also been looked at in a number of research. For instance, it has been demonstrated that shikonin and chemotherapeutic drugs together can boost chemotherapy's anticancer effects (Huang et al., 2017). Shikonin has also been reported to increase the antibacterial action of several antibiotics, including erythromycin and tetracycline. Despite its pharmacological potential, the use of shikonin is limited as a result of its limited availability and low absorption. To overcome these limitations, various approaches, such as nanoparticle-based drug delivery systems, have been investigated to improve the therapeutic efficacy of shikonin (Zhou et al., 2017).

**Organic acids:** Studies have shown that *A. euchroma* contains several organic acids, including benzoic, cinnamic, caffeic, and ferulic acids. These acids are synthesized through the shikimate and phenylpropanoid pathways in the plant (Sing et al., 2015). Based on reports, the organic acids in *A. euchroma* exhibit a variety of pharmacological functions, which comprise antioxidative, antibacterial, anti-inflammatory, and anticancer actions. Benzoic acid is one of the most common organic acids found in *A. euchroma*. Studies have indicated its antimicrobial properties, anti-inflammatory, and antitumor activities (Zhang et al., 2014). In a study by Wanninger et al. (2018), benzoic acid has been shown to successfully stop the development of human cancerous cells in the intestines. Cinnamic acid is another organic acid found in *A. euchroma*, which has been reported to exhibit anti-inflammatory and antioxidant properties (Pandey et al., 2017). Caffeic acid, a well-known antioxidant and anti-inflammatory agent, has also been isolated from *A. euchroma*. It has been shown to possess anti-cancer properties against various types of cancer, such as lung, colon, and breast cancer (Singh et al., 2015; Zhang et al., 2014). Ferulic acid is another organic acid found in *A. euchroma*, which has been reported to exhibit antioxidant and anti-inflammatory properties (Pandey et al., 2017). In addition to their pharmacological properties, organic acids extracted from *A. euchroma* have also been used in the food and cosmetic industries. For example, benzoic acid is commonly used as a preservative in food products, while ferulic acid is used in cosmetic formulations due to its antioxidant properties (Singh et al., 2015).

**Naphthoquinones:** One of the major groups of compounds found in the plant are the naphthoquinones, which include alkannin, shikonin, acetylshikonin, and  $\beta,\beta$ -dimethylacrylshikonin. These compounds have received significant attention due to the possible pharmacological effects of shikonin encompass its potential to exhibit anti-inflammatory, antioxidative, antimicrobial, and anticancer characteristics. Alkannin and shikonin are two of the most extensively studied naphthoquinones in *A. euchroma*. Alkannin has been shown to exhibit anti-inflammatory and antioxidant activities, as well as wound-healing properties (Amanpour et al., 2015). In a study conducted on mice, alkannin was found to have significant anti-inflammatory effects, reducing the production of inflammatory cytokines and prostaglandins (Kim et al., 2019). Shikonin has also been shown to possess anti-inflammatory and antioxidant activities, as well as anticancer properties against various cancer cell lines (Liu et al., 2010). One study found that shikonin inhibited the proliferation of breast cancer cells by inducing cell cycle arrest and apoptosis (Sharma et al., 2020). Acetylshikonin and  $\beta,\beta$ -dimethylacrylshikonin are two other naphthoquinones that have received attention for their potential pharmacological activities. Acetylshikonin has been reported to have anti-inflammatory, antioxidant, and antiproliferative activities against cancer cells (Li, 2010 and 2015).  $\beta,\beta$ -dimethylacrylshikonin has been shown to have anticancer effects against lung cancer cells by inducing apoptosis (Lee et al., 2017). In addition to their pharmacological activities, naphthoquinones extracted from *A. euchroma* have also

been investigated for their potential use in various industries. Alkannin and shikonin have been used as natural dyes in the food, cosmetic, and textile industries (Zhao et al., 2018). Shikonin has also been used as a colorant in the pharmaceutical industry (Yang, 2016).

