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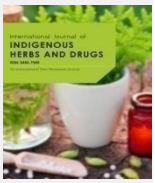

RUDBECKIA HIRTA L.: AN UPDATE REVIEW OF ITS PHYTOCHEMISTRY, TRADITIONAL USES AND ETHNOPHARMACOLOGY

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ABSTRACT

The demand for ornamental plants is expected to increase in the future due to the growth of global trade. Nowadays, interactions with urban green infrastructure largely define people's encounters with nature within cities.Black-eyed Susan (Rudbeckia hirta L.), a flowering plant with various traditional medicinal uses, has recently garnered interest for its therapeutic properties. However, little is known about the potential therapeutic activities of the plant species.Rudbeckia, a genus within the Asteraceae family, is native to North America. This review aims to examine the literature on the ethnobotany, chemical composition, and bioactivity to date on this genus to provide a basis for future exploration into its medicinal potential.The species has several chemical constituents that are thought to contribute to its potential bioactive properties. These include flavonoids with anti-oxidant, anti-inflammatory, and anti-bacterial activities, such as quercetin and its glycosides, kaempferol and quercetagetin derivatives, patuletin and eupatolin. Several polyphenolic acids, such as caffeic and chlorogenic acids, are also known to be present in the plant. Other chemical constituents of R. hirta include terpenes, which are thought to be responsible for the plant's distinctive taste and smell and its antibacterial properties. Further studies on this plant must be carried out to explore some other important, necessary, and unknown benefits.

Keywords: *Rudbeckia hirta, Black-eyed Susan, folk medicine, ethnopharmacology.*

INTRODUCTION

For centuries, herb plants are used as a source of medicine. World Health Organization (WHO) reports that the world's population resort to folk medicine for their primary healthcare needs. In this context, natural products, such as plant extracts, either as pure compounds or as standardized extracts, provide unlimited opportunities for new drug discoveries. Also, vegetable materials are used from ancient time as source of flavouring, beverages, fragrances, and cosmetics products. This is because the plant materials have unique properties to synthesize biologically active compounds resulted as metabolites from their so-called secondary metabolism. Due to the development of new growing areas, where traditional varieties cannot be adapted, the need to produce new varieties of ornamental plants with improved properties has increased. At the beginning of the 20thcentury, plant biologists established that the frequency and efficiency of genetic modifications in treated seeds could be increased by using chemical and radiation technology [1,2].

Asteraceae is the largest flowering plant family and has more than 32,000 species spread across approximately 1,911 genera. Among those genera, numerous plants have significant ethnobotanical importance as food, dyes, and medicine. The genus Rudbeckia L. (Asteraceae) is distributed throughout North America, except in extreme northern and southern regions, and primarily grows east of the Rocky Mountains in prairies and grasslands. However, Rudbeckia spp., which are also referred to as coneflowers or black-eyed Susan, have made their way around the world as a popular garden ornamental and, in areas such as Europe, some species have been naturalized.The genus Rudbeckia was described in 1753 by Linnaeus and named after Swiss botanists Olaus and Johan Rudbeck. When initially described, Rudbeckia consisted of all 'coneflowers',plants characterized by elongated receptacles and colourful

reflexed or spreading ray corollas.The genus Rudbeckia contains more than 20 species, of which Rudbeckia hirta L., R. fulgida, R. laciniata, R. maxima, R. occidentalis and R. triloba are best known for their decorative value [2,3].

R. hirta, also known as black-eyed Susan or yellow coneflower, is a popular wildflower native to North America. The plant is known for its striking yellow petals and dark center that resembles a black eye, giving it its common name. A hardy and easy-to-grow plant, R. hirta is often seen in meadows and prairies but also along roadsides. The plant can bloom well into the fall but usually does not bloom until mid to late summer. Its drought tolerance makes it a great option for gardeners looking for low-maintenance plants. The species belongs to the Asteraceae family, which is the best-represented and most widespread family of dicotyledonous plants and consists of approximately 1500 genera and more than 23,000 species that illustrate a great morphological diversity.

Rudbeckia hirta (R. hirta) has been classified as annual, biennial or perennial, depending on its habitat and genetic characteristics. The plant is an herbaceous species with a semi-erect stem that is covered with bristles and can grow up to 1 m in height. The stem supports a single flower head and is surrounded by a basal rosette of leaves. Small, dark brown or black disk florets form the dark core of the flower, which is surrounded by a ring of yellow ray florets. Like the stem, the leaves and bracts are covered with hairs, which explains the scientific name of the species, the Latin term "hirta" meaning "hairy".

