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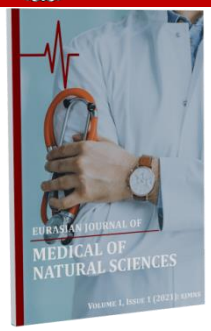

BIOECOLOGICAL AND MEDICINAL PROPERTIES OF BIDENS FRONDOSA L.

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ABSTRACT
The article presents information on the bioecological characteristics of the plant Bidens frondosa L., including its botanical description, taxonomic position, medicinal properties, and chemical composition that determines its pharmacological activity.

INTRODUCTION. Present, globally, scientific research is being conducted to develop effective and safe anti-inflammatory drugs and biologically active supplements based on natural plant raw materials. These studies include qualitative and quantitative analysis, identification, pharmacological research, and approval of regulatory documentation.

Special attention is also given to expanding the assortment of local plant raw materials with anti-inflammatory effects, conducting comprehensive pharmacognostic studies, and introducing them into medical practice.

Within the framework of ongoing reforms in the pharmaceutical sector of our Republic, significant progress is being made in studying the composition of local medicinal plants, standardizing them using modern physical-chemical methods, and developing pharmaceuticals based on them.

LITERATURE REVIEW AND METHODOLOGY. Only specialists in a narrow field are aware that Bidens frondosa L. has begun to spread widely in Uzbekistan. Therefore, this plant still requires thorough pharmacognostic investigation. Its bioecological characteristics have been studied by American scientists Strother J.L. and Weedon R.R. (2006), Belarusian researchers O.V. Molchan, M.A. Dzhus, T.A. Skuratovich, and V.O. Petrinchik (2016), as well as Russian scientists E.A. Glazkova (2005) and M.A. Galkina (2014). In Uzbekistan, relevant studies have been conducted by I.I. Maltsev (2013) and K.Sh. Tojibayev with Kh.K. Esanov (2021). However, the pharmaceutical aspects of this plant species growing under the conditions of Uzbekistan have not yet been explored.

The genus *Bidens* (Bídens L.) includes approximately 230–280 species, among which *Bidens tripartita* L., *Bidens frondosa* L., *Bidens pilosa* L., *Bidens cernua* L., and *Bidens radiata* L.

are notable representatives. Most species of this genus are distributed across tropical, subtropical, and moderately warm temperate regions. They are typically annual herbaceous plants. The stem is erect, extensively branched, and reaches a height of up to 80–120 cm. The leaves are opposite, entire or divided into 3–5 lobes, sometimes irregularly dissected. The flower heads are solitary or grouped into inflorescences. The involucral bracts are hemispherical or bell-shaped; the outer bracts are linear-lanceolate, while the inner ones are nearly membranous. The receptacle is chaffy; the marginal florets are sterile, ligulate, yellow, and may sometimes be absent; the central florets are tubular. The fruits are flattened or three-angled achenes covered with bristles.

As raw medicinal material, representatives of the *Bidens* genus are typically used in the form of leafy stems cut into pieces up to 20 cm in length and 0.4 cm in diameter, consisting of whole or crushed leaves, capitula (flower heads), and seeds. The stem is green or greenish-purple; the leaves and outer bracts are green or greenish-brown; the inner bracts are yellowish-brown with numerous purple veins. The flowers are yellow, and the seeds are dark brown to black. The plant has a weak characteristic odor [1].

Bidens frondosa L. is an annual herbaceous plant that grows to a height of 100–200 (up to 280) cm. Its stem is erect, branched, four-angled, with the upper part slightly reddish and sparsely covered with hairs [2].

The long petioles of the plant bear opposite leaves, which are divided or deeply lobed into 3–5 segments, and occasionally into 5–7 lobes. Toward the top, the leaves become simpler and smaller. The leaf blades are up to 7 cm long and 6 cm wide. The middle lobes of the dissected leaves are usually significantly larger—up to 5 cm long and 2 cm wide. The leaf shape is broadly lanceolate, with serrated margins and covered with hairs; the venation is reticulate. At the base of the petiole, there are ciliate hairs about 4–5 mm long.