**Phenolics:** Numerous studies have demonstrated that *A. euchroma* contains several phenolic compounds, such as flavonoids, coumarins, and phenolic acids, which are synthesized via the phenylpropanoid pathway in the plant (Li, 2015). These phenolic compounds possess diverse pharmacological activities, including antioxidant, anti-inflammatory, antimicrobial, and antitumor effects. Quercetin, kaempferol, and rutin are among the most abundant flavonoids found in *A. euchroma*, and they have been reported to exhibit antioxidant, anti-inflammatory, and antitumor properties (Hussain et al., 2019). Quercetin has been found to suppress breast cancer cell growth, while kaempferol has anti-tumor properties against different types of cancer, such as prostate, liver, and colon cancer (Choudhary et al., 2004). *A. euchroma* also contains coumarins such as scopoletin and esculetin, which exhibit antioxidant and anti-inflammatory properties (Li, 2015). Scopoletin has been demonstrated to have antimicrobial activity against various bacterial strains, including *Staphylococcus aureus* and *Escherichia coli* (Wang et al., 2019). Moreover, *A. euchroma* also contains phenolic acids such as gallic acid, caffeic acid, and ferulic acid, which possess antioxidant, anti-inflammatory, and antitumor activities (Hussain et al., 2019). Gallic acid has been found to inhibit breast cancer cell growth, while caffeic acid and ferulic acid have antitumor properties against various types of cancer. In addition to their pharmacological properties, phenolic compounds from *A. euchroma* have various applications in the food and cosmetic industries. For example, quercetin and kaempferol are commonly used as natural food colorants, while gallic acid and caffeic acid are employed in cosmetic formulations due to their antioxidant properties (Choudhary et al., 2004).

Table 1. Chemical compounds reported from *Arnebia euchroma*

№	Compound names	Part of plants	References
1	Shikonin		(Sankawa et al, 1977; Lin et al, 1980)
2	Acetyl-shikonin		Kashiwada et al, (1995)
3	$\beta,\beta$ -Dimethylacrylshikonin		(Jain et al, 2000; Ganie et al, 2012)
4	Deoxyshikonin		
5	Isovalerylshikonin		(Andujar et al., 2002)
6	$\beta$ -Hydroxyisovalerylshikonin	Roots	(Hosseini et al., 2018)
7	Arnebin-1		(Yang et al., 1992)
10	Arnebin-6		(Yuzbasioglu et al., 2020).
11	Isobutylshikonin		(Andujar et al., 2002; Parray et al., 2015).
12	Stigmasterol		(Liu et al., 2010)
13	Teracrylalkannin		(Yuzbasioglu et al., 2020)
14	Tormentic acid		
15	Triterpenic acids		
16	2 $\alpha$ -Hydroxyursolic acid		
17	Naphthoquinone		
18	Tormentic chemical	Roots bark, flower and leaves	(Yang et al., 1992; Roeder et al., 1993; Srivastava et al., 1999; Singh et al., 2001)
19	Octylferulate		
20	Butyrylalkannin		
21	Isohexenylnaphthazarin		
22	O <sup>7</sup> - Angeloylretronecine		
23	O <sup>9</sup> - Angeloylretronecine		
26	Alkaloids		
27	Pyrrolizidine	Roots bark, flower and leaves	(Liu et al., 2010; Ashkani-Esfahani et al., 2012; Sharma et al, 2020).
28	2 $\alpha$ -Hydroxyursolic acid		
29	O <sup>7</sup> - Angeloylretronecine		
30	Betulin, lupeol	Roots bark, flower and leaves	(Yang et al, 1992; Roeder et al, 1993; Srivastava et al, 1999; Singh et al, 2001)
31	Pyrrolizidine		
33	$\beta$ -Amyrin acetate		

Table 1. Chemical compounds reported from *Arnebia euchroma* (continued)

34	Butyryl-alkannin		
35	Octyl-ferulate		
36	Copsamine		
37	Ethyl 9-(2,5-dihydroxyphenyl) nonanoate		
38	Lycopsamine		
39	Tetrabenzoylalkannin		
40	$\beta$ -Methylanthracene	Roots bark, flower and leaves	(Liu et al., 2010; Ashkani-Esfahani et al., 2012)
41	Tetrabromoalkannin		
42	Dimethoxyalkannin		
43	Dicarboxyalkannin	Roots bark, flower and leaves	(Ashkani-Esfahani et al., 2012)
44	Naphthoquinones, alkannin		
45	$\beta$ -Acetoxyisovalerylalkannin		
46	Isovalerylalkannin dimer	Roots bark, flower and leaves	(Liao et al., 2020)
47	Isovalerylalkannin		
48	$\beta$ -Acetoxyisovalerylalkannin dimer		
49	2,3-Secodiplopterol dioic acid	Roots	(Cao et al., 2020)
50	Shikometabolin H		