The plant is commonly used for landscaping but can also be used to control soil erosion and provide shelter for several species of birds. In addition to its ornamental value, the species has long been used in traditional medicine in several regions of North America. For example, the Cherokee and Iroquois tribes used the plant as an anthelmintic, especially in the form of infusions prepared from the roots. Various root extracts have also been used to treat gynecological conditions and sexually transmitted diseases. The plant has been used to treat fevers, colds, and headaches and is believed to have anti-inflammatory and analgesic properties. In addition, the plant's roots, leaves, and flowers have been used to make tea and various extracts, as well as poultices and ointments. The plant is also thought to have antimicrobial properties. Given these potential applications, the plant becomes attractive for additional purification processes that may lead to the discovery of therapeutically useful compounds.

Given that R. hirta can be found in different geographical regions, its growth and development, as well as the production of secondary metabolites, can be influenced by various factors such as origin, the altitude at which the plant grows, amount of rainfall, temperature, exposure to sunlight, soil quality, and composition. In addition, the number of secondary metabolites produced by the plant can vary with the age and degree of growth, but also with the conditions of collection, drying and storage of the plant material [4-6].

COMMON NAMES

The specific epithet hirta is Latin for "hairy", and refers to the trichomes occurring on leaves and stems. Other common names for this plant include: brown-eyed Susan, brown betty, gloriosa daisy, golden Jerusalem, English bull's eye, poor-land daisy, yellow daisy, and yellow ox-eye daisy [3,7].

Table 01: Taxonomy

Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Asterales
Family	Asteraceae
Genus	*Rudbeckia*
Species	*R. hirta*
Botanical name	***Rudbeckia hirta L.***
Scientific Name	***Rudbeckia hirta L. var. hirta***

Figure 01: Rudbeckia hirtaplant

DESCRIPTION

Rudbeckia hirta, or black-eyed or brown-eyed Susan, is one of nine species of Rudbeckia native to Florida. As with many of the Asteraceae, the flowers are found on a head with both ray and disk flowers. The ray flowers are golden yellow and as the common name suggests, the disk flowers are dark brown. Black-eyed Susan blooms during the months of July through October, offering nectar to pollinators such as butterflies and bees.Annual, biennial, or (short-lived) perennial herbs, 30–100 cm tall; rootstock a distinct taproot (in annual or biennial plants) or roots fibrous. Stems simple (and plants often scapiform) or branched at base, mid-stem, or only in inflorescence, striate although often drying plicate (especially in the inflorescence), leafy throughout or basally, coarsely hispid (from the remnant bases of broken hairs) to hirsute or sericeous, hairs spreading, 1+ mm long, septate, uniseriate, multicellular, and eglandular, apical cell acute to long-acute.

Leaves petiolate (mostly basal), pseudopetiolate, or sessile (mostly upper), lamina elliptic, lanceolate, broadly linear, spathulate or ovate (not lobed) to orbiculate, 3-veined, secondary venation pinnate, basal leaves 8–30 cm long x 0.5–7 cm wide, cauline leaves 3–20 cm long x 0.4–4 cm wide, bases attenuate to cuneate, margins entire or

serrate to serrulate, apices acute, both surfaces coarsely hispid to hirsute. Inflorescence of 1–5 capitula in terminal, laxly corymbiform, branches ascending or divergent, flowering portion 1/3 to ½ plant height, peduncle/pedicels plicate, ridges paler coloured and sparsely hispid to hirsute.

Capitula heterogamous and discoid, heterochromous (disc usually appearing blackish or brownish-purple, and 12-22 x 10-20 mm; involucre patelliform; phyllaries hispid to hirsute, to c. 30 mm long; receptacle hemispheric to ovoid; paleae 4-6 mm, apices acute, often attenuate, apices hirsute to hispid abaxially. Ray florets 8-16, ray limbs elliptic to oblong or oblanceolate, 15-45 x 5-10 mm, abaxially hispid to hirsute apically 2-lobed, usually uniformly yellow (our material) to yellow-orange or with a basal maroon or brownish-red splotch (particularly amongst cultivars, but see Discussion below), sometimes mostly maroon. Disc florets hermaphrodite, 250-500+, corollas actinomorphic, 5-lobed, lobes corolla tube yellowish green at base, distally dark brownish-purple, 3-4.2 mm long; anther cylinder scarcely exserted from corolla tube, apical anther appendages broadly triangular, brownish, few-glanded; style arms c. 1.5 mm long, apices subulate. Achenes 1.5-2.7 mm long, quadrangular, apex truncate, glabrous; pappus absent. 2n=38 [8-11].

