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Ethnomedicinal and economic significance of Annatto (*Bixa orellana* L.)**Kumari Sunita¹, Sanjeet Kumar² and Sweta Mishra^{2*}**¹Department of Botany, Plant Physiology and PGPR Lab, Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur, Uttar Pradesh, India²Ambika Prasad Research Foundation, Odisha, India***E-mail:** swetamishra.aprf@gmail.com**ABSTRACT**

Bixa orellana L., commonly known as annatto, achiote or lipstick tree. It is a tropical plant widely recognized for its medicinal, cultural and economic importance. It is native to tropical America, but has been extensively cultivated across Asia, Africa, and other tropical regions. Indigenous communities have traditionally used annatto for medicinal purposes, body painting, food coloring and ritual practices. The plant contains numerous bioactive compounds such as carotenoids, flavonoids, terpenoids and alkaloids that contribute to its pharmacological activities. Ethnomedicinally, it is used for treating inflammation, gastrointestinal disorders, infections, diabetes and skin diseases. In addition to its medicinal value, annatto has profound cultural significance among indigenous populations, particularly in Latin America, where it has historically been used for body paint, cosmetics and ceremonial rituals. The seeds produce annatto dye, an important natural colorant widely used in food, pharmaceutical and cosmetic industries. This review explores the ethnomedicinal uses and economic importance of *B. orellana*. Understanding these traditional applications can contribute to future pharmacological research and the conservation of ethnobotanical knowledge.

Keywords: Annatto, cultural significance, ethnomedicine, phytochemistry, traditional knowledge

INTRODUCTION

Bixa orellana L., belonging to the family Bixaceae and commonly known as annatto or the lipstick tree, is a tropical ornamental plant with significant traditional and economic importance (Pandey et al. 2019). The species is native to South and Central America as well as the Caribbean islands. It is widely cultivated in tropical regions across the world, particularly in countries such as Colombia, Mexico, Ecuador, the Peruvian Andes, Indonesia, India, Kenya and other parts of East Africa (Oliveira et al. 2022). In Asia, the plant is mainly grown in India, the Philippines and Sri Lanka. In India, it is commonly referred to as “Sinduri” or “Latkan,” while its English name is annatto and it is known as “Orlean” in German (Pandey et al. 2019). Annatto was domesticated and cultivated throughout the Neotropics before European contact, primarily for the bright red-orange pigment present in the aril surrounding its seeds (Ul-Islam et al. 2016). This pigment has been traditionally used in various cultural contexts, including body painting, food coloration, and ceremonial practices (Moreira et al. 2015). Initially, annatto gained prominence as a natural food coloring and condiment used to enhance the appearance of culinary preparations. Over time, its applications have expanded into several industrial sectors. Today, annatto pigments are widely used in the food, cosmetic, and pharmaceutical industries (Patel et al. 2023). The pigment is incorporated into products such as cosmetics, sunscreens and other personal care formulations, and recent studies have highlighted its potential health benefits due to the presence of bioactive compounds (Raju et al. 2022). It has been traditionally used by indigenous communities in tropical regions for centuries, particularly in South and Central America, Asia, and Africa. Various parts of the plant, including seeds, leaves, roots, and bark, are utilized in traditional medicine for the treatment of a wide range of ailments (Pandey et al. 2019). In traditional medicine systems, *B. orellana* is used for treating several health disorders. The leaves are commonly used to treat fever, bronchitis, sore throat, eye inflammation and gastrointestinal disorders. Leaf decoctions are also applied to wounds and skin infections because of their antimicrobial and anti-inflammatory properties (Purushothaman and Irfanamol 2021). The seeds are slightly purgative and are used in the treatment of dysentery, kidney disorders, and fever. In some traditional practices, seed extracts are used to treat infections of microbial origin (Giorgi et al. 2013). The bark and roots are also used medicinally. Root infusions are traditionally

used to treat skin diseases, diarrhea and uterine disorders, while bark preparations are used for fever and blood-related diseases.

In certain indigenous communities, the plant is also used to manage diabetes, hypertension, jaundice and respiratory problems (Sanglakpam et al. 2012). Modern pharmacological studies have shown that *B. orellana* possesses antioxidant, antimicrobial, anti-inflammatory and hypoglycemic properties. Apart from its medicinal importance, *B. orellana* has significant cultural value among many indigenous communities. The bright red pigment extracted from the seeds has traditionally been used for body painting, ritual decoration and cosmetic purposes. In several Amazonian tribes, the pigment is applied on the skin during religious ceremonies and festivals, symbolizing protection, beauty and cultural identity. The pigment is also believed to act as a natural sunscreen and insect repellent (Vilar Dde et al. 2014).