## 5. Traditional Uses

*A. euchroma* has been employed in Central Asia, as well as in Ayurvedic and herbal medicine for an extended duration. It is valuable in managing nausea and vomiting, specifically in cases of motion sickness and hyperemesis gravidarum.

Use in Kyrgyzstan: *Arnebia euchroma*, known by its common name "Boyochu Endik," has a long history of traditional use in Kyrgyzstan, where it holds both cultural and medicinal significance. Found in various parts of the country, this versatile plant has been an integral part of Kyrgyz traditional medicine for centuries, with its roots being a key component of many remedies. One prominent use of *A. euchroma* in traditional medicine is in the treatment of digestive ailments. Infusions or decoctions made from the plant's roots are commonly consumed to alleviate indigestion, bloating, and general discomfort after meals. It is also used to manage various stomach-related issues, including gastritis and gastralgia, as it is believed to have soothing properties for the gastrointestinal tract (Israili, 2009). In Kyrgyzstan's cold climate, respiratory ailments are common, and *A. euchroma* plays a role in addressing these health concerns. Traditional preparations often include *A. euchroma* to alleviate symptoms of common respiratory infections such as coughs and colds. This is attributed to its potential anti-inflammatory and antimicrobial properties that are beneficial for respiratory health. *A. euchroma* is highly regarded for its potential to treat a variety of skin issues in Kyrgyz traditional medicine, particularly skin conditions like eczema and dermatitis. The roots of the plant are prized for their skin-healing properties, and ointments and poultices made from these roots are applied topically to soothe irritated skin. Traditional healers also utilize *A. euchroma* to accelerate the healing process of minor wounds, cuts, and burns, given its effectiveness in reducing inflammation and promoting tissue regeneration (Uysal, 2018). Beyond its medicinal uses, *A. euchroma* finds its way into Kyrgyz cosmetics. The plant's soothing and healing properties make it a suitable ingredient in skincare products, including creams and lotions. These products are employed to maintain healthy and radiant skin. Moreover, one of the most renowned traditional uses of *A. euchroma* in Kyrgyzstan is its role as a natural dye. The roots of the plant are used to create natural dyes that impart a range of red and purple hues to textiles. This age-old dyeing tradition has left an indelible mark on the vibrant colors of traditional Kyrgyz clothing and textiles (Bazarbayev, 2020). Currently, some regions of Central Asia, including Kyrgyzstan, are experiencing excessive sales of rootstocks to neighboring countries and depletion of stocks. This raises concerns about the sustainability of plant utilization (Sujatha, 2016). To address these concerns, several efforts have been made to promote sustainable cultivation and conservation of *A. euchroma* in Kyrgyzstan. For example, a study conducted by scientists from Kyrgyzstan and Germany

investigated the optimal conditions for the cultivation of this plant in the country. Other initiatives aim to promote the use of alternative natural dyes to reduce the burden of *A. euchroma* (Baktybekov, 2017).