DISTRIBUTION

Since the distribution of the varieties has a distinct geographical pattern. R. hirta var. hirta: United States (Alabama, Arkansas, Connecticut, Delaware, Georgia, Illinois, Indiana, Kentucky, Maine, Maryland, Mass., Michigan, Mississippi, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Vermont, Virginia, West Virginia); [30–300 m]; var. pulcherrima: Canada (Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, Nova Scotia, Ontario, Prince Edward Island, Quebec, Saskatchewan). Unites States Alabama, Arkansas, California, Colorado, Connecticut, Delaware, District of Columbia, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming; [10–500 m]; var. angustifolia: United States (Alabama, Florida, Georgia, Louisiana, Mississippi, South Carolina, Texas); [20–80 m]; var. floridana: United States (Florida); [0–20 m].

Figure 02: Rudbeckia hirtaleaves

ADAPTATION

Black-eyed Susan is an early successional species adapted to clay, loam, and sandy soils. This forb prefers acidic soils less than 6.8 pH and grows well in full sun with slightly moist to moderately dry soil conditions.

Figure 03: Black-eyed Susan is a pollen and nectar source for bees

CULTIVATION

Rudbeckia hirta is widely cultivated in parks and gardens, for summer bedding schemes, borders, containers, wildflower gardens, prairie-style plantings and cut flowers. Numerous cultivars have been developed, of which 'Indian Summer' and 'Toto' have gained the Royal Horticultural Society's Award of Garden Merit. Other popular cultivars include 'Double Gold' and 'Marmalade'.Gloriosa daisies are tetraploid cultivars having much larger flower heads than the wild species, often doubled or with contrasting markings on the ray florets. They were first bred by Alfred Blakeslee of Smith College by applying colchicine to R. hirta seeds; Blakeslee's stock was further developed and introduced to commerce at the 1957 Philadelphia Flower Show. Gloriosa daisies are generally treated as annuals or short-lived perennials and are typically grown from seed, though there are some named cultivars [12-15].

HABITAT AND GROWTH CONDITIONS

- **Soil:** Prefers well-drained, loamy to sandy soils but can tolerate a variety of soil types.
- **Light:** Thrives in full sun but can tolerate partial shade.
- **Watering:** Moderate drought tolerance, requiring regular watering during establishment.
- **Hardiness:** USDA zones 3 to 9.

Figure 04: Rudbeckia hirta flower

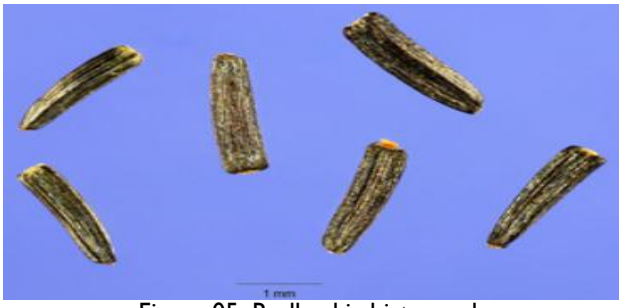

Figure 05: Rudbeckia hirta seed

TRADITIONAL NATIVE AMERICAN USES

The plant is thought to be an herbal medicine by Native American for various ailments. The roots, though not the seedheads, of Rudbeckia hirta can be used to boost immunity and fight colds, flu, and infections. The Ojibwa people used it as a poultice for snake bites and to make an infusion for treating colds and worms in children.

Flavonol glycosides, amongst several phenolic metabolites have also been found in extracts of 'flowers' in Rudbeckia hirta, and the laboratory studies of 5-LOX inhibitory, immunomodulatory, and anti-oxidant activities of these compounds have been evaluated providing scientific evidence for the ethnopharmacological use of the plant in inflammatory conditions.American Indians use the root tea for worms and colds, but also as an external wash for sores, snakebites, swellings, and the root juice for earaches.

Native American Indian tribes utilized the entire black-eyed Susan plant. Yellow and green dyes were produced from the blooms. Derivatives from roots, stems, leaves, and florets were used to treat various ailments. The Cherokee prepared a leaf wash to heal swelling caused by worms. Sores were bathed with root infusions and earaches treated with root oozes. The Iroquois used root infusions to treat children with worms and a root decoction for heart medicine. The Potawatomi treated colds with root infusions[16,17].

