Lawsonia inermis L.

Monograph

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1 Introduction

Lawsonia inermis L., commonly known as henna, is a perennial shrub or small tree widely recognized for its economic, cultural and biological importance. Native to regions of North Africa, the Middle East and South Asia this species has been cultivated for thousands of years due to the natural dye compound lawsone found in its leaves. This pigment has been traditionally used for body art, hair coloring, textiles and medicinal purposes, making *Lawsonia inermis* a plant of both historical and modern significance.

The adaptability of henna to semi-arid tropical environments has allowed it to expand far beyond its original range. Its ability to tolerate drought, high temperatures, and poor soils makes it a valuable crop in regions where other plants may struggle to survive. These ecological characteristics not only explain its wide geographic distribution but also highlight its importance in sustainable agricultural systems, particularly in developing regions where environmental conditions are limiting.

From a biological perspective, *Lawsonia inermis* exhibits traits that support its survival and productivity, including efficient photosynthesis under high light intensity, deep root systems for water uptake and reproductive strategies that allow both natural and controlled propagation. Its life cycle, from seed germination to flowering and fruit production, reflects adaptations that optimize growth in warm climates with seasonal rainfall.

In addition to its ecological and biological relevance, henna plays a significant role in global and local economies. It supports rural livelihoods through cultivation, processing, and trade, while also contributing to international markets as demand for natural and organic products continues to grow. Furthermore, its deep cultural significance in ceremonies and traditions reinforces its continued use and value across different societies.

This monograph explores the ecology, biology, propagation, and economic importance of *Lawsonia inermis,* providing a comprehensive understanding of the factors that contribute to its success as both a natural species and a cultivated crop.

2 Ecology

2.1 Distributional Context

2.1.1 Affinities

Plant taxonomy is divided into several hierarchical categories.

Table 1

Taxonomy of *Henna (Lawsonia inermis* L.*)*

Kingdom	Plantae
Phylum	Magnoliophyta
Class	Magnoliopsida
Order	Myrtales
Family	Lythraceae
Genus	Lawsonia
Species	*Lawsonia inermis L.*

As seen in the table above, the taxonomy of a plant has a hierarchical system used to classify living organisms according to shared characteristics and evolutionary relationships (Wikipedia contributors, 2026). The classification starts with the **Kingdom,** which is the largest category. *Lawsonia inermis* belongs to the kingdom **Plantae,** which includes all multicellular organisms that are capable of photosynthesis (EPPO Global Database, n.d.; Supian & Osman, 2023).

Then the **Phylum** is **Magnoliophyta**, also known as the flowering plants. Plants in this group reproduce through flowers and produce seeds inside their fruit. *Lawsonia inermis* is classified here because it makes small fragrant flowers, as seen in **Figure 1,** that then develop into fruits with seeds inside (American Journal of Plant Sciences, 2022; Supian & Osman, 2023).