The flower heads (capitula) are located at the ends of branches, upright, and almost equal in diameter and height. The involucre consists of two rows of bracts: the outer ones are green and elongated, while the inner ones are brownish-yellow, oval, and smaller than the flowers. The flowers are tubular, bisexual, and pale yellow. The flower heads are erect, 0.4 to 1.2 cm in diameter, surrounded by up to 8 elongated lanceolate bracts that are equal to or twice as long as the capitulum. The inner involucral bracts are translucent, membranous, elongated-oval, and do not exceed the length of the corolla or fruit [3].

The corolla lobes are small, tubular, with slightly notched apices. The flower heads are typically solitary, rarely paired or in threes, with diameters up to 3 cm and lengths of 1–4 (up to 8) cm. The marginal bracts are often ciliate, and the inner row contains 6–12 nearly membranous, elongated-ovate bracts, each 5–9 mm long. Ray florets are usually absent but may occasionally occur in numbers from 1 to 3 or more, and are golden-yellow in color. There are 20–60 or more tubular disc florets with corollas 2–3.5 mm long and dark yellow in color.

The achenes (seeds) have hook-shaped bristles that curve downward and sideways and are distributed over the entire seed surface. Their color ranges from olive to dark brown [4].

The biological characteristics of *Bidens frondosa* L. are distinctive. During its ontogeny, the seeds begin to germinate approximately two weeks after sowing, whereas in *Bidens tripartita* this process usually starts 2–4 weeks after sowing. The cotyledons are green, with a linear, shallowly notched apex. The first pair of true leaves appears about two weeks after germination

and consists of three elongated, ovate-lanceolate lobes of equal size. The upper leaves are slightly larger than the lower ones, and the lobes become more prominent, forming a distinct leaf blade that is not fused at the base, giving the appearance of a petiole. These leaves are not merely trifoliate but exhibit a three-layered structure [5].

The plant flowers from June to August and reproduces exclusively by seeds. The seeds are covered with numerous hairs and possess two tooth-like, hook-shaped bristles. These easily adhere to clothing or animal fur, facilitating the plant's rapid and widespread distribution.

The composition of *Bidens frondosa* L. includes key groups of biologically active compounds, notably phenolic compounds—primarily flavonoids—alongside polysaccharides and essential oils [6]. Among these, phenolic compounds are the most extensively studied group in *B. frondosa*. Their content and component profiles were first investigated using chromatographic and spectrophotometric methods by researchers such as G. Romussi, E. Pagani, A.G. Serbin, and T.I. Isakova. Later, these studies were continued by Japanese scientists H. Karikome, K. Ogawa, and Y. Sashida [7].

These early researchers were among the first to isolate and elucidate the structures of flavonoids belonging to the chalcone group. Notable examples include:

- Okanin-4'-O-(6''-O-acetyl-2''-O-caffeoyl-β-D-glucopyranoside),
- Okanin-4'-O-(2''-O-caffeoyl-6''-O-p-coumaroyl-β-D-glucopyranoside),
- 4-O-methylokanin-4'-O-(6''-O-p-coumaroyl-β-D-glucopyranoside),
- 4-O-methylokanin-4'-O-(6''-O-acetyl-β-D-glucopyranoside),
- 4-O-methylokanin-4'-O-(6''-O-acetyl-2''-O-caffeoyl-β-D-glucopyranoside).

These findings confirmed the presence of several types of flavonoids in *B. frondosa*, including:

- **Chalcones**: okanin derivatives such as okanin-4'-O-(6''-O-p-coumaroyl-β-D-glucopyranoside), okanin-4'-O-(6''-O-acetyl-β-D-glucopyranoside), and okanin itself;
- **Aurones**: (Z)-6''-O-p-coumaroylmaritimein, (Z)-6''-O-acetylmaritimein;
- **Flavones**: apigenin, luteolin, luteolin-7-O-β-D-glucopyranoside;
- **Flavonol**: kaempferol-3-O-β-D-glucopyranoside.

