ANTIOXIDANT ACTIVITY AND PHENOLIC COMPOUNDS OF LAWSON MOLECULE EXTRACTED FROM *LAWSONIA INERMIS* (HENNA)

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ABSTRACT

The henna plant (*Lawsonia inermis*) which is known and used as a dye plant from past to present, plays a role in our lives with its cultural effects. The cosmetic feature of this plant is the lawson molecule, a red-orange pigment, which is the main coloring agent found in its leaves, and this molecule is a subgroup of naphthoquinones. Although it comes to the fore with its cosmetic feature, it is a medicinal product that has positive effects on health with its anticarcinogenic, antimicrobial, anti-inflammatory, analgesic, and antipyretic properties thanks to its bioactive compounds such as flavonoids, naphthoquinones, quinoids, naphthalene derivatives, triterpenoids, organic acids, tannins, phenolic and phenolic glycosides. determined to be a plant. This review was mainly written to give information about the phenolic, antioxidant and antimicrobial studies on the henna plant and the coloring agent Lawson molecule obtained from it.

Keywords: *Henna, Lawson molecule, phenolic compounds, antioxidant activity.*

INTRODUCTION

Lawsonia inermis L, known as henna, is a plant in the Lythraceae family with a historical past **[1].** It has been used traditionally for longer than 5000 years in Pakistan, India, Africa, and the Middle East **[2]**. At the end of the

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19th century, the use of henna in Europe became commercialized **[3].** It is commonly used to dye hair, skin for hand and foot decorations, and nails, especially **[1].** Though it is mostly known from a cosmetic perspective, it is rich in terms of health too. It is a desert plant that tolerates long drought and low humidity, along with poor, stony, and sandy soils. It grows in dry tropical and subtropical regions including North Africa, India, Sri Lanka, and the Middle East, and is commercially cultivated in west India, Pakistan, Morocco, Yemen, Iran, Sudan, and Libya. It is a small tree with many-branched hairless shrubs widely grown as an ornamental and dye plant. Young branches are green and rectangular and turn red over time **[1, 4, 5]**. Henna is a fragrant aromatic plant **[6, 7]** because it contains essential oils such as containing citronellol, limonene, linalool, eugenol, and a-terpineol in the leaves and other portions of the plant **[6]**. The diversity of these oils ensures the diversification of the odor and aroma of many henna varieties. In phytochemical studies of *L. inermis L* extract, hundreds of secondary metabolites with various chemical structures were found **[8-12]**. Although there are many pharmacological research findings, studies on antioxidant and antimicrobial activities draw attention with each new phenolic component discovery. This review is to give information about the henna plant and one of the important phenolic components, lawson of naphthoquinone derivative, and its bioactive properties.

Bioactive Compounds in Henna

The henna plant is included among traditional and folk drugs in the present day. Containing nearly one hundred plant compounds, henna is rich in terms of phenolic compounds including coumarins, glycosides, phytosterols, steroids, saponins, tannins, flavonoids, quinones and naphthoquinones. This biological wealth in henna was determined to develop as a result of iversification of active compounds as protective mechanisms against threats in the dry climates in which it grows. Studies showed henna contains nearly 70 phenolic compounds. In Table 1 **[13],** some types of phenolic compounds found in the henna plant and the parts isolated from the plant are given. The pharmacological activities of henna are related to the naphthoquinone dye agents are connected, while terpene and β-ionone were identified to be largely responsible for pungency and hardening of volatile oils isolated from flowers **[13].** Quinones are secondary metabolite molecules formed of six member α, β-dienonic rings and the law-

sone naphthoquinone molecule was stated to be one of the most common quinone species in nature **[14-17].** Flavonoids and glycosides are known to have common antimicrobial activity **[18].** Naturally occurring tricyclic quinone alkaloids have a broad range of biological properties from antimicrobial capacity to cytotoxicity and are reported to be synthetically obtainable. At the same time, bis-naphthoquinones **[19]** are reported to be anti-parasitic agents **[20-24].** Henna, with low health risk **[25-27],** was found to have a variety of pharmacological uses due to antitumor, anti-helminthic, antioxidant, immunomodulatory, burn wound healing, UV protective and antimicrobial properties **[28-32].** A study about the henna plant by Uddin et al. (2011) **[33]** performed solvent extractions from the leaves of *Lawsonia alba* Lam and isolated three new flavonoids of lawsochrysin, lawsochrysinin, and lawsonaringenin with a variety of chromatographic techniques. A study by Zohourian et al. **[34]** obtained extracts with hydrothermal extraction supported by microwaving at 300-700 W power for *Lawsonia inermis* leaves and examined the presence of polyphenolic compounds and antioxidant activities.