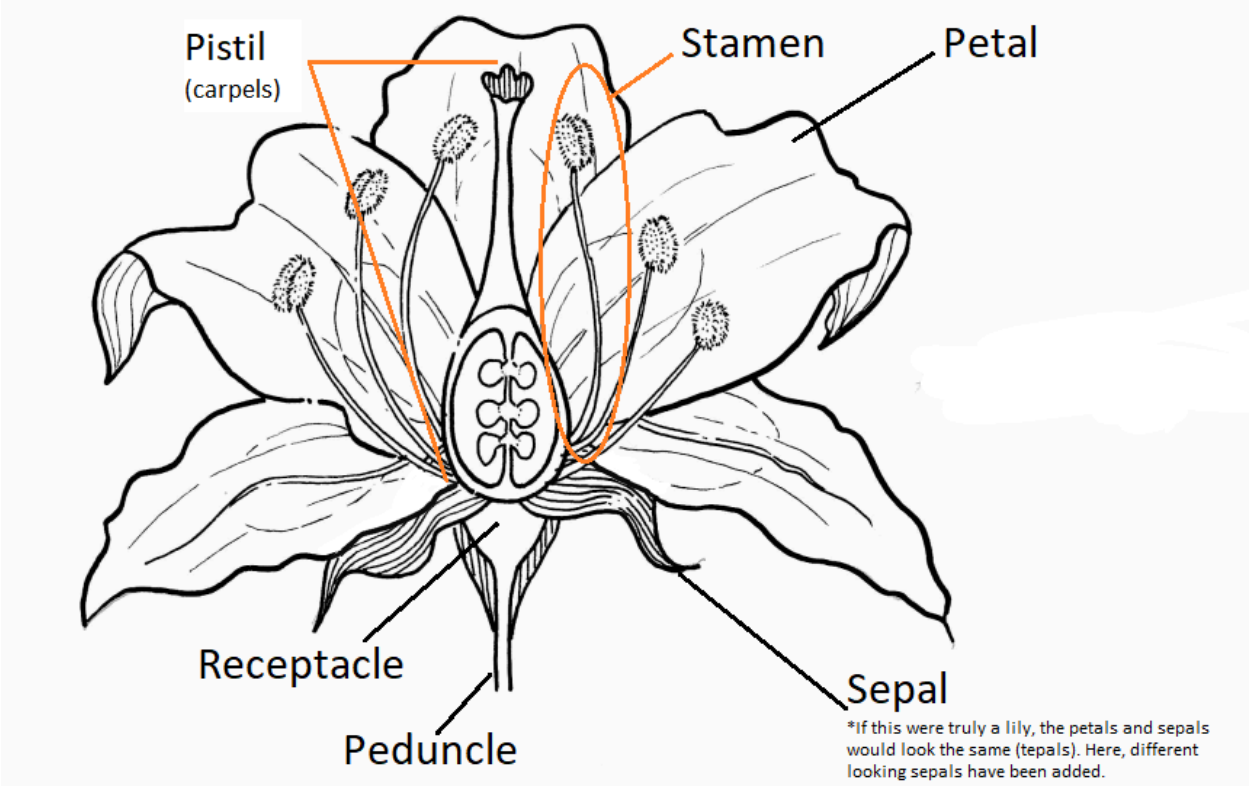
Figure 1:
Photo of flowers of *Lawsonia inermis* (Seedville USA, n.d.)

The **Class** is **Magnoliopsida,** which includes dicotyledonous plants, usually known as dicots. Dicots are characterized by having two embryonic leaves (cotyledons) in their seeds, as well as net like leaf venation and vascular bundles arranged in a ring. (American Journal of Plant Sciences, 2022).

Following the class is the **Order, Myrtales,** a group of flowering plants such as shrubs and trees with well developed vascular tissues and usually aromatic compounds. Plants who belong in this order frequently have opposite leaves and flowers with multiple stamens, like those in **Figure 2** (Supian & Osman, 2023; EPPO Global Database, n.d).

Figure 2:

Diagram of sepals, petals, stamens, and carpels (Ha et al., n.d)



The next level is the **Family, Lythraceae,** commonly known as the loosestrife family. Plants in this family are mostly shrubs or small trees and are characterized by simple leaves and small flowers with multiple petals (Supian & Osman, 2023). Like those we can also observe in **Figure 1.**

The **genus** is **Lawsonia,** a small genus of flowering plants within the Lythraceae family. The most notable and widely known member of this genus is the *Lawsonia inermis,* since it is highly cultivated for the natural dye extracted from its leaves (Supian & Osman, 2023; EPPO Global Database, n.d.).

2.2 Fossil record

The fossil record for *Lawsonia Inermis* is limited however fossil evidence exists for the genus **Lawsonia** in the family **Lythraceae.** Fossil seed clusters discovered in the late Miocene deposits in the north western area of Germany were originally described as ***Carpolithus lawsonioides*** by Menzel in 1913. The studies compared their morphology with modern seeds of *Lawsonia* and reclassified them as *Lawsonia lawsonioides.* These fossils show several characteristics consistent with the seeds of modern *Lawsonia*, including their own pyramidal shape, as seen in **Figure 3,** with their thick seed coat and attachment to a central placenta inside the fruit. This evidence suggests that evolutionary lineage of the genus *Lawsonia* was already present during the Miocene times, approximately 16 to 12 million years ago (Graham, 2013).