In addition, Korean researchers Dalrae Ahn and Dae Keun Kim confirmed the presence of other phenolic compounds in this plant, such as quercetin-3-O-β-D-glucopyranoside, luteolin-7-O-β-D-glucopyranoside, and okanin. They also identified compounds like okanin-4-O-β-D-glucopyranoside and 7,8,3',4'-tetrahydroxyflavanones [8] (see Fig. 1.3).

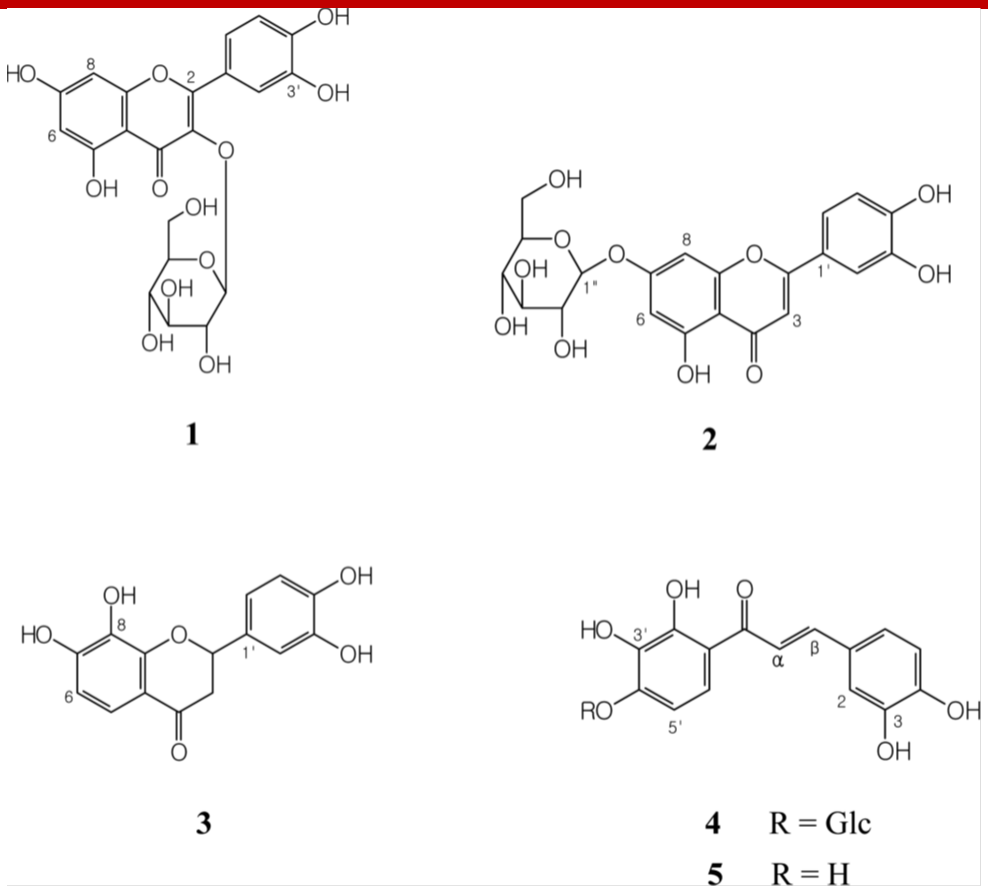

Figure 1.3. Chemical structures of compounds isolated from the methanolic extracts of *Bidens frondosa* L.:

1. Quercetin-3-O-β-D-glucopyranoside *(Isoquercetin)*
2. Luteolin-7-O-β-D-glucopyranoside
3. 7,8,3′,4′-Tetrahydroxyflavanone
4. Okanin-4-O-β-D-glucopyranoside
5. Okanin.