Historically, the dye obtained from the seeds of *B. orellana* has been widely used for coloring textiles, ceramics and traditional artifacts, and it plays an important role in the cultural traditions of many indigenous communities, particularly for ceremonial body decoration and artistic expression (Ahirwar and Bhoi 2025). Economically, the plant is highly valued for its natural pigments, mainly bixin and norbixin, which are extensively used as natural food colorants in products such as butter, cheese, ice cream etc (Giridhar and Parimalan 2010). Because of its natural origin and safety, annatto dye is considered an important alternative to synthetic food dyes. Beyond the food industry, annatto pigments are also used in cosmetic and textile industries for producing items such as lipstick, soaps, hair products, and for dyeing fabrics like cotton, silk and wool (Raddatz-Mota et al. 2017). The seed press cake is used as animal fodder, bark fibers are utilized for cordage, and the wood serves as fuel (Parimalan et al. 2007).

Recent studies have also explored the potential of annatto by-products in renewable energy production and other industrial applications such as leather processing and natural dye manufacturing. The diverse medicinal, cultural, and economic applications of *B. orellana* highlight its importance as a multifunctional plant resource and emphasize the need for further research and sustainable utilization.

MORPHOLOGY

It is a tropical evergreen shrub or small tree belonging to the family Bixaceae. It typically grows to a height of 3-10 m with a spreading crown and a short trunk. The stem is woody and young branches are often covered with fine hairs. The leaves are simple, alternate and broadly ovate to heart-shaped with a pointed apex and entire margins. They measure about 8-20 cm long and are borne on long petioles. The leaf surface is smooth and dark green on the upper side and lighter beneath. The plant produces attractive terminal clusters of showy flowers that are usually pink, white, or light purple. Each flower has five delicate petals and numerous yellow stamens in the center, giving it a rose-like appearance. Flowering is followed by the development of distinctive capsule-type fruits. These fruits are ovoid or heart-shaped and covered with soft spines or bristles. When mature, the capsule splits open to reveal numerous small triangular seeds. The seeds are coated with a bright reddish-orange waxy aril that contains the natural pigment annatto, mainly composed of carotenoid compounds such as bixin and norbixin. This pigment is widely used as a natural dye and food colorant (Oliveira et al. 2022; Win et al. 2023; Figure 1).

ETHNOMEDICINAL USES

Seeds

The seeds of *B. orellana* are among the most widely used plant parts in traditional medicine and cultural practices. They are slightly purgative and possess considerable nutritive value. In several regions of West Africa, New Guinea and Guyana, the seeds are used for the treatment of dysentery, fever, kidney disorders, and poisoning caused by cassava consumption (Pandey et al. 2019). In Central and South America, seeds are traditionally used for treating infections of microbial origin (Ganju and Ganju 2014). The Amazon tribes of Brazil use seed extracts for body painting, which is believed to repel insects and protect the skin from environmental stress (Giorgi et al. 2013). Studies among Wajapi tribal women of Brazil also support the insect-repellent property of the seed pigment. Seeds are also used for dyeing fabrics and preparing natural pigments. Assamese tribes in India mix dried seed powder with slaked lime for dyeing cotton and silk garments (Pandey et al. 2019). In

