

***Lawsonia inermis* Linn; Review of Plant with Both Industrial and Medicinal Properties**

Aremu Abdulfatai^{1*}  and Oridupa Olayinka Ayotunde² 

¹Department of Veterinary Pharmacology and Toxicology, Faculty of Veterinary Medicine, University of Ilorin, Nigeria

²Department of Veterinary Pharmacology and Toxicology, Faculty of Veterinary Medicine, University of Ibadan, Nigeria

*E-mail: aremu.a@unilorin.edu.ng

ABSTRACT

Plants are very important in the global settings, both human and animals make use of them for food and medicinal purpose. More than 75% of the entire world populace makes use of plants for their medicinal activities. This usage of medicinal plant is due to the fact that they have fewer side effects and possess higher degree of synergism when compared to synthetic chemotherapeutic agents. Reports showed that modern synthetic chemotherapeutic drugs have their origin from various medicinal plants. *Lawsonia inermis* is one of the most important medicinal plants in use. This plant has been in existence several decades ago as drugs, cosmetics and preservative in many cultures and tribes across the globe especially India and Africa. This plant has been prescribed in African alternative therapy as purgatives, abortifacient and astringent. Henna has also been reported for some pharmacological potentials which includes; pain reliever, anti-diabetes, liver protective, immune booster, antioxidant, anticancer, anti-inflammatory and inhibiting action against microbes, fungal, viral, trypanosome and plasmodium. There is a believed in India that when *Lawsonia inermis* is mixed with vinegar, it can serve as a remedy for headaches. It is also used as a coagulant when there is an open wound. In addition, when a poultice is made from the leaves of *Lawsonia inermis*, it is reported to soothe burns and certain types of eczema. Henna as a medicinal plant is now considered as a valuable source of distinct natural phytochemicals for development of potential new drugs against various diseases in both human and animals.

Keywords: *Lawsonia inermis*; Medicinal plant; Industrial activities

INTRODUCTION

Plants with medicinal potential possess various phytochemical constituents which serve as a chemotherapeutic agent for treating both human and animal ailment (Barliana *et al.*, 2014). Herbal therapy which is normally adopted by traditional medical practitioner provides an insight in the under-explored use of various medicinal plants which opens an avenue for discovery of new drugs. This discovery will assist in overcoming the persistent problem of resistance and toxicity commonly associated various synthetic chemotherapeutic agents (Spellberger *et al.*, 2008). In folk medical practices; the uses of plants with medicinal potential play a significant role in covering the basic health requirement in most developing countries. Recent report shows an increase in the interest of scientist around the world in the exploration of various pharmacological activities of medicinal plants and to ascertain the assertion made about their efficacy by Ayurveda (Kasture *et al.*, 2001).

Lawsonia inermis Linn (henna plant) has been reported to be an important medicinal plant across the world. It is a popular plant especially when the leaves are used in staining different part of the body such as nails, beard and hair (Chengaiha *et al.*, 2010).

Leaves of *Lawsonia inermis* have been employed in the treatment of many diseases such as diabetes mellitus, measles, poliomyelitis and other various conditions among the major tribe of South-Western part of Nigeria (Oladunmoye and Kehinde, 2011). Various reports have shown that the seeds of this plant possess deodorant activities thereby making it useful in the treatment of various gynecological conditions such as vaginal discharge, menorrhagia and leucorrhoea (Nawagishet *et al.*, 2007). Henna that is from *Lawsonia inermis* is a potent dyeing agent use in cosmetic industry in many parts of the world (Chengaiha *et al.*, 2010).

The multifaceted uses of *Lawsonia inermis* have been widely explored in Nigeria as reported for its cosmetic and antimalarial activities (Idowu *et al.*, 2010) and its abortifacient activities (Aguwa, 1987). The paste made from roasted seed of henna plant when combines with ginger leaves is used for treating ring worm. Decoction produces from the leaves of this plant is said to be employed in wound cleaning and healing (Kumari *et al.*, 2011). Reports have also shown that many people of South West Nigeria make use of henna plant for haematopoiesis activities in anaemic individuals (Idowu *et al.*, 2010).

Judging by all these benefits, this review focuses in exploring the hidden potential towards the benefit of mankind. This review laid more

emphases on the ecology, habitat, botanical description, phytochemical constituent, pharmacological, social and industrial use of this under-explored plant.

REVIEW

Ecology and Distribution

Henna plant botanically known as *Lawsonia inermis* Linn is found enormously throughout Africa; especially in areas like central Africa, Sahel, and in the middle east of the continent. The plant grows spontaneously along water courses and semi-arid regions. It is known for its adaptation in various situation such as withstanding longer drought during lower air humidity. High temperatures are needed for henna to attain optimal germination and growth (Orwa *et al.*, 2009).

Henna plant may also be seen mostly in various places in the tropics and subtropics. These zones include North Africa, India, Sri Lanka and Middle East. Reports have shown that henna is widespread to Southwest Asia, North Africa, and India. It has also become naturalized in warmer parts of South and North America, Australia and the West Indies, where it is often referred to as “West Indian Mignonette” (Jallad and Jallad, 2008). Lately, it has been cultivated commercially on a large scale, especially in India, Pakistan, Morocco, Yemen, Iran, Afghanistan,

Somalia, Sudan, Libya, Egypt, and Bangladesh (Jallad and Jallad, 2008).