Use in Xinjiang, East Turkistan (China): *Arnebia euchroma*, renowned for its medicinal properties, is an integral component of Traditional Chinese Medicine (TCM), a holistic approach that harnesses natural substances for therapeutic purposes. TCM embraces the versatile capabilities of *A. euchroma*, particularly in the realms of skin health and wound care. It stands as a potent remedy for various skin conditions, effectively soothing irritations caused by allergies, insect bites, and contact dermatitis. The application of ointments or creams infused with *A. euchroma* extracts brings much-needed relief (Li, 2015). Moreover, *A. euchroma* extends its healing potential to the treatment of minor burns, with its anti-inflammatory attributes playing a pivotal role in reducing inflammation and promoting the healing process of burn wounds. Traditional practitioners also employ this botanical wonder to combat skin infections, including bacterial and fungal maladies, through topical applications on affected areas. Expanding its horizons, *A. euchroma* assumes a prominent role in addressing respiratory issues within the realm of TCM. Traditional preparations seamlessly incorporate the plant to alleviate the discomfort of common respiratory infections such as coughs and bronchitis. This therapeutic prowess is attributed to the plant's potential anti-inflammatory and antimicrobial properties, enhancing its effectiveness in respiratory care (Zhang, 2019). Beyond its pivotal role in Traditional Chinese Medicine, *A. euchroma* makes a remarkable entrance into the world of Chinese cosmetics. The plant's soothing and rejuvenating attributes make it a prized ingredient in skincare products like creams, lotions, and serums. These formulations harness *A. euchroma* extracts to amplify their efficacy, contributing to the attainment of healthy and radiant skin. In the tapestry of traditional Chinese crafts, *A. euchroma* weaves a vibrant thread into the fabric of textile and fabric dyeing traditions. The roots of this botanical gem serve as the source of natural dyes, bestowing textiles with rich hues of red and purple. This dyeing tradition, deeply entrenched in Chinese culture and craftsmanship, exerts a profound influence on the colors and intricate patterns adorning traditional Chinese clothing, particularly in regions like Tibet (Li, 2015). However, the unrelenting over-harvesting and depletion of *A. euchroma* in its natural habitat have cast a shadow of concern over its sustainability. In response, dedicated efforts have been undertaken to champion the cause of sustainable cultivation and conservation, seeking to redress the challenges stemming from over-harvesting and habitat loss (Wang, 2019).

Use in Iranian traditional medicine: Skin Conditions: *A. euchroma* has been traditionally used in Iran to treat various skin conditions, including eczema and psoriasis. A study published in the Journal of Ethnopharmacology found that *A. euchroma* root extract has potent anti-inflammatory and wound-healing properties that may support its traditional use in these conditions (Rustaiyan et al., 2001).

Respiratory ailments: *A. euchroma* has been traditionally used to treat respiratory diseases, including cough and asthma. A study published in the Journal of Ethnopharmacology found that plant root extract has significant bronchodilator activity, which may support its traditional use in these conditions (Monsef-Esfahani et al., 2004), Digestive Disorders: *A. euchroma* is traditionally used in Iran to treat digestive disorders such as diarrhea and dysentery. A study published in the Journal of Medicinal Plants Research found that *A. euchroma* root extract has significant anti-inflammatory and antispasmodic effects on the digestive system, which may support its traditional use in these conditions (Tavakoli et al., 2010). Pain Relief: *A. euchroma* has been traditionally used for pain relief, including joint pain and headache. A study published in the Journal of Medicinal Plants Research found that *A. euchroma* root extract has significant analgesic and anti-inflammatory effects that may support its traditional use for pain relief (Saeedi et al., 2011)

Use in traditional Indian medicine: *A. euchroma*, also known as "Lal Jari" in Hindi, has a long history of use in traditional Indian medicine, also known as Ayurveda. Here are some examples of its traditional use in Ayurveda and links to supporting studies: *A. euchroma* has been traditionally used in Ayurveda to treat various skin conditions, including wounds, burns, and eczema. A study published in the Journal of Ethnopharmacology found that *A. euchroma* root extract has potent wound healing and anti-inflammatory properties that may support its traditional use in these conditions (Saeedi et al., 2001). *A. euchroma* is also traditionally used in Ayurveda to treat respiratory ailments such as cough and asthma. A study published in the Journal of Ethnopharmacology found that *A. euchroma* root extract has significant bronchodilator activity, which may support its traditional use in these conditions