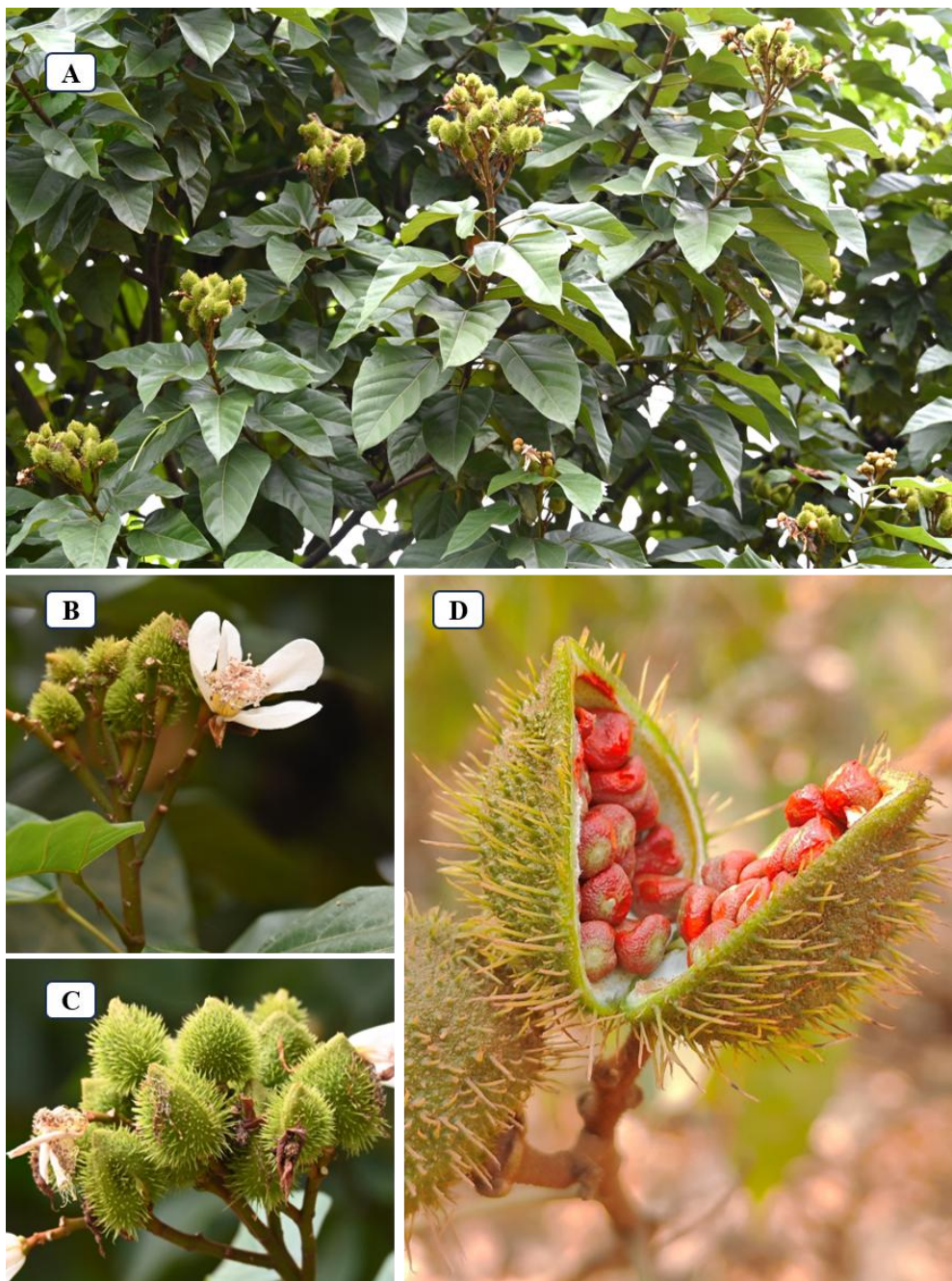


Figure 1: Vegetative parts of *B. orellana*; A) Canopy, B) Flower, C) Fruits, D) Seeds

Manipur, India, the Meitei and Rongmei tribes soak seeds in water to extract a red dye used for coloring yarn and traditional clothes (Potsangbam et al.

2008). Medicinally, seeds are used to treat skin diseases and intestinal problems among the Baiga and Gond tribes of Chhattisgarh (Ahirwar and Bhoi 2025). The pulp of the seed is also administered by the Koyas and Konda Reddi tribes of Andhra Pradesh for the treatment of dysentery and diarrhea (Venugopalan et al. 2011).

Leaves

Leaves of *B. orellana* are widely used in traditional medicine for treating numerous ailments. Leaf decoctions are used in Gabon to control vomiting and in the Democratic Republic of Congo as a gargle for sore throat and tonsillitis, as well as for treating itching (Pandey et al. 2019). In Mauritius, leaf infusions are used to relieve headaches, while in Ethiopia, the leaves are applied as wound dressings (Pandey et al. 2019). The infusion of leaves is also used to treat bronchitis, sore throat, and eye inflammation. In Trinidad and Tobago, leaf preparations are traditionally used to treat diabetes, jaundice, and hypertension (Lans 2006). Among the Bedes tribes of Bangladesh, leaf paste is applied externally to injured or painful areas twice daily for about seven days (Seraj et al. 2012). In Cameroon, the leaves are commonly used to treat joint pain, fever, jaundice, gastrointestinal disorders, and asthma. They are also used as a gargle for sore throats and possess antimicrobial, antifungal, anti-inflammatory, analgesic, anticonvulsant, and anti-leishmanial properties (Purushothaman and Irfanamol 2021).