Survey of *Lawsonia inermis*

In 2010, Idowu *et al.*, carried out an ethno-botanical survey in South West, Nigeria. The result showed that most of people which constitute of about 7.41% of the respondents use the leaves of henna for treatment of malaria. The result further indicated that most respondent prefer to use the plant when soaked in water.

Description of *Lawsonia inermis*

The plant is a branched small tree with spiny and glabrous shrub and range from 200-800 cm in height. The branches of the young plant are quadrangular and green but most part of the branches turn to red as they mature (Orwa *et al.*, 2009). The plant tree is about 1.8 to 7.6 m in height. The leaves are mostly seen growing opposite each other on the stem. They are long and wider at mid part and their dimensions reads 0.15–50 mm x 0.05–20 mm or 0.6–2 in x 0.2–0.8). They possess depressed veins mostly at the dorsal surface. The flowers of henna plant have both sepals and calyx tube anchored by spread lobes. The petals of this distinct plant are obviate showing white or red stamens which is mostly found in pairs on the rim of the calyx tube. The ovary is about 5 mm long; four celled which most times found in erect position. The fruits of henna have

small brownish capsules and they are about 0.4–0.8 cm in diameter and having about 31–50 seeds in a single fruit. The fruit open irregularly and formed into four splits when fully ripened (Kumar *et al.*, 2005).

The seeds of henna which are mostly dark brown color have typical pyramidal shape. The average dimensions of the seed are 15.1 cm (thickness) x 22.02 cm (length) x 18.87 cm (width). The powder of henna plant is odorless and bitter to taste. Transverse section of henna seed is about 2-3 layered which have a yellow-brown testa together with a thick endosperm incorporated in tiny embryo (Kumar *et al.*, 2005).

Cultivation of *Lawsonia inermis*

Lawsonia inermis Linn (Henna) is mostly cultivated in various part of the world such as North Africa, North Australia, Southern or Western Asia, in tropics and semi-arid zones. (Encyclopaedia Britannica, 2013). The plant gives the most dye when cultivated at slightly high temperature of about 35-45 °C (Becholdet *et al.*, 2009) and grows rapidly during the onset of precipitation leading to production new shoots that later regress after sprouting. Leaves of *Lawsonia inermis* Linn (henna) later turn to yellow and which later fall during prolong season. It does not thrive well and may die at low temperatures (Bechold *et al.*, 2009).

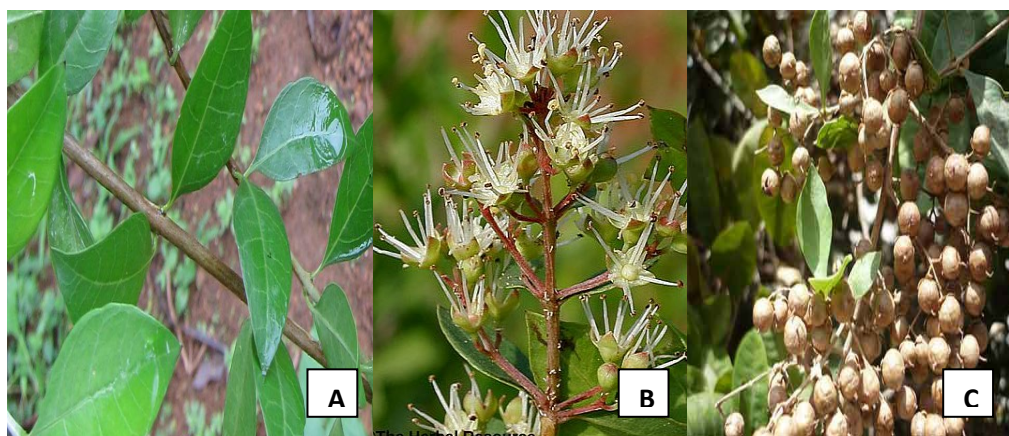


Figure 1. *Lawsonia inermis*. **A:** *L. inermis* leaves. **B:** *L. inermis* flowers. **C:** *L. inermis* seeds. (Source : ©The Herbal Resource)

Parts of *Lawsonia inermis* used

It is mostly the leaves of henna that are used as both herbal medicine and dye for staining. The bark and the oil

extracted from the flowers have been used to some extent. The leaves should be collected from plants that are about three years old, dried and ground into a

powder in achieving these purposes (Hensel and Wolfgang, 2008).