Figure 3:

Picture that shows the shape of the *Lawsonia inermis* seeds (The Henna Page, n.d.)

Although direct fossils of the modern species *Lawsonia inermis* are rare, these fossil seeds provide clear evidence for the ancient evolutionary history of the genus within the Lythraceae family and the support of the idea that members of this lineage existed long before the plant became cultivated for the natural dye henna (Graham, 2013).

2.3 Origin and Current Distribution

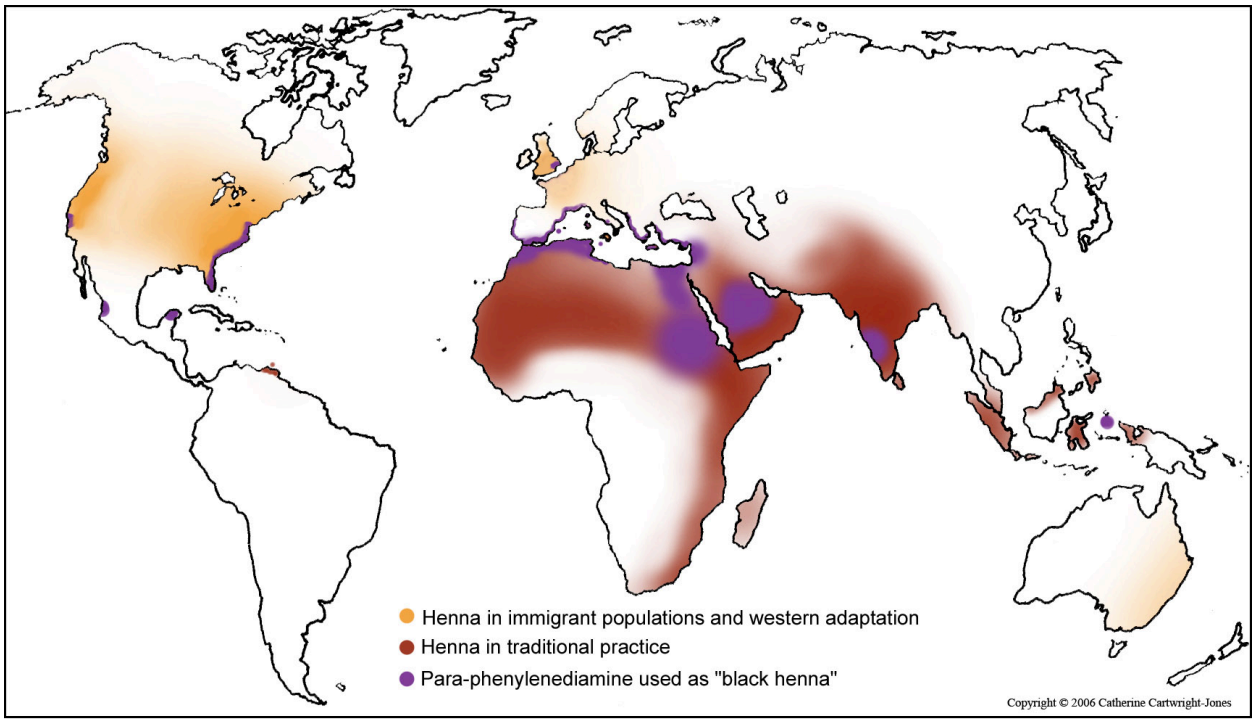
2.3.1 Origin and Domestication

Lawsonia inermis is a plant species believed to have originated in North Africa, the Middle East and parts of South Asia, where it naturally grows in semi arid and tropical environments (Orwa et al., 2009). The plant has been cultivated for thousands of years because its leaves contain lawsone**,** a natural dye compound used to color skin, hair, textiles and leather (Bechtold & Mussak, 2009).