MEDICINAL USES

Rudbeckia hirta (Black-eyed Susan) has been traditionally used by Indigenous peoples of North America for various medicinal purposes. While not as widely known for its uses as some other medicinal plants, it holds significance in herbal medicine. Here are some of its traditional uses:

Immune Support:

The roots and leaves of Rudbeckia hirta have been used similarly to Echinacea (purple coneflower) for boosting the immune system. It has been used to treat ailments like colds, flu, and infections, and to support general immunity.

Treatment of Infections:

Poultices: The roots were sometimes mashed and applied as a poultice to wounds, snake bites, and infections to reduce inflammation and promote healing.

Washes/Infusions: A tea or infusion made from the roots was used as a wash for external sores, wounds, and snake bites to help disinfect and soothe the skin.

Respiratory Health

Infusions or teas made from the leaves or roots were used to treat coughs, colds, and minor respiratory infections, particularly among the Cherokee people.

Gastrointestinal Issues:

Some Native American tribes used infusions of Rudbeckia hirta to treat various digestive ailments such as diarrhea.

Urinary Health:

- It has been used as a diuretic to help with urinary problems and kidney health.

Eye Infections:

- Black-eyed Susan was used in traditional remedies as a mild eyewash for treating eye irritation or infections, likely to reduce inflammation and promote healing.

General Tonic:

- The plant was sometimes used as a general tonic to support overall health and wellness, especially after illness.

Symbolic and Ceremonial Use:

- In some cultures, Rudbeckia hirta was used in ceremonial contexts or as a symbol of encouragement and perseverance due to its bright, resilient nature.

PATHOGENICITY

Pathogenicity was confirmed by dusting conidia on healthy potted plants of R. hirta, non-inoculated plants serving as control. Inoculated plants developed the original powdery mildew symptoms after 8-10 days whereas control plants remained healthy.

Ecological importance

Pollinators: Attracts bees, butterflies, and other beneficial insects.

Wildlife: Seeds are a food source for birds, particularly finches.

PHYTOCHEMISTRY

The phytochemistry of R. hirta involves a variety of bioactive compounds, many of which contribute to its traditional medicinal uses. Although this plant has not been as extensively studied as some other medicinal herbs, several key phytochemical groups have been identified. The leaves of Rudbeckia hirta L., harvested in Belarus in different phases of plant development, contain from 1.93 to 4.82% of the sum of hydroxycinnamic acids and about 1.74% of the amount of chlorogenic acids. The aerial part of Rudbeckia hirta contains caffeic and chlorogenic acids.

The flowers of Rudbeckia hirta include β-resorcilic, p-coumaric, caffeic, 5-O-caffeic quinic acids, as well as 5-O-p-cumaroyl quinicacid and its methyl ester. The methanol extract obtained from the frozen leaves of Rudbeckia hirta contains various esterification products of quinic acid with caffeic acid.The flowers of Rudbeckia hirta L. contain gossipetin-7-O-β-glucopyranoside, quercethagetin-7-O-β-D-glucopyranoside, eupatolin, patulitrin and chrysosplenol D.Petalscontain flavonols, patulitrin, quercetagetin and 6,7-dimethoxy-3',4',5-trihydroxyflavon-3-O-glucoside. The herb Rudbeckia hirtacontains quercetahetin-7-O-galactoside and patuletin-7-O-galactoside.

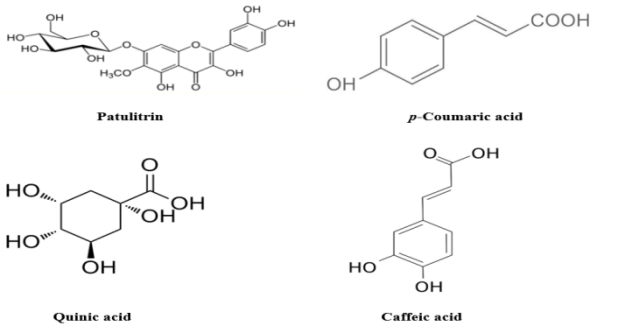

Figure 06: Phytochemical constituents in Rudbeckia hirta L.