Bark

The bark of *B. orellana* is traditionally used in India for treating fever, gonorrhea, phlegm-related disorders, blood diseases and headaches (Kumaran 2014). Some studies also suggest that the plant does not cause urogenital complications when used in the treatment of gonorrhea (Stohs 2014). Among the Chothe tribe of Manipur, bark preparations are used as an antidote for snake bites and also serve as astringent and antipyretic remedies (Sanglakpam et al. 2012).

Roots

Roots of *B. orellana* are also used medicinally in several traditional communities. The Bagata tribes of Andhra Pradesh administer root extracts

orally twice daily for two days to treat fever (Sri and Seetharami 2019). Among Amazonian tribes, infusions prepared from roots are used to treat uterine disorders and vaginal discharge (Purushothaman and Irfanamol 2021). In the Piura tribe of the Amazon rainforest, tea prepared from young roots is used to treat skin problems and is believed to act as an aphrodisiac and astringent (Raddatz-Mota et al. 2017).

Flowers and Buds

Flowers and buds also have ethnomedicinal importance. Infusions prepared from the flowers are used by the Cojedes tribe of South America to reduce mucus production in infants (Ulbricht et al. 2012). Among the Khonds tribe of Andhra Pradesh, buds and flowers are primarily used as natural food colorants (Vilar Dde et al. 2014).

Whole Plant

In some traditional medical systems, the whole plant is utilized for therapeutic purposes. For instance, the Tonchongya tribes of Bangladesh apply powdered whole plant material topically to relieve breast pain (Yong et al. 2013). Traditional medicine systems across the world use *B. orellana* for the prevention and treatment of numerous diseases including jaundice, epilepsy, dysentery, fever, gonorrhea and blood disorders (Purushothaman and Irfanamol 2021).

INDUSTRIAL AND ECONOMIC USES

Food industry

The seeds of *B. orellana* contain natural pigments such as bixin and norbixin, which produce yellow to orange-red coloration and are widely used as natural food colorants. These pigments are considered safe for food use and are exempted from certification requirements by regulatory authorities such as the FDA and the European Union (Aberoumand 2011). Due to increasing demand for natural additives, annatto colorants are extensively used in the food industry in many countries (Ganju and Ganju 2014; Dequigiovanni et al. 2018). Annatto pigments are mainly used in dairy, confectionery and bakery products (Shahid-ul-Islam et al. 2016; Srineeraja 2017). The dye is non-toxic,

lipid-soluble and contains trace amounts of vitamin A, which makes it suitable for coloring various food products such as margarine, butter, cheese, ice cream, candies, oils and bakery products. In Latin American countries, annatto is widely used to impart a red color to rice dishes, fish and meat preparations and also serves as a vegetable dye similar to turmeric (Galindo-Cuspinera et al. 2002). Historically, achiote seed extracts have been used in Europe and North America for more than two centuries to provide red-orange-yellow coloration to food products (Smith 2006). Today, bixin ranks among the most important natural food colorants used worldwide (Lauro and Francis, 2000; Giridhar and Parimalan, 2010; Chuyen et al. 2012). Several commercial forms of annatto extracts are available for use in food and pharmaceutical industries, including oil-soluble extracts, oil suspensions, water-soluble extracts and emulsified extracts (Raddatz-Mota et al. 2017). The color intensity and hue depend on the proportion of bixin and norbixin present in the extract, which varies according to extraction method and temperature (Smith 2006). Oil-soluble annatto extracts, obtained using vegetable oils such as soybean, grapeseed or sunflower oil, contain mainly cis-bixin and produce colors ranging from yellow to reddish-orange. These extracts are commonly used in dairy products such as cream cheese, American cheese, salad dressings and aperitifs (Raddatz-Mota et al. 2017; Figure 2). Water-soluble annatto extracts contain norbixin in alkaline solution and are widely used in beverages and dairy products. Cheese is one of the most common products colored using norbixin solutions, and studies report that a small quantity of norbixin solution can color large amounts of cheese efficiently (Manoja et al. 2022). Emulsified annatto extracts, containing bixin or norbixin along with emulsifiers, are used in foods that contain both oil and water phases, such as ice cream, margarine, mayonnaise, creamy sauces and bakery products (Smith 2006).