Phytochemical Component of *Lawsonia inermis*

Leaves: Phytochemical screening of both ethanol and aqueous extracts of the leaves of henna plants showed various constituent such as alkaloids, carbohydrates, resins, saponins, flavonoids, Coumarins and Steroids (Sukh, 2003). Reports also showed that the leaves of henna contain soluble matter such as tannins, gallic acid, sugars (glucose and mannitol) fat, resin and mucilage in different fraction the extracts (Kawo and Kwa, 2011). 2-Hydroxy-1, 4-naphthoquinone (HNQ) known to be the principal natural dye seen in 1-1.5 % of henna leaves (Sukh, 2003). Some of the other important chemicals extracted from the leaves of henna includes; 1,4-dihydroxynaphthalene, 1,4-naphthoquinone, 1,2-dihydroxyglucoyl oxynaphthalene and 2-hydroxyl 1,4-diglucoyl oxynaphthalene. Report showed that gas chromatography and mass spectrophotometer (GCMS) screening of essential oil from the leaves of this plant contained about 36 compounds. and this constituent is about 80% of the oil. These compounds include; methyl linolenate (4%), methyl cinnamate (11%), ethyl hexadecanoate (24%), beta-ionone (6%) and isocaryophyllene (8%) (Oyedeji *et al.*, 2005).

Seed: Few researches have been conducted on the phytochemical properties of the seeds of henna plant. Thus, there has been dearth of information as far as the standardization and analysis of seeds of henna plant is concerned. Based on the ethno-medicinal properties of henna seeds, aqueous extract provides the highest phytochemical properties compared to other non-polar solvent. Report showed that percentage ash values were 3.06 for the total extract but showed 0.76 in acid insoluble ash and 0.84 in water soluble ash and about 9.09 % is loss on drying. Reports on the pH of henna was 7.04 in aqueous extract, foaming index of 1080g/l, resin is about 5.53% and the oil is about 1.429%. Both ethanol and aqueous analysis of the Hanna seed extracts indicate that it contains protein, carbohydrates, phenolics and triterpenoids among other compounds (Nawagishet *al.*, 2007).

Bark: The bark of *Lawsonia inermis* Linn contains compounds such as Naphthoquinones, Isoplumbagin, Triterpenoids, Hennadiol and Aliphatic (3-methylnonacosan-1-ol) (Sukh, 2003)

Flower: The flower of henna plant upon steam distillation result in the production of essential oil about 0.02 % which is rich in ionones (90 %) and β -ionones is more predominant (Sukh, 2003)

Chemical composition

Boubaya *et al.*, 2011, set out to establish the chemical composition of henna plant. The outcome of the study pointed out that the leaves of henna contain calcium, sodium, phosphorous and potassium which ranges from 0.2-4%. Magnesium was observed to be less than 0.2% while copper, zinc and iron were above 0.5, 1.1 and 15%. Manganese and nitrogen matter were

seen below 1.5%. The study further revealed that phosphorous and potassium in the stem were above 5.12 and 0.5% respectively. Magnesium was less than 0.08%, while the sodium and calcium were also less than 0.2%. Copper, zinc, iron and manganese were less than 0.95, 1.7, 4 and 0.5%, respectively and nitrogen matter was less than 0.2% (Boubaya *et al.*, 2011).

Table 1. The various chemical compound isolated from *Lawsonia inermis* is tabulated below :

Class of compounds	Bioactive constituents	Major part present	Reference
Flavonoids	Quercetin, Apigenin, apigenin-7-glucoside, apigenin-4-glycoside, luteolin-7-glucoside, luteolin-3-glucoside (+)-pinoresinol di-o- β -d-glucopyranoside	Leaves	Uddin <i>et al.</i> (2011) Afzal <i>et al.</i> (1990)
Naphthoquinone	Lawsone (2-hydroxy 1,4-naphthoquinone), Also called Hennotannic acid, 1, 3-dihydroxy naphthalene, 1, 4-naphthoquinone, 1, 2-dihydroxy-4-glucosylnaphthalene, Lawsoniaside (1,3,4-trihydroxynaphthalene 1, 4-di- β -d-glucopyranoside), 5-hydroxy-2-methyl-1, 4-naphthoquinone	Leaves, Stem and Bark	Afzal <i>et al.</i> (1990) Hsounaet <i>al.</i> , 2011 Pratibha and Korwar, 1999 Gupta <i>et al.</i> , 1993
Naphthalenes (small amount)	Lawsoniaside, 1,2,4-trihydroxynaphtalene-1-0- β -glucopyranoside, naphthalene carboxylates, Lawsonaphtholate (A-C) and 1, 2-Dihydroxy-4-0-glucosyloxynaphthalene	Leaves and aerial part of the plant	Semwal <i>et al.</i> , 2014. Afzal <i>et al.</i> (1990)
Xanthones	Laxanthone I (1, 3 dihydroxy-6 7 dimethoxy xanthone), Laxanthone II (1-hydroxy-3-6 diacetoxy-7-methoxyxanthone), Laxanthone III (1-	Whole plant	Bhardwaj <i>et al.</i> , 1998