(Monsef-Esfahani et al., 2004). *A. euchroma* has traditionally been used in Ayurveda to treat gastrointestinal disorders such as diarrhea, dysentery, and stomach ulcers. A study published in the Journal of Ethnopharmacology found that *A. euchroma* root extract has significant anti-inflammatory and anti-ulcer effects on the digestive system, which may support its traditional use in these conditions (Husain et al., 2001). *A. euchroma* is also traditionally used as an antimicrobial agent in Ayurveda. A study published in the Journal of Ethnopharmacology showed that *A. euchroma* root extract has significant antimicrobial activity against various bacteria and fungi, which may support its traditional use for these purposes (Singh et al., 2006). *A. euchroma* is traditionally used as an anti-inflammatory agent in Ayurveda. A study published in the Journal of Ethnopharmacology found that *A. euchroma* root extract has significant anti-inflammatory effects that may support its traditional use in various inflammatory conditions. These studies suggest that *A. euchroma* has potential medicinal properties supporting its traditional Ayurveda use. However, further research is needed to fully understand the therapeutic effects of this plant and its active compounds.

## 6. Pharmacological Activities

*A. euchroma* is a medicinal plant that has been traditionally used for various ailments. It is known for its pharmacological activities such as anti-inflammatory, antioxidant, antibacterial, wound healing, antitumor, and hepatoprotective activities. *A. euchroma* contains several bioactive compounds such as shikonin, alkannin, phenolic compounds, and flavonoids, which contribute to its various pharmacological activities. These compounds have been studied in vitro and in animal models, and have shown promising results in treating inflammation, oxidative stress, bacterial infections, wound healing, cancer, and liver diseases.

**Wound healing:** *A. euchroma* has traditionally been used as a wound-healing agent. Studies have shown that *A. euchroma* root extract has pronounced wound-healing properties, accelerating wound-healing and promoting tissue regeneration (Yagn et al., 2021).

**Anti-inflammatory and analgesic:** *A. euchroma* has been reported to have anti-inflammatory and analgesic properties. Studies have shown that *A. euchroma* root extract has significant anti-inflammatory and analgesic effects (Ali, 2007).

**Antibacterial:** *A. euchroma* has potent antibacterial activity against a range of bacteria. The root extract is effective against Gram-positive and Gram-negative bacteria, making it a potential alternative to conventional antibiotics (Ali, 2007).

**Antifungal activity:** *A. euchroma* has been found to have antifungal activity against several fungal pathogens, including *Candida albicans* and *Aspergillus niger*. The root extract has been shown to inhibit the growth of these fungi, making it a potential alternative to conventional antifungal drugs (Mirage et al., 2019).

**Antioxidant activity:** *A. euchroma* is rich in phenolic compounds and is reported to have antioxidant properties. Studies have shown that *A. euchroma* root extract has significant antioxidant activity that may help prevent diseases associated with oxidative stress (Mirage et al., 2019).

**Dermatological Uses:** *A. euchroma* is used in traditional medicine to treat various skin conditions such as psoriasis, eczema, and dermatitis. The root extract is used in topical formulations to treat burns, wounds, and skin infections (Singh et al., 2003).

**Anticancer activity:** *A. euchroma* has been found to exhibit anticancer properties due to naphthoquinone compounds such as shikonin and alkannin. These compounds have been shown to inhibit the growth of various cancer cells, including breast, lung, and colon cancer cells (Yang, 2021).

**Hepatoprotective:** *A. euchroma* has been reported to have hepatoprotective properties and protect the liver from damage caused by various toxins and drugs. The root extract has been shown to reduce liver damage caused by carbon tetrachloride, paracetamol, and other hepatotoxic agents in animals (Mirage et al., 2019).

**Neuroprotective:** *A. euchroma* has been found to exhibit neuroprotective properties due to shikonin and other compounds. These compounds have been shown to protect neurons from damage caused by oxidative stress, inflammation, and other neurotoxic effects (Yang, 2021).

**Anti-diabetic:** *A. euchroma* is used in traditional medicine to treat diabetes. The root extract has been found to have significant anti-diabetic activity, lowering blood glucose levels and improving glucose tolerance in animal models (Khan, 2015).

**Anti-ulcer properties:** *A. euchroma* is reported to have anti-ulcer properties. The root extract has been shown to protect the gastric mucosa from ulceration caused by various factors such as alcohol, stress, and non-steroidal anti-inflammatory drugs (NSAIDs) (Sujhata et al., 2016).

**Anti-arthritic activity:** *A. euchroma* has been reported to have anti-arthritic properties. Studies have shown that *A. euchroma* root extract has significant anti-arthritic effects by reducing inflammation and joint destruction in animal models of arthritis (Yang, 2021).