The composition of the aerial part (herb) of Rudbeckia hirta includes aglycone eupatolitin, flavonol glycosides (quercetin-7-O-glucoside, quercetagytin-7-O-glucoside) and methoxy derivative of quercetin (eupatolin), as well as dimethoxy-3,5,4′-trihydroxyflavone-3- O-ramnoside. The content of patulitrin in flowers is 1.90%, in leaves 0.82% and in stems 0.12%. Only patulitrin was found in stem culture. The herb includes hyperoside and rutin.The flavonoid composition of the petals of Rudbeckia hirta is kaempferol and its 3-O- and 7-O-glucosides; 6-methoxykaempferol; 7-methoxykaempferol; 6-hydroxykaempferol; 7,8-dimethoxykaempferol-3-O-glucoside; quercetin and its 3-O-glucoside; 7-methoxyquercetin and quercethagetin-3-O-glucoside. Additionally, eupatolitin-3-O-β-D-(6″-O-acetyl)-glucopyranoside was found in the petals. The total content of flavonoids in the petals of Rudbeckia hirta L. is 4.72%. The leaves contain carotenoids, chlorophylls a and b, albumin, globulins, gluteins and prolamins. The roots and grass contain lectins and alkylamides. The flowers contain the rud-beckolide-sesquiterpene lactone.

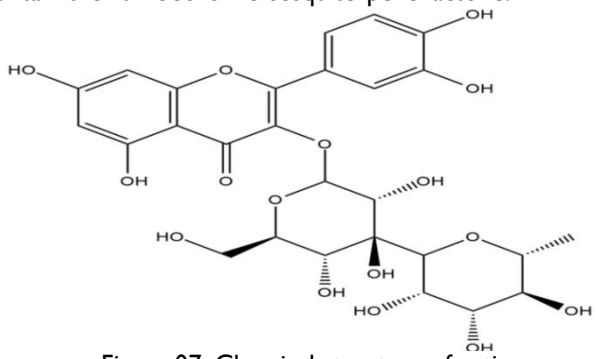

Figure 07: Chemical structure of rutin

ETHNOPHARMACOLOGY

Methanol extraction from flowers and individual components of Rudbeckia hirta L. exhibit immunomodulatory, anti-oxidantand anti-inflammatory property.The anti-oxidant properties of the extracts obtained by extraction with petroleum ether, chloroform, ethyl acetate, n-butanol, ethanol. Polyacetylenes and thiophenes of Rudbeckia hirta L. have a photosensitizing effect.

Rudbeckia hirta to treat gastrointestinal disturbances such as diarrhea and stomach cramps. It was also employed as a diuretic to address urinary tract issues.Rudbeckia hirta has been employed for a range of therapeutic applications due to its anti-microbial, and wound-healing properties. Extractions from the roots of plants containing tiarubrin C or pentaenen have insecticidal and anthelmintic properties. Tiarubrin C, isolated from the roots of Rudbeckia hirta exhibits pronounced antibacterial and antifungal properties and can be used as an anti-septic.

PHYTOCHEMISTRY SUPPORTING ETHNOPHARMACOLOGY

Rudbeckia hirta flowers have anti-microbial, 5-LOX inhibitory, immunomodulatory, anti-oxidant and cytotoxic properties.Rudbeckia hirta's traditional uses are supported by its diverse range of bioactive compounds, which include:

Flavonoids: These antioxidants reduce inflammation and boost the immune system, which supports its use in treating respiratory infections, fevers, and wounds.

Polyacetylenes: Known for antimicrobial activity, these compounds contribute to the plant's ability to fight infections and heal wounds. And also possess insecticidal properties against mosquito larvae under different light regimes.

Tannins: Astringent properties aid in the treatment of wounds and may help reduce bleeding.

Terpenoids and essential oils: These volatile compounds possess anti-inflammatory and antimicrobial properties, supporting their traditional use for respiratory and skin infections.

Caffeic acid derivatives: These compounds exhibit anti-oxidant and anti-inflammatory effects, helping to reduce inflammation in gastrointestinal and urinary conditions[9,11,18-22].

CONCLUSION

Recently medicinal plants are used to prepare many medicines. Rudbeckia hirta is a medicinal plant used for many purposes. The present compilation provides sufficientsupport regarding the usefulness of this valuablemedicinal plant. The various pharmacological activities areattributed to the boundless coverage of variousphytochemicals that the plant possesses. The complex of biologically active substances found in the plant and its pharmacological properties provide the basis for further in-depth study of Rudbeckia hirta and its application in medicine.Implicitly, the discovery of such a wide range of bio-substances, together with the biological activity observed for the studied extract in these preliminary in vitro studies, paves the way for future investigation of the potential application of the plant in the pharmaceutical and nutraceutical sectors. Further, this investigation will be helpful to identify the plant and also provide valuable information to the researchers to establish the pharmacological activities supported with possible mode of action.

AUTHOR CONTRIBUTIONS

All authors contributed to data collection, drafting or revising the article, gave final approval of the version to be published, and agreed to be accountable for all aspects of the work.

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