The biologically active compounds present in Bidens frondosa L. are noteworthy for their potential to exhibit anti-inflammatory activity, which substantiates the therapeutic relevance of this plant species in the treatment of inflammatory conditions.

According to the literature, N. Korozhan and G. Buzuk identified luteolin (0–3.0 mg/g dry weight), luteolin-7-O-β-D-glucopyranoside (9.5–33.0 mg/g dry weight), and caffeic acid (1.5–4.0 mg/g dry weight) in the aerial parts of Bidens frondosa L. growing in the Republic of Belarus. It has also been reported that the total flavonoid content in the medicinal plant raw material varies depending on the plant's vegetation stage and drying conditions.

From the germination stage to the budding phase, the flavonoid content in Bidens frondosa L. gradually increases, reaching its peak at the beginning of the budding and flowering stages. During the flowering and seed-setting phases, the flavonoid content decreases significantly, amounting to 45–50% during flowering and 35–40% during seed maturation, relative to the maximum amount retained in the plant. It was found that during the vegetation period, the main chemical component of the aerial part of Bidens frondosa L. is luteolin-7-O-glucoside, which exhibits a stable presence [9].

It was found that when the plant material was dried at 40°C without ventilation, the flavonoid content did not differ significantly from that of raw material dried under natural conditions. However, a further increase in temperature without ventilation led to a 15–25% decrease in the flavonoid content. Raw material dried with forced ventilation was shown to retain more flavonoids than plant material dried at 40–50°C without ventilation. Under these conditions, a further increase in temperature caused a 5–10% decrease in flavonoid content. Moreover, it was revealed that aerial parts of the plant dried at 40°C without ventilation contained 2.5 times more luteolin and an approximately equal amount of luteolin-7-O-glucoside compared to plant material dried naturally (i.e., in a well-ventilated shaded area). Increasing the temperature under non-ventilated conditions led to a significant reduction in the content of luteolin-7-O-glucoside and other flavonoids. Literature sources indicate that drying raw material at 40°C preserves a high concentration of luteolin-7-O-glucoside [10].

Species of the genus *Bidens* have long been widely used in traditional and folk medicine in various countries for the treatment of a range of diseases, as well as utilized as food products. According to data from literature sources, plants belonging to the *Bidens* genus contain various biologically active compounds, including flavonoids, phenylpropanoids, triterpenoids, and organic acids, among which flavonoids are considered to be some of the most effective constituents [11].

In European and Central Asian countries, the young shoots or leaves of plants belonging to this species are widely used in phytotherapy in the form of various salads, soups, and especially herbal teas. In its primary range—the United States and Canada - Bidens frondosa is commonly used in the treatment of upper respiratory tract infections, cardiovascular, and urinary tract diseases [12]. According to various literature sources, the leaves and inflorescences of this species contain significant amounts of flavonoids, carotenoids, and other compounds with antioxidant activity. Experimental studies conducted in Eastern European countries have identified the plant's spasmolytic, diaphoretic, and expectorant properties, and its promising pharmaceutical applications have been highlighted [13–14].

CONCLUSION. It has been established that the content of the main active constituents—polysaccharides and flavonoids—in Bidens frondosa L. is dependent on the harvesting period and drying conditions of the medicinal plant material. Based on the accumulation dynamics of polysaccharides and flavonoids, the optimal time for collecting Bidens frondosa L. is recommended to be at the budding and early flowering stages. The optimal drying conditions are identified as either natural air drying or forced ventilation at temperatures not exceeding 40°C.

Data have been reported on the antioxidant, antimicrobial, antiallergic, hypoglycemic, and antidiabetic effects of Bidens frondosa L. extracts, as well as the anti-inflammatory activity of certain individual plant components. Based on the above, Bidens frondosa L., a plant with high pharmacological potential, can be considered a promising source for the development of new innovative pharmaceuticals—particularly those with antiallergic effects—and as a natural source of flavonoids such as luteolin and its derivatives.

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