They noted that best results were obtained with microwave power producing 100-120 °C temperature with short radiation duration. Strong antioxidant activity against DPPH was determined by the most active compound, 1,2,4-trihydroxy naphthalene-1-O-β-D-glucopyranoside **[34]**. In another study, they determined the antioxidant activity of the extractant obtained from methanol and henna leaves as 71.5 mg/g (dry weight) chlorogenic acid equivalent on dry weight **[13, 35].**

Table 1. Bioactive Component of *Lawsonia inermis* **[13].**

BCH	Phenolic compounds	Parts of the henna plant	Referances
Flavono-ids	Acacetin, Acacetin-7-O-glucoside R=glucoside, Luteolin, Luteolin-7-O-glucoside, Apiin, Apigenin-7-O-β-D-glucopyranoside, cosmosiin, Isoscutellarin, Lawsochrysin, Lawsochrysinin, Lawsonaringenin,3',4'-Dimethoxy flavone, 7-Hyd roxy flavone, 3,3',4',7-Tetrahydroxy flavanone, Rhoifolin , catechin, Luteolin-7-O-rutinoside, Diosmetin-7-O-rutinoside	Aerial parts of henna stems and leaves ha-iry roots	**[9, 13, 25, 27-30]**
Coumarins	Lacoumarin, Fraxetin, Scopoletin, Esculetin, Daphneside, Daphnorin, Agrimonolide 6-O-β-D-glucopyranoside	Whole plant	**[1, 13, 29, 31, 32]**
Tannins	1,2,3,6-Tetra-O-gallolyl-β-D-glucose, 1,2,3,4,6-Penta-O-gallolyl-β-D-glucose, Lawsoniaside, 1,2,4-Trihydroxynaphthale-ne-1-O-β-D-glucopyranoside, Lawsonaphthoate, Lawsonaphthoate, Lawsonaphthoate, 1,2-Dihydroxy-4-Oglucosyloxy-naphthalene	The hairy roots	**13, 30, 33]**

Table 1. (continued)

Naphthalenes	Lawsoniaside R=β-Dglucopyranoside, Lawsonaphthoate A, Lawsonaphthoate B, Lawsonaphthoate C, 1,2-Dihydroxy-4-Oglucosyloxynaphthalene	Stems and leaves of henna	**[9, 13, 34-36]**
Naphthoquinones	2-Methoxy-3-methyl-1,4-naphthaquinone, Lawsone, Isoplumbagin, Lawsonadeem,4-Hydroxy-α-tetralone,3-Amino-2-methoxycarbonyl-1,4-naphthaquinone, 3α,4α-Dihydroxy-α-tetralone,	Leaves of henna leafpetioles	**[9, 13, 28, 37-41]**
Xanthones	Laxanthone-I, Laxanthone-II, Laxanthone-III	Leaves of henna	**[13, 27, 31]**
Lignans	(+)-Syringaresinol-O-β-D-glucopyranoside, (+)-Pinoresinol-di-O-β-D-glucopyranoside, Syringaresinol-di-O-β-D-glucopyranoside	Leaves of henna	**[13, 29]**
Alkylphenones	Lalioside, Lawsoniaside A, 2,4,6-Trihydroxyacetophenone-2-O-β-D-glucopyranoside	Leaves of henna	**[13, 34, 35]**
Other phenolic compounds	Lawsonicin, p-Coumaric acid, Gallic Acid, Lawsochylin A, Lawsochylin B, Lawsochylin C,4-Hydroxybenzaldehyde, Dihydrodehydrodiconyferyl alcohol, Lawsoniaside B, Syringinosol di-O-β-D-glucopyranoside, glucopyranosyl-(1→6)-β-glucopyranoside	Stems and leaves	**[9, 13, 28, 29, 33, 41]**

BHC: Bioactive Component of Henna

In a study on phenolic content, they determined the maximum phenolic content of henna leaves (*Lawsonia inermis*) at 7203.74 mg GAE/100g under optimized conditions determined as 73.78 minutes at 39.57 °C and 48.07% acetone concentration **[51]**.

As a result, Lawson (2-hydroxy-1,4-naphthoquinone), the main active ingredient of *Lawsonia inermis* Linn, has many biological activities such as antioxidant, antibacterial and antifungal, anti-inflammatory, antipyretic and analgesic, anticancer and cytotoxic determined **[52-56].** In another study, the antibacterial effects of henna extracts obtained with different solvents against coagulase negative staphylococci, *Staphylococcus aureus*, ß-hemolytic streptococci and *Pseudomonas aeruginosa* were investigated. In this study, it was determined that alcoholic and oily extracts of henna plant had a higher effect against these pathogenic bacteria than the extracts obtained with water **[28]**. The 1,4-naphthoquinone molecules obtained from henna leaf extracts were determined to have antimicrobial effect against *Staphylococcus spp.*, *Sarcinalutea*, *Streptococcus sp.*, *Corynebacterium* pyo, *Corynebacterium* sp., *Enterbacterium* sp., *Shiegella*, and *Staphylococcus aureus*. At 60-80 mg/mL concentrations, they were determined to have antibacterial effects from 15-26 mm against *Shigella flexneri*, *Escherichia coli*, *Klebsiella aerogenes*, *Mycobacterium phlei*, *Salmonella paratyphi*, *Bacillus subtilis* and *Pseudomonas aeruginosa* **[57].** Similarly, another study **[58]** used aqueous extracts (1.25% and 2.5%) of henna ecotypes and investigated the antibacterial effects against gram-positive and gram-negative bacteria including *Staphylococcus sp.*, *Streptococcus sp., Bacillus sp., Corynebacterium sp., Klebsiella pneumonia* sp., *Escherichia coli* sp. and *Salmonella sp*. *K. pneumonia* and *B. cereus* species were determined to display higher resistance compared to the other bacterial species.