	hydroxy-6- acetoxy xanthone)		
Benzopyrone	5-allyoxy-7-hydroxycoumarin, Frexetin	Whole plant	Bhardwaj <i>et al.</i> , 1998
Terpenes and terpenoids	3 β , 30-dihydroxylup-20(29)-ene (hannadiol), (20S)-3 β , 30-dihydroxylupane, 30-nor-lupan-3 β -ol-20-one, botulin acid, lawnermis acid (3 β -28 β -hydroxy-urs-12,20-diene-28-oic acid) and its methyl ester, -(Z)-2-hexenol, linalool, α -ionone, β -ionone, α -terpineol, terpinolene, δ -3-carene and γ -terpineol	Stem Bark, Seeds and essential oil from Leaf and Flower	Handa <i>et al.</i> , 1997, Satyalet <i>et al.</i> , 2012. Rahmat <i>et al.</i> , 2006, Siddiqui <i>et al.</i> , 2003. Siddiqui and Kardar 2001
Coumarins	Licourmarin, Fraxetin, Scopoletin, esculetin, daphnaside, dephenorin and agrimonolide	Whole plant	Bhardwaj <i>et al.</i> , 1998
Polyphenolic components	Lalioside (2,3,4,6-tetrahydroxyacetoxy-2- β -d-glucopyranoside), Lawsoniaside B (3-(4-0-a-d-glucopyranosyl-3,5-dimethoxy) phenyl-2E-propenol), syringinoside, dapheneside, daphenorin, agrimonolide, syringaresinolsyringaresinolisoscuteellarin. Gallic acid	Stem Bark and leaves	Cartwright 2006 and Takeda and Fatope 1988
Phytosterols and aliphatic compounds	Lawsaritol. Stigmasterol and β -sitosterol, 2-methyl-nonacosan-1-ol, n-trycontyl n-tridecanoate	Seeds, Stem and Root	Gupta <i>et al.</i> , 1992
Tannins (Small amounts)	Gallic acid, tannic acid, 1,2,3,6 Tetra-0-gallolyl-b- D-glucose and 1,2,3,4,6-Penta-0-gallolyl- β -D-glucose	Whole plant	Semwal <i>et al.</i> , 2014 and Mikhaeil <i>et al.</i> , 2004
Ligans	(+)-syringaresinol-0-b-D glucopyranoside, (+)- syringaresimol-di-0-b-D-glucopyranoside, (+)-pinoresinol-di-0-b-D-glucopyranoside etc	Leaves	Semwal <i>et al.</i> , 2014 and Mikhaeil <i>et al.</i> , 2004
Miscellaneous chemical constituents	Carbohydrate, proteins, fibers and Trace metal (Cu, Ni, Mo, V, Mn, Sr, Ba, Fe, and Al) Minerals- Na ₂ O, CaO and K ₂ O	Whole plant	Mahmoud <i>et al.</i> , 1980

Social and industrial properties of *Lawsonia inermis*

Dyeing and beautifying potential of Henna:

It is an ancient practice among women to engage beautifying various parts of their bodies. They indulge in body decorations so as to enhance their beauty while others use it for social and religious purposes. Henna which is a temporary stain is used mainly for beautification and drawing of designs on the body. Various reports showed that henna art has been practiced in countries like India, many part of Africa, and Middle East for centuries where there is a common believe that the plant bring love, good fortune and protection against evil (Idowu *et al.*, 2010).

Henna also known as "Lalle" in northern part of Nigeria is locally used during sallah festival, marriages, passage of adolescent and in time important joyous moment. The paste which is produced from the leaves when applied to the skin surface for a few moments and subsequently removed, it leads to beautiful markings of orange, red or even black dye decoration on the applied part of the body. These markings later fade off naturally in the course of 2-3 weeks. Reports showed that in recent time, henna is produced commercially and sold in a ready-made factory fitted containers thereby enhancing easy usage for the artists. Unlike before when extensive work has to be done

before one can make use of it (Idowu *et al.*, 2010).

Henna is widely known for its aesthetic use, traditional uses and application processes have gone contemporary as the plant is not only used for body decoration but also as dyeing of hair. Henna is highly recommended for both sexes to dye their hair because it is a natural product and has less or no carcinogenic effect compared to other synthetic dying agents (Mohammed *et al.*, 2012). It is a well-established practice in Northern part of Nigeria during wedding festival that is henna is celebrated as part of the marriage rites traditionally known 'Ranar Kunshi' meaning 'Henna Day' that is mostly set aside as part of the wedding ceremonies where the bride and her friends adorned themselves with various designs and decoration (Mohammed *et al.*, 2012).

In Asia sub-continent like India and Pakistan, Henna is usually known as Mehndi and is naturally applied to various parts of the body during Hindu weddings, festivals like Diwali and Teej. North Indian wedding ceremonies include one evening solely dedicated for adorning the bride and groom in Mehndi. This night is referred to as 'Mehndi ki raat'. Indian tradition says that the longer your Henna stays on your hand, the longer it is believed your in-laws will treat you well. If the Henna fades out quickly, it is a sign of an unhappy marriage. Muslims in the

South Asia countries like Malaysia also apply henna (Mehndi) during weddings and festivals such as Eid-Fitr and Eid-Adha. Malaysian women also use to adorn the bride and groom's hands before the wedding at a *berinai* ceremony (Arpitha Associates (2005).

There exists a folk tale that using henna during marriage celebration leads to increase love and fertility between the couple especially when the bride adorns herself with henna designs and decoration before coming to the husband's house as it brings good luck to the family (Mohammed *et al.*, 2012).