Historically, henna became culturally significant in regions such as Egypt, India and Persia, where it was used in medicine, ceremonial traditions and cosmetics. This can be clearly seen in **Figure 4.** The cultivation of the plant spread throughout trade networks connecting Africa, the Middle East and Asia, which contributed to its domestication and integration into the agricultural systems (Orwa et al., 2009).

Figure 4:

Map of areas of henna body art practices between 200 and 2006 (Cartwright-Jones, n.d.)



Areas of henna body art practices between 2000 and 2006

2.3.2 Global Expansion and Cultivation

Today, *Lawsonia inermis* is widely distributed across tropical and subtropical regions of Africa, Asia and parts of Australia, as also seen in **Figure 4** (Wikipedia contributors, 2025). It grows well in the Sahel region of Africa and many areas of the Middle East and South Asia (Orwa et al., 2009). The species is cultivated in several countries such as India, Pakistan, Sudan, Egypt, Morocco, Iran and Yemen, where henna leaves are harvested, dried and ground into powder used for natural dye production. In many of the regions henna helps local economies (Food Plants International, 2023).

2.4 Ecoregion

An ecoregion is a geographical area with similar environmental conditions, including climate, soils and biological conditions, and their biological communities (microbes, plants and animals). The *Lawsonia inermis* in particular is found in partially arid tropical and subtropical ecoregions where high temperatures and seasonal rainfall are common (Orwa et al., 2009).

2.4.1 Elevation and Climate

Henna plants naturally grow in environments ranging from sea level to approximately 1350 meters above sea level, especially in hot and dry regions (K Leela & Dr. Anita R J Singh, 2020). The plant is highly tolerable to droughts and low humidity and is adapted to climates with high temperatures and strong sunlight (Orwa et al., 2009).

2.4.2 Type of Ecoregion

The typical habitats of *Lawsonia inermis* include partially arid savannas, dry scrublands and tropical desert margins. These ecosystems are characterized by open vegetation, seasonal rainfall and soils that drain water quickly (Easyscape Plant Profile, 2024). Wild populations are often found in rock crevices, hillsides and riverbanks where the plant receives full sunlight and can survive drought conditions (Kampala Capital City Authority, 2023).

2.4.3 Altitudinal Influence

Altitude affects environmental conditions such as temperature and humidity. *Lawsonia inermis* typically grows at low to medium elevations, where warm temperatures support optimal growth. And in medium elevations is where warm temperatures support the best plant growth and dye production. At higher altitudes, lower temperatures slow down the development of Lawsonia inermis plants since lower temperatures slow down the plant development (K Leela & Dr. Anita R J Singh, 2020).

2.4.4 Natural habitat

In its natural habitat, *Lawsonia inermis* grows as a large shrub or a small tree in partially arid environments, especially along riverbanks and dry valleys (K Leela & Dr. Anita R J Singh, 2020). The species is highly adaptable and can tolerate poor soils, drought and low humidity. This ecological adaptability explains why henna can survive in difficult environments and is used as a hedge or ornamental plant in dry landscapes.

2.5 Climate

2.5.1 Precipitation

Henna plants grow best with moderate annual rainfall, typically between 500 and 1500 mm per year, although they can tolerate a much wider range of precipitation conditions (K Leela & Dr. Anita R J Singh, 2020). The plant is drought resistant due to its deep root system which allows it to access water from deeper soil layers. However excessive rainfall and poor drainage may increase the risk of root disease and negatively affect the plants growth.

2.6 Geology and Soil Requirements

2.6.1 Geology and Soils

Lawsonia inermis can grow in a wide range of soils formed from sandy, rocky or alluvial geological materials, although it prefers well drained soils that allow proper root development (Orwa et al., 2009). The geological characteristics of soils influence important factors such as mineral content, soil structure and water retention, which directly affects the plant's growth.