**Antitumor:** *A. euchroma* has been found to have potential antitumor activity. Studies have shown that *A. euchroma* root extract has a cytotoxic effect on cancer cell lines, including lung, liver, and breast cancer (Yang, 2021).

**Anti-aging properties:** *A. euchroma* is reported to have anti-aging properties. Studies have shown that *A. euchroma* root extract has a significant anti-aging effect that reduces oxidative stress and improves skin elasticity (Mirage et al., 2019).

**Gastrointestinal Disorders:** *A. euchroma* is used in traditional medicine to treat gastrointestinal disorders such as diarrhea and dysentery. The root extract is used in oral preparations to treat these conditions (Singh et al., 2001).

**Cardiovascular health:** *A. euchroma* is reported to have heart-protective properties, including lowering blood pressure and cholesterol levels. The root extract has been shown to improve heart function and reduce oxidative stress in animal models of cardiovascular disease (Yang, 2021).

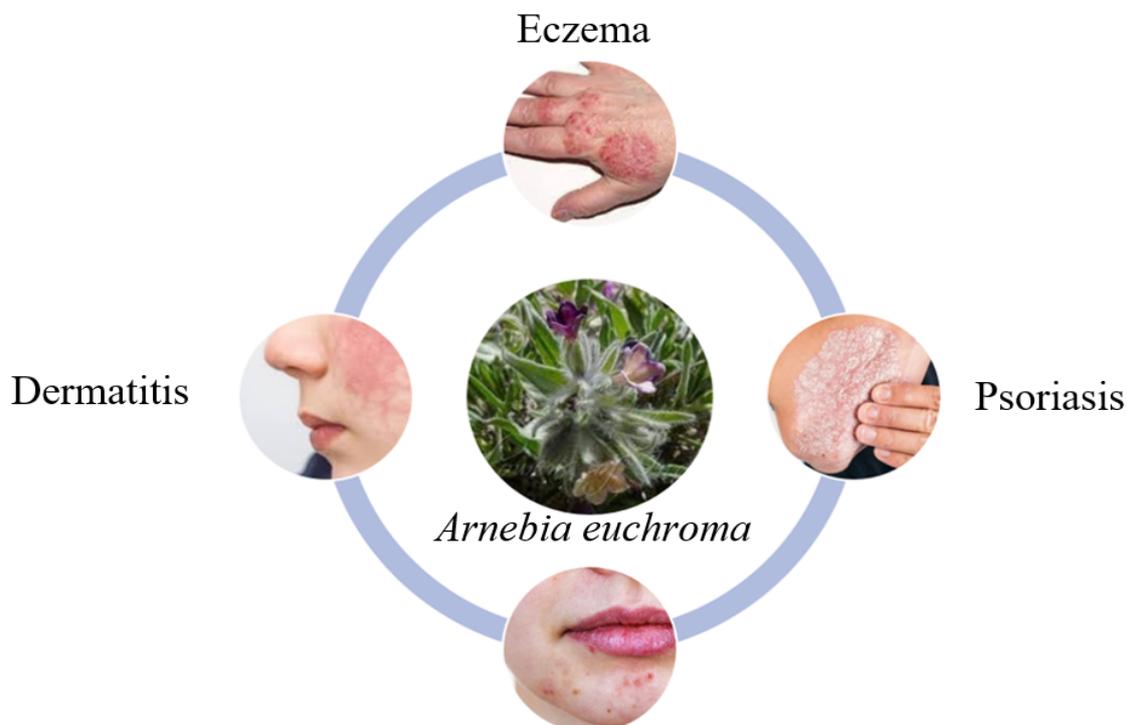


Figure 3. Relevance of the roots of *Arnebia euchroma* for the treatment of skin diseases.