Anticorrosion potential: Corrosion is natural processes which convert a refined metal to a more chemically form such as its oxide or sulphide (Philip *et al.*, 2010). The aqueous extract of *Lawsonia inermis* was studied to know the anticorrosive effect on various metals and alloys using the polarization method. The outcome showed degree of anticorrosion activities depend on the both the type of metal and the medium used. The study further emphasized that the metals steel and nickel anticorrosive efficiency increased in the order of the medium ranging from alkaline to neutral and neutral to acidic. Anticorrosive properties of zinc followed the reverse order as to those of steel and nickel. The study concluded that the anticorrosive properties of henna plant extract possess a mixed inhibition effect on various metals (El-Etre *et al.*, 2005).

Henna plant and its main compounds such as lawsone, α -D- Glucose, gallic acid, and tannic acid are known to possess anticorrosive effect on iron steel especially at acidic solution. The anti-corrosive potential was studied using electrochemical method and surface analysis. The result obtained when polarization measurements was taken showed that the studied constituent act as a mixed inhibitor which increases with the concentration of the medium. It was noted that maximum inhibitory efficiency was obtained at 1.2 g/l of henna plant extract and this efficiency increases in the order of the compounds lawsone to α -D-Glucose and to tannic acid (Ostovari *et al.*, 2009).

Al-Sehaibani *et al.*, 2000 conducted another study assessing the extract of henna leaves for its anticorrosive potentials. The aqueous extracts of the leaves were used on steel, aluminum saline, acid and alkaline medium. The result of the study showed that maximum efficiency was seen at 20g/L of the extract. The anticorrosive efficiency of iron steel in acid medium by the extract was 96% and the effect on the aluminum in alkaline medium is almost 100%. The study concluded that the extract did not show anti-corrosive action on both steel and aluminum in alkaline medium (Al-Sehaibani *et al.*, 2000).

Rehan (2003) investigated the anticorrosive action of aqueous extracts from the leaves of various plants such as *Phoenix dactylifera* (date palm plant),

Lawsonia inermis (henna plant) and *Zea mays* (corn plant) on some metals such as steel, aluminum and copper in acidic and alkaline medium using the weight loss and medium analysis potential for scoring. The outcome showed that the inhibitory action depends on the type of metal and the composition of the medium. *Phoenix dactylifera* and *Lawsonia inermis* extracts were found to possess the best anticorrosive rate on the steel in acidic medium and aluminum in alkaline medium. It was stated that the anticorrosive efficiency increased with increasing concentration of the extract (Rehan, 2003). The anticorrosive effect was interpreted using chemical absorption of some active constituent in the leaves according to their Temkin isotherm (Temkin isotherm is a model that assumes the adsorption of heat in all molecules. The adsorption is mostly characterized by a uniform distribution of binding energies.) (Buchweishaija, 2009).

Microbiological staining potential: Gram staining is the main procedure adopted by microbiologist in the identification of Gram positive and Gram negative bacterial. Reports showed that both aqueous and ethanol extracts of henna plant leaves can be used as a counter stain in Gram staining. Chukwu *et al.*, (2011) conducted a study on the different extracts of henna plant.

The extracts were fractionated into different staining solution having

different concentrations which were later modified using different solution such as hydrogen peroxide, ferric chloride, potassium alum and potassium permanganate. These extracts were used to stain bacterial isolates using Gram staining method. The henna plant extracts were compared conventional counter stains serving as standard control. The result showed that aqueous extracts of the *Lawsonia inermis* gave a better staining reaction with Gram negative bacteria, while the ethanol extract had no staining reaction with Gram negative bacteria. The study concluded that *Lawsonia inermis* can be used in place standard counter stains used in Gram staining technique in the microbiology laboratories (Chukwu *et al.*, 2011).

Ethno-pharmacological potentials

Anti-diabetic potential: Diabetic mellitus simply referred to as a clinical and genetical heterogeneous group of metabolic disorders with common features abnormal rise in blood glucose (WHO, 2010). Various reports have shown that methanolic leaves extract of *Lawsonia inermis* have been used in the management of diabetes.

Syamusudin and Winarno 2008, assessed hypoglycemic effect of methanolic leaves extract of *Lawsonia inermis* on diabetic mice. Treatments with the extract were done at day of 0, 3, 7, and 14th after diabetes induction. The results of their studies revealed that

the extract of *Lawsonia inermis* reduce high blood glucose to normal after 14 days treatment. A similar result was observed on the cholesterol and triglyceride values (Syamusudin and Winarno, 2008).

Another research conducted by Arayneet *al.*, assessed the methanolic (95 %) extract of the leaves of *L. inermis* on the rats induced with diabetes, the result showed significant *in-vitro* antihyperglycemic effect (Arayneet *al.*, 2007).