Lawsone Molecule and Dye Properties

Henna, which has pure dye features, was popularized due to intense demand as a natural colorizer used as hair dye **[59].** The colorizing properties of this plant are arised from the lawsone molecule found in the leaves, which has a red-orange dye. The highest concentrations of Lawsone molecules are present in the small young leaves and leaf stems of the henna plant **[6, 60].** The henna plant contains 25-33% water-soluble matter and aqueous solutions have orange color. Lawson molecule, which is the main coloring agent, is found in the dried leaves at a concentration of 0.4-1.5%

and is in the structure of 2-hydroxy-1,4-naphthoquinone **[4, 5, 31, 50, 61, 62].** Lawson molecule, rich in quinones, has two carbonyl groups in the ortho or para positions of the benzyl ring **[63, 64]** and its molecular formula is $C_{10}H_6O_3$. It has a melting point of 190 °C and the most stable form is 1,2-naphthoquinone **[65, 66]**.

Bioactive Compounds in Lawsone Molecule

Naphthoquinone compounds have the ability to act as intermediate agent in the synthesis of heterocyclic compounds. They have become a focus of research in recent years due to displaying a variety of biochemical, therapeutic and additionally photodynamic therapeutic properties like antibacterial, antiviral and anti-inflammatory activities. Additionally, beneficial uses of these heterocyclic compounds include use as dyes, fluorescent material to visualize biomolecules and laser technologies **[24, 67-72].** In the study on the antioxidant activity of the lawsone molecule, derived from naphthoquinone and naphthoquinone derivatives, Lawson molecule was determined as 62.05 μmol·L $^{-1}$ and its derivatives were determined in the range of 22.83-50.26 μmol·L $^{-1}$ **[56].** A study by Tekin et al. (2013) **[73]** obtained extracts from leaves of the henna plant, purified them with a high-pressure liquid chromatography (HPLC) system and obtained the lawsone (2-hydroxy-1,4-naphthoquinone) compound.The lawsone molecule, derived from naphthoquinone with antibacterial properties, was studied as a wound covering material with the aim of using its antibacterial functional features **[74].** In a study, it was determined that dimeric naphthoquinones derived from Lawsone inhibited the proliferation of *Candida albicans*. **[56, 75]**. Among henna ecotypes, the 2-hydroxy-1,4-naphthoquinone Bam ecotype was identified to have highest antibacterial effects. The 2.5% concentration of the Shahdad extract was determined to display highest antioxidant capacity. The lawsone molecule was radio-labelled and injected into mice and they determined it displayed high rates of involvement in the bladder, stomach and prostate compared to other organs. As a result of the study, they showed the lawsone compound may be a resource for more advanced studies about uses with diagnostic and therapeutic purposes. In a study on Lawsone encapsulated chitosan/polyethylene oxide nanofiber mat as a potential antibacterial biobased wound dressing, nanofibrous mats containing chitosan/polyethylene oxide (PEO) fibers containing various concentrations of lawson (10%, 1, 3, 7, 10% by weight) were

electro-spinned. It has been determined that the Lawson molecule, which has antibacterial activity against gram-negative and -positive bacteria, has this effect on the mats produced. It has been determined that it reduces cytotoxicity and increases the cell viability of normal human fibroblast cells. It has been determined that biocompatible nanofiber mats have the potential to use antibacterial dressings **[76].** As a result of food study **[77]** assessed the use of henna leaf extract as oxidizing agent in soya bean oil. Extracts obtained using water increased the peroxide amounts in oil, while extracts with methanol were identified to be lower.

CONCLUSION

With the discovery of valuable compounds contained in the henna plant, is famous for use for cosmetic purposes, in vivo and in vitro studies which will be demonstrated the pharmacological effects of bioactive compounds should be increased. The obtained bioactive compounds should be standardized and developed for use in terms of public health. Thanks to the bioactive properties of the Lawson such as antioxidant and antimicrobial, studies should be increased to improve the physiological functionality of foods and the preservation of foods.

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