## 7. Future Considerations

The current investigation aims to elucidate the inherited knowledge of *A. euchroma*. There is a need for extensive research and awareness in the Naryn region and neighboring regions in Kyrgyzstan. Although the foliage and roots of *A. euchroma* are frequently applied in ethno-medicine treatments, information on the formulations and usage of such medicinal plants is limited to books and a handful of regional practitioners, highlighting the urgent need to explore these traditional practices among the younger generation. Because root harvesting is a damaging method, it is critical to protect these therapeutic plants from over-exploitation. While some aspects of ethno-medicine science have been studied, more work needs to be done from various perspectives, such as corona and cancer treatment, dose administration, antioxidants, geo-tagging, metabolomics, bioinformatics, genomics, proteomics, and data-based studies. Studies on secondary metabolites, including phenolic compounds, need to be conducted using in vitro methods for animal issues. The majority of the study focused on the pharmacological and therapeutic applications of *A. euchroma*; however, the biotechnological features of the medicinal plant, such as cell culture, were not well examined. The natural surroundings of *A. euchroma* in Naryn are situated in the At-Bashy regions (Naryn), requiring care for commerce and numerous reasons. Using scientific tools and conventional methods, forest agencies, research institutions, and non-governmental organizations (NGOs) should collaborate to protect *A. euchroma* and its natural locations. To enhance the competitiveness of domestic *A. euchroma* production, it is crucial to strive for high-quality *A. euchroma* products with a high yield in the production-to-consumption chain. Working with wide genetic variation in breeding programs is effective in developing new varieties, and hybridization between different subspecies can create broad variation. Crossbreeding the *A. euchroma* plant with commercial varieties can produce high-yielding commercial varieties that are more resistant to disease and stress conditions such as cold tolerance. Preventing yield losses due to stressors of commercial varieties can increase the yield of *A. euchroma*, even at low levels, which can significantly increase the amount of product produced. This increase in yield will boost our country's exports abroad.

## Conclusion

In conclusion, this literature review on the phytochemistry and pharmacological activity of *Arnebia euchroma* shows the profound importance of this plant in Central Asian countries. The traditional use of this plant for a wide range of health problems has been confirmed by scientific studies, which have revealed a whole clade of biologically active compounds with significant therapeutic potential. The significance of *A. euchroma* in Central Asian countries cannot be overstated. Its historical role as a remedy for respiratory, gastrointestinal, and dermatological ailments has been enriched by the discovery of phytochemicals such as flavonoids, tannins, alkaloids, saponins, and phenolic compounds. These compounds exhibit diverse pharmacological properties, including antioxidant, anti-inflammatory, antimicrobial, and even anticancer effects, aligning with the plant's traditional applications. *A. euchroma*'s relevance extends beyond its medicinal uses. It plays a crucial role in the cultural fabric of Central Asian societies and contributes to textile dyeing traditions, imparting vibrant shades of red and purple to fabrics. Its cultural significance, particularly in ceremonial and symbolic contexts, adds a layer of value to this botanical treasure. However, the over-harvesting and depletion of *A. euchroma* in its natural habitat raise serious concerns about its sustainability. To address these challenges, it is imperative to explore conservation measures employing biotechnological methods. Initiatives aimed at sustainable cultivation and preservation of the plant's genetic diversity are vital to ensure its continued availability for traditional practices and scientific research. Encouraging and promoting the sustainable cultivation of *A. euchroma* in controlled environments can help meet the demand for this valuable plant while reducing pressure on wild populations. Conservation efforts should prioritize the preservation of the plant's genetic diversity. This can be achieved through the establishment of germplasm banks and genetic resource management programs. Investing in biotechnological research can lead to the development of propagation methods, tissue culture techniques, and genetic improvement strategies that enhance the plant's resilience and productivity. Involving local communities in conservation efforts can create a sense of ownership and responsibility, fostering a collaborative approach to the sustainable management of *A. euchroma*. Enforcing and strengthening legislative protections for the plant and its

natural habitat is crucial to prevent over-exploitation and habitat loss. *A. euchroma* is not just a botanical species but a cultural and medicinal heritage deeply rooted in different parts of the world. Its traditional uses have found validation in modern scientific research, revealing a reservoir of potential therapeutic benefits. To ensure the continued availability of this precious resource, it is imperative to embrace conservation practices that combine traditional wisdom with biotechnological advancements. This holistic approach will safeguard *A. euchroma* for generations to come, preserving its rich legacy and offering hope for the development of novel medicinal remedies.

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