Antimicrobial potential: In 2005, a study was carried out by Muhammed *et al.*, to ascertain the *in vitro* antimicrobial activities of *Lawsonia inermis* on different bacterial and fungal isolates. The isolates were treated with the leaves extract of henna plant for antimicrobial potential using *in vitro* agar incorporation and agar plate diffusion methods. The outcome of the studies confirm that the extracts inhibit the growth pattern of both bacterial and fungi isolates (Muhammed and Muhammed, 2005). In a similar study, Abdilmoneim (2007) examined the leaf extract of *Lawsonia inermis* in Dammar region of northern Sudan for possible antimicrobial effect. The extraction was aqueous, methanol and chloroform at different concentrations. The extracts were used *in vitro* to determine their bioactivity effect on the growth of pathogenic bacterial and fungi. The bioactivity of the three extracts were compared. It was noticed that aqueous extract was more effective even though

there are extreme fluctuations in the activities recorded. The Phyto compound screening showed the presence of anthraquinones as the main component of the leaves. The presence of anthraquinones in the leaves was attributed to antimicrobial activity of the plant (Abdilmoneim 2007).

To further establish the antimicrobial activity of this popular plant, Bhuvaneswari *et al.* (2002) reported using *Lawsonia inermis* leaves in the treatment of urinary tract infection (UTI) that is caused by various pathogenic bacterial. The result showed that *Lawsonia inermis* leaves suspension yielded Gram negative: 55-85 µg/ml and for Gram positive >95 µg/ml for broth dilution method: Disc diffusion method showed >95 µg/ml for both Gram negative and Gram-positive organisms. Antimicrobial activity - Disc diffusion method: *E. coli*: 10 µg/disc and for *S. aureus*: 25 µg/disc. The study concluded that *L. inermis* leaves have definite antimicrobial activity against the common urinary pathogens and the leaf components which are responsible for this action have to be isolated (Bhuvaneswari *et al.* 2002).

The leaves extract of this great plant can also be combined with synthetic anti-biotic for its synergistic effects against the resistant organisms. Ajaiyeoba (2000) embarked on a study to check the synergistic effects of *Lawsonia inermis* together with two different antibiotics; those acting on the cell wall (gentamycin and erythromycin) and

those acting on the nucleic acid (tetracycline and chloramphenicol). The result showed that there is a good synergism between the drug and the plant extract. It was concluded that the synergism can be adopted in modern medicine for treating different diseases especially those organisms that can easily resist conventional antibiotics (Ajaiyeoba, 2000).

Tuberculostatic potential: Tuberculosis is an infectious disease that usually affects the lungs and about 9 million people are affected yearly (WHO, 2015). Reports state that *Lawsonia inermis* have extended spectrum of activities inhibiting the growth of mycobacterium.

Sharma (1990) assessed the effect of henna plant and he tested for both *in-vitro* and *in-vivo* activities on the Lowenstein Jensen medium (LJM). Outcome of the study showed that the growth of mycobacterium was inhibited at 6 µg/ml of the extract. Another *in vivo* study on both mice and guinea noted that the henna plant extract at 5 mg/kg brings about significant reduction of Mycobacterium infection (Sharma, 1990).

Anti-malarial potential: Malaria which is endemic disease in most developing countries of the world. Despite intensive efforts, about higher number cases of malaria occurs annually and five hundred thousand deaths were reported in 2015 (WHO 2016). There have been various reports that many medicinal plants have antimalarial

activities in traditional medicine and such plants includes; *Chromolaena odorata* *Lawsonia inermis* and *Tithonia diversifolia* (Afolayan et al., 2014). The result of the study conducted by Afolayan et al., 2016 concluded that *Lawsonia inermis* when combined with other plant possess significant antimalarial properties on *P. falciparum*. In a similar report in Yemen, when dried flowers of henna are used on people suffering from malaria, there is significant improvement in the patient treated traditionally (Ali et al., 2004).

Fungicidal potential: The leaves of *Lawsonia inermis* has been reported to have strong anti-fungi activities. The minimum dose that is effective against fungi was stated as 1000ppm (Tripathi et al., 1978). Different fractions of the leaves of *Lawsonia inermis* have been postulated to have defensive effects on the spore eruption of *Drechslera oryzae* (Natarajan and Lalithakumar, 2000). Lawsonia which is one of the major constituents of henna has been reported to have a significant effect on both fungi and bacterial. Raveesha et al., assessed the antifungal potential of *Lawsonia inermis* leaves on different species of *Aspergillus* isolated from seed samples of maize paddy and sorghum. The result showed that *Aspergillus flavus* is the most susceptible even though different fraction has significant effect on the fungi (Raveesha et al., 2007). In a similar experiment, Aghelet et al. (2005) obtained the essential oil component of henna leaves by hydro-distillation.

Upon analysis using GC-MS method, their result showed significant antifungal effect (Aghelet *et al.*, 2005). Khan and Nasreen (2010), conducted a study to assess the antifungal potential of five plants using methanolic extracts against ten pathogenic fungi of plant and *Candida albicans* (B017). Result of the study showed that hennahave the highest percentage in the mycelial inhibition thereby altering the growth of target fungi for almost 76-88% in comparisonwith other plant. The main compounds responsible for antifungal activities were proteins and they have significant activities on plant pathogens (Khan and Nasreen, 2010).