2.6.2 Soil type and texture

Henna plants usually grow best in sandy or sandy loamy soils which provide good drainage and aeration (Orwa et al., 2009). However, the species can also resist poorer soils, such as stony or clay soils as long as waterlogging (too much water per soil) does not occur.

2.6.3 Soil depth and drainage

Deep and well drained soils are important for henna cultivation because they allow the roots to grow properly and prevent excess water accumulation. Poorly drained soils may cause root rot and reduce plant productivity Easyscape Plant Profile, 2024).

2.6.4 Soil Management Practices

Agricultural practices such as organic fertilization, irrigation management and pruning can improve henna production. Farmers usually prune henna plants to stimulate new leaf growth, since the leaves are the main source of dye used in cosmetics and textiles (Orwa et al., 2009).

2.7 Light and Temperature Regimes

2.7.1 Temperature Regime

Lawsonia inermis grows best in warm climates with temperatures between 19°C and 27°C, although it can tolerate higher temperatures typical of desert environments (Orwa et al., 2009). The plant is sensitive to frost and temperature below 11°C significantly slows its growth (Wikipedia contributors, 2025).

2.7.2 Light Intensity and Quality

Henna requires high light intensity and full sun exposure for optimal growth. Plants grown in shaded areas usually produce fewer leaves and lower concentrations of dye compounds (Easyscape Plant Profile, 2024).

2.7.3 Water and Transpiration

Water is essential for physiological processes such as nutrient transport and photosynthesis. Although henna plants are drought tolerant, a proper water availability is necessary for healthy leaf production and optimal growth (Orwa et al., 2009).

2.7.4 Integrated Light–Temperature–Water Relationship

The productivity of *Lawsonia inermis* depends on the interaction between temperature sunlight and water availability. Warm temperatures and high sunlight levels support photosynthesis, while moderate water availability ensures proper nutrient transport in the plant (Orwa et al., 2009).

These environmental factors explain why henna plants are most successful in hot, semi arid regions within well drained soils and full sunlight

3. Biology

3.1 Chromosome Complement

The chromosome complement refers to the total number and structure of chromosomes present in the cells of an organism. *Lawsonia inermis* is considered a diploid species belonging to the family Lythraceae, meaning it possesses two sets of chromosomes. Cytogenetic studies have consistently identified the diploid chromosome number as 2n = 30, typically of many flowering plants (Royal Botanic Gardens Kew, n.d.). As a diploid, *L. inermis* possesses two homologous sets of chromosomes (n = 15). This genomic structure is typical of the order Myrtales and makes it easier to regulate bivalent pairing during meiosis. This process allows for genetic recombination, which is the primary driver of the phenotypic adaptability observed in the species. Such genetic variation is crucial for the plant's adaptation to stressors (Orwa et al., 2009). Diploid plants contain one set of chromosomes inherited from each parent, which allows genetic recombination during meiosis and contributes to genetic diversity in plant populations. Genetic variations within populations of *Lawsonia inermis* plays an important role in adaptation to environmental conditions such as drought, soil type and temperature. This adaptability is one reason why henna plants are able to grow in a wide range of tropical and semi arid environments across Africa and Asia (Orwa et al., 2009).

3.2 Life Cycle and Phenology

3.2.1 Life Cycle

The life cycle of *Lawsonia inermis* begins with a seed germination and continues through vegetative growth, flowering, fruit development and seed dispersal. The plant is classified as a perennial shrub or small tree, meaning that it can survive and reproduce for multiple years rather than completing its life cycle in a single growing season (Encyclopaedia Britannica, n.d.). Henna plants typically reach heights of 2-6 meters and develop woody stems and extensive branching structures as they mature (Orwa et al., 2009). As shown in **Figure 5**, mature plants produce large clusters of small fragrant flowers that later develop into capsules fruits containing lots of seeds. Perennial plants such as *Lawsonia inermis* allocate energy between vegetative growth and reproduction depending on environmental conditions such as temperature, sunlight and water availability (Taiz et al., 2015).