Cosmetic and textile industries

Annatto is an important natural dye-yielding plant widely used in cosmetic, textile and leather industries (Shahid-ul-Islam et al. 2016; Dequigiovanni et al. 2018; Figure 2). The dye extracted from annatto seeds has gained attention due to its natural origin and safety compared to synthetic dyes. In the cosmetic industry, annatto pigment is used in the production of lipstick, nail polish, hair oil, soap and other beauty products (Raddatz-Mota et al. 2017; Figure 2). It is also used in various household products including furniture polish, floor wax,

brass lacquer, shoe polish, and wood stain. In the textile industry, annatto dye is used for coloring natural fibers such as wool, cotton and silk, producing an orange-red shade. When used in combination with wood ash or sodium carbonate and treated with tartaric or citric acid, the color can change to yellow. Studies have shown that woolen yarn dyed with annatto seeds exhibits reduced lightness when treated with ammonia (Shahid-ul-Islam et al. 2014). Although the dye tends to fade in sunlight, it is resistant to washing, acids and alkalis. The dye is also used for coloring bamboo, rattan, and wood products. Recent technological studies suggest that artificial neural networks (ANN) can be used to optimize the extraction of dye from annatto seeds, which may improve industrial efficiency in natural dye production (Sinha et al. 2013).

Other industrial

Besides its applications in food and textile industries, *B. orellana* has several other economic uses. The press cake obtained after pigment extraction from seeds and fruits is used as animal fodder. The wood of the plant is used as firewood, while bark fibers are utilized for making cordage (Raddatz-Mota et al. 2017; Figure 2).

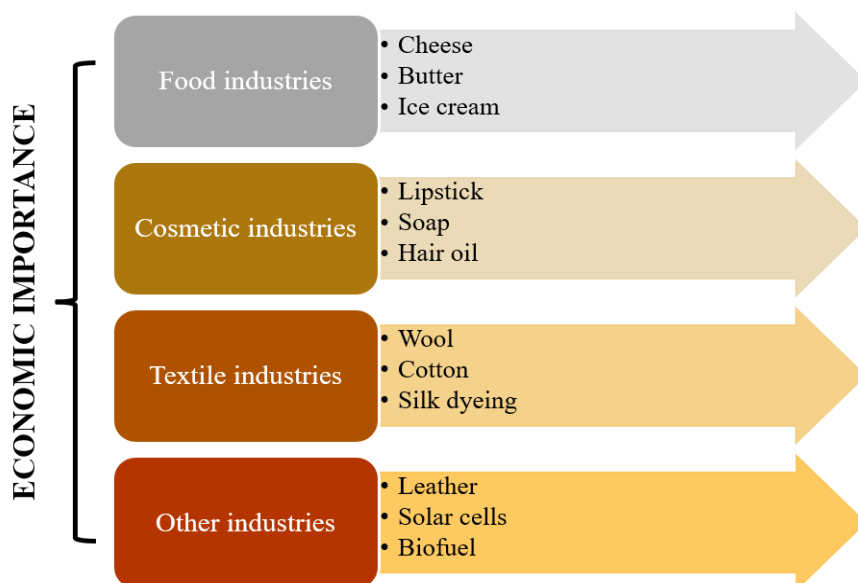


Figure 2: Economic importance of *B. orellana*

In West Africa, particularly among the Baoule community of Cote d'Ivoire, crushed annatto seeds mixed with lemon juice and water are used for painting toys, wooden masks and doorposts (Pandey et al. 2019). The dye is also traditionally used for coloring ceramics and decorative objects. Annatto pigments have also been investigated for industrial applications such as leather processing, solar cell technology, and natural dye production (Shahid-ul-Islam et al. 2016; Dequigiovanni et al. 2018). Another promising application is the use of the fruit pericarp, a by-product of the color extraction industry, as a potential biofuel source. Studies indicate that the pericarp has a higher fuel value index compared to many other plant biomass sources, suggesting its suitability for renewable energy production (Parimalan et al. 2007).

CONCLUSION

B. orellana is an ethnobotanically significant plant with immense medicinal, cultural and economic value. Traditionally used by indigenous communities for treating various ailments and for ceremonial practices, annatto continues to be an important natural resource worldwide. Scientific research has validated many of its traditional medicinal properties, particularly its antimicrobial, antioxidant, and anti-inflammatory activities. Pigments present in the plant are widely used as natural food colorants and have substantial industrial importance. Preserving traditional knowledge and promoting sustainable utilization of *B. orellana* will contribute to the development of new pharmaceuticals and natural products. Further interdisciplinary research combining ethnobotany, phytochemistry and pharmacology may unlock additional therapeutic potential of this remarkable plant.

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