Antiviral potential: It has been reported thatthe soluble ethanol fraction of henna plantfruits showed highly potent virucidal effect on Sembiki forest virus *in vivo* model of both mice and chick embryo having about 65-80% antiviral effects following ten to twenty-five days of viral challenge (Khan *et al.*, 1991).

Liver protective potential: Many parts of *Lawsonia inermis* have shown significant liver protecting effect when liver damage is induced in both rats and mice. Ahmed *et al.*, assessed the liver protective action of ethanolic extract of henna plant in rats. Result showed that henna brings about protection of hepatic cells by ensuring that elevated liver enzyme (ALT and AST), lipid peroxidation, bilirubin content, total protein, and various anti-oxidant markers were within normal

range (Ahmed *et al.*, 2000). In a similar work embarked by Hemalatha *et al.*, who examined the liver protective effect of ethanolic extract of henna plant leaves together with its various crude fractions in carbon tetrachloride induced liver damage in mice. The outcome of the study showed that extract and its fractions hepatic damage when compared to the control (Hemalatha *et al.*, 2004).

Chaudhary *et al.*, also assessed the hepatoprotective potential of different fractions of hennaseeds on induced liver damage in rats. The result showed that Pre-treated rats have a significant alteration in the enzymes markers of the damaged liver when induced by carbon tetrachloride using 0.5 ml/kg intraperitoneally. Following this observation, the crude and fraction of the seed of henna prevented carbon tetrachloride induce liver damage (Chaudhary *et al.*, 2012).

Anthelmintic potential: Tadesse and Mirutse 2009, assessed the ant helminthic activities of various medicinal plant such henna and other two plantson both the eggs and adult stage of round worm (*Haemochuscontortus*). The outcome showed henna was not dose-dependent and did not prevent hatching of the eggs of round worm significantly in comparisonto the other plants. The findings of the study postulated that henna and the other tested plant have a possible compound with ant helminthic potential (Tadesse and Mirutse, 2009).

Anti - Trypanosome potential:

Trypanosomosis is diseases of both man and animals which is characterized by anaemia, abortion, infertility and death especially at the acute phase (Adeyemi *et al.*, 2012). There has been report that that *Lawsonia inermis* has effects on trypanosome organisms. Wurochekkeet *al.* researched on the antitrypanosomal potential of henna plantleaves using both *in-vitro* and *in vivo* methods in mice. The study noted that methanolic extract of henna leaves possess *in-vitro* activity against *Trypanosoma brucei* while *in-vivo* study indicated that henna extract ameliorates the trypanosomosis but the parasitemia and PCV of blood were affected (Wurochekkeet *al.*, 2004).

Abortifacient potential: In order to establish the maternal and toxic effects of *Lawsonia inermis*, Aguwa (1987) conducted research using the methanolic root extracts of the plant for its abortifacient action. The outcome showed that the methanolic extract was very effective in the induction of abortion in mice, rats and guinea pig. The observed abortifacient effect was dose-dependent. To further confirmed the ethno-medicinal use in the procurement of abortion in humans in many parts of Nigeria (Aguwa, 1987).

Anticoagulant effect: The important constituent of henna leaves known as lawsone. It is oxazine constituent and one of the compounds isolated from the leaves of *Lawsonia inermis*. This compound has been reported to possess

a significant anticoagulant action (Kumar *et al.*, 1995).

Antioxidant potential: Anti-oxidant are groups of compounds that prevent oxidation. Dasgupta *et al.*, 2003, conducted a study to check effect of the leaves of henna plant on the metabolizing enzymes and the antioxidant system using different dosages of ethanol extract in mice. Standard reference of antioxidant enzymes was used as the control. The result showed a significant inhibition of tumor burden cells thereby confirming the anti-oxidant potential of henna plant (Dasgupta *et al.*, 2003). Prakash *et al.*, confirmed that phenolic compound *Lawsonia inermis* at different concentrations has the same effect when compare with synthetic antioxidant like selenium and vitamins (Prakash *et al.*, 2007). In a similar study conducted by Philip *et al.*, the free radical scavenging and reducing power of hennaseeds using the antioxidant activity was assessed. The phenolic and flavonoid content of different fractions were investigated. In all the fractions assayed, ethanol showed the highest potential for scavenging of free radicals and inhibition lipid peroxidation. The study showed that the antioxidant activities depend on the concentrations of phenols and flavonoids which are always in proportionate to each other. The study concluded that the ethanolic extract of henna seeds plant can be used as good antioxidants (Philips *et al.*, 2011).

Wound healing potential: Nayaket *al.*, conducted a study to see the wound healing potential of ethanolic extract of henna plant. Experimental rats were grouped into three excision model while two groups were in the incision model and dead space models. The extract was applied topically in the excision wound model; they were dosed orally in the other model. The outcome showed that subjects treated with the extracts showed rapid wound healing when compared with controls. The study concluded that henna can promote faster wound healing due to its effect on enhanced wound contraction, hydroxyproline, increased and skin breaking strength (Nayaket *al.*, 2007).