Figure 5:
Mature *Lawsonia inermis* (Santhi Online Plants, n.d.)

3.2.2 Seedling Development

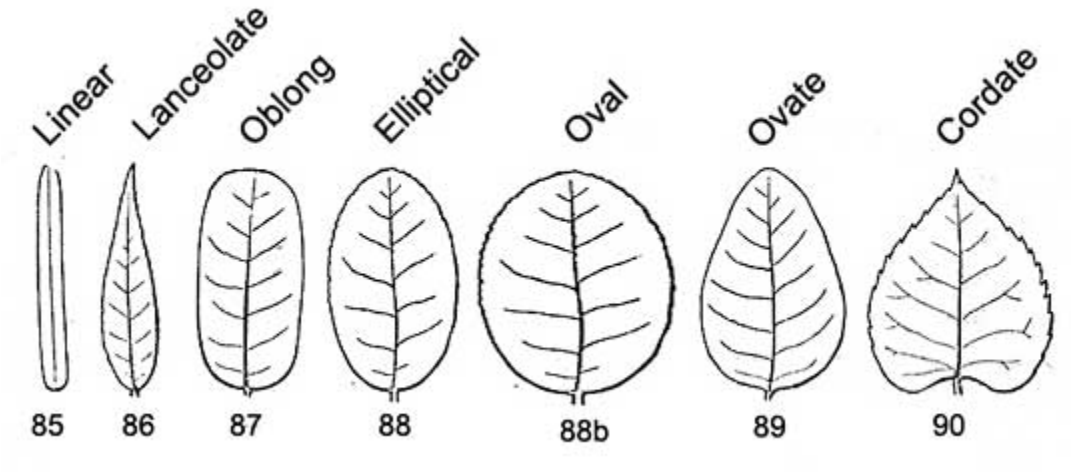
Seed germination begins when the seed absorbs water from the soil, which activates enzymes and metabolic pathways necessary for growth. The first structure to emerge is the radicle which develops into the primary root and anchors the plant into the soil (Taiz et al., 2015).

3.2.3 Vegetative Growth

During the vegetative stage *Lawsonia inermis* produces dense foliage and extensive branching. The leaves are opposite, elliptic to lanceolate and approximately 1.5 to 5 cm long as shown in **Figure 6** (PlantUse PROSEA, n.d.). The leaves contain the compound lawsone (2-hydroxy-1-4-naphthoquinone), which is responsible for the reddish orange dye traditionally known as henna. This pigment binds strongly to protein in skin, hair and fabric, which explains its widespread use as a natural dye. The concentration of lawsone in henna leaves is influenced by environmental factors such as temperature, sunlight and soil nutrients (Bechtold & Mussak, 2009).

Figure 6:

Forms of Leaves as to General Outline (Gray, 1880)



3.2.4 Flowering

The flowering stage marks the reproductive phase of the plant's life cycle. Henna plants produce numerous small fragrant flowers that are typically white or pinkish in color. These flowers are arranged in large terminal clusters known as panicles. Each flower contains reproductive structures including sepals, petals, stamens and a pistil as we can see in **Figure 2,** which enable sexual reproduction through pollination and fertilization. Flowering generally happens during warm seasons when environmental conditions such as temperature and light availability support reproductive development (Encyclopaedia Britannica, n.d.).

3.2.5 Fruit Development and Seed Set

Following successful pollination and fertilization the ovary of the flower develops into a small spherical capsule fruit measuring around 4-8 mm in diameter. These fruits contain several small angular seeds that are released when the capsule dries and splits open. The thick seed coating protects the embryo and allows seeds to remain viable until favorable environmental conditions allow germination (PlantUse PROSEA, n.d.).

4. Propagation and Management

4.1 Natural Regeneration

Natural regeneration happens when seeds released from mature fruits germinate in suitable environmental conditions. In natural ecosystems henna plants can establish new populations in areas with proper sunlight, warm temperatures and well drained soils. Seed dispersal may happen through gravity, water movement or human agricultural activities (Orwa et al., 2009).

4.2 Nursery Propagation

4.2.1 Seed propagation

Propagation by seed is the most common method used to cultivate *Lawsonia inermis.* Seeds are usually scattered in nursery beds or containers with well drained soil (PlantUse PROSEA, n.d).

4.2.1.1 Preparation and implications for Germination

Seeds may be soaked in water before planting in order to soften the seed coat and improve germination rates (Orwa et al., 2009).

4.2.1.2 Sowing and Germination Process

Seeds germinate best in warm conditions with temperature between 25°C and 30°C which allows rapid seedling establishment (Food Plants International, 2023)

4.2.1.3 Storage

Seeds should be stored in dry and cool environments to maintain viability and prevent fungal contamination (Orwa et al., 2009).

5. Importance, Markets, and Uses

5.1 Economic Importance

Lawsonia inermis is an economically important plant at local, regional, and international levels due to its use as a natural dye and cosmetic product. In many countries across North Africa, the Middle East, South Asia, henna cultivation provides a source of income for small scale farmers and rural communities. The leaves of the plant are harvested, dried, and processed into powder, which is then sold in local markets or exported internationally (Orwa et al., 2009; Food Plants International, 2023).

At a regional level, countries such as India, Sudan, and Morocco depend on henna production as part of their agricultural economy. India is considered one of the largest producers and exporters of henna, supplying both domestic and global markets. The cultivation and processing of henna contribute to employment in farming, processing, packaging and trade sectors (Food Plants International, 2023).

5.2 Global Production and Trade

Henna is widely cultivated in tropical and subtropical regions, particularly in India, Pakistan, Sudan, Egypt, Iran and Yemen. Although exact global production data is limited, the plant is recognized as an important non timber agricultural product in arid and semi arid regions (Orwa et al., 2009).

The international trade of henna is mainly based on processed leaf powder, which is exported to markets in Europe, North America and parts of Asia where demand for natural cosmetic products has increased. The growing global preference for natural and organic products has significantly increased the demand for henna in recent years, especially as an alternative to synthetic dyes (Bechtold & Mussak, 2009).

5.3 Market Characteristics

The henna market is characterized by a combination of local consumption and international trade In producing countries, henna is commonly sold in local markets for traditional uses such as body art and hair dye. At the same time, large quantities are processed and exported to global markets. The market structure includes small scale farmers, local processors, and international distributors. In some regions, production is decentralized, with many small producers contributing to the supply chain. This makes the henna market relatively competitive, although certain countries dominate global exports (Food Plants International, 2023). Also the demand for henna is influenced by cultural practices, including weddings and religious celebrations, where henna body art plays an important role. This creates seasonal variations in demand particularly in South Asia and the Middle East.

5.4 Uses and Value-Added Products

The primary use of *Lawsonia inermis* is the production of natural dye derived from its leaves. The active compound, lawsone, binds to proteins in the skin, hair, and textiles, producing a reddish brown color (Bechtold & Mussak, 2009).

Henna is widely used in:

- Cosmetics: hair dye, skin decoration (henna tattoos), and natural beauty products
- Textiles: dyeing fabrics and leather
- Traditional medicine: treatment of skin conditions, wounds and infections

In addition to raw leaf powder henna is often processed into value added products such as:

- Pre mixed henna paste for body art
- Packaged cosmetic powders
- Hair care products such as shampoos and conditioners

These value added products increase the economic value of the crop and expand its market beyond traditional uses (Food Plants International, 2023).

5.5 Cultural and Social Importance

Beyond its economic value, *Lawsonia inermis* holds significant cultural importance in many societies. Henna has been used for centuries in ceremonies such as weddings, religious festivals and social celebrations, particularly in India, the Middle East and North Africa

The cultural significance of henna contributes to its continued demand and reinforces its role as both an economic and social resource. This combination of cultural relevance and commercial value explains the widespread cultivation and global distribution of the plant (Cartwright-Jones, n.d.).

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