In another experiment conducted by Muhammed and Muhammed(2005)to investigate the effects of henna on the micro-organisms of burnt wound. The result showed that the extract of henna leaves prevents the growth of microorganisms that causes burn wound. This assertion supports the use of *Lawsonia inermis* in the treatment of wound caused by infectious agents (Muhammed and Muhammed, 2005).

Antidermatophytic potential: The antidermatophytic effect of different fractions of *Lawsonia inermis* were assessed on different strains of ringworm such as *Tinea species*. The entire fraction from the extracts of henna showed a significant antidermatophytic properties following *in-vitro* modeling (Natarajan and Menon, 2000).

Antiparasitic potential: Ethno pharmacological survey was carried out in Ivory Coast to check the antiparasitic potential of medicinal plants frequently used. Seventeen different plants were pointed and assembled. Both the polar and non-polar portion the extracts of the various parts tested for *in vitro* against various parasites like *plasmodium spp*, *leishmania spp*, lice and various worms. The study concluded that *Lawsonia inermis* showed significant trypanocidal activities (Okpekonet *al.*, 2004).

Molluscicidal potential:Mollusca represent one of the most important carriers of cestode which in turn damage the internal organ of grazing animals. Research was embarked on to assess the anti-molluscal potential of *Lawsonia inermis*.The outcome of the study showed henna plant possess a significant Molluscicidal activity (Singh and Singh, 2001).

Contraceptive potential: It has been shown that ethanolic extract produced from grinded seeds of henna plant was observed not to be devoid of antifertility effect but subsequent studies showed that when theleaves is use as suspension or added to the feed of rats, fertility will be inhibited. The induced anti-fertilityaction is a permanent one thereby leading to sterility (Munshi *et al.*, 1997). Samagoroet *al.*, 2012, conducted research in rats using the roots of *Lawsonia inermis* which is known to be

the most widely used anti-fertility agent. Healthy male and female rats were used in the experiment. The parameters determined includes; weight, Pre-implantation, mating ratio and Corpora lutea. The outcome of the study showed decreased body weight and loss of implantation sites the test group in comparison with the control group. There exists a significant relationship between the number of implantation sites and the dose-response among the tested doses of henna extract and ethinyl estradiol. It was further established that there exists a significant difference in the number of Corpora lutea in all treated and control groups. Furthermore, there is also a significant difference in percentage pre-implantation loss in all the test and control groups. The study concluded that henna plant extract has anti-fertility action and this finding explains why *Lawsonia inermis* is used as antifertility agent in traditional medicine (Samagoro et al., 2012).

Anti-inflammatory potential: Reports showed that crude ethanolic extract of henna produce a significant and dose-dependent anti-inflammatory effect. The researcher; Gupta et al., assessed the anti-inflammation of two compounds that were isolated from stem, bark and root of henna in Wistar rats which is induced with oedema. The study followed that the constituents isoplumbagin and lawsaritol and phenylbutazone given at a dosage 100 mg/kg per os (orally). The outcome

pointed out that the compounds showed 61%, 60% and 40% inhibition when compared with the controls. The study concluded that isoplumbagin possess anti-inflammatory effect just like phenylbutazone (Gupta et al., 1993). In a separate report by a group of researchers, it was stated that both chloroform and butanol fractions of henna plant possess a more potent antipyretic, anti-inflammatory and analgesic potential when compared with both crude ethanol and aqueous extract (Alia et al., 1995).

Analgesic and anti-pyretic potential: Analgesic and anti-pyretic properties are not very common in most plant but the crude ethanolic extract of *Lawsonia inermis* is known to produce significant anti-pyretic and analgesic action. Moshinet al., studied 25 plants commonly used in Arabian Peninsula for the treating pain related rheumatism and fever. It further assayed for both of their antipyretic and analgesic potential. *Lawsonia inermis* extract showed a significant effect regarding both antipyretic and analgesic action (Moshinet al. 1989). In a separate study the oil from seeds of *Lawsonia inermis* plant was screened *in-vivo* and *in-vitro* for their pharmacological activity. The study stated that the oil obtained from the seed of *Lawsonia inermis* possess significant analgesic properties (Bagi et al., 1988).

Immunomodulatory potential: The immunomodulatory action of methanolic leaves extract of henna plant

was studied by a group of researchers using bioassay-guided fractionation. Seven compounds were isolated of which they found three new compounds in the plant. The immunomodulatory properties of these compound were assayed by *in vitro* lymphocytic transformation, free radical scavenging and immunoassay. Results of the study showed that methanol extract of henna leaves plant at a concentration of 1mg/ml showed immunostimulatory activities by increasing the number of T-lymphocyte formation (Mikhaeil *et al.*, 2004). Though, previous reports noted that naphthoquinone fraction obtained from leaves of henna plant have a significant immunostimulant activities (Dikshit *et al.*, 2000).

Tumoricidal potential: It is a common assertion that cancer is among the deadliest disease occurring in both human and animal. *Lawsonia inermis* has been reported to possess anti-cancer activities. This plant destroys cancer cells by inducing cell apoptosis as a result of decrease in intracellular hydrogen ion or increase in intracellular hydrogen peroxide leading to excessive production of free radicals to cancerous cells. Researchers conducted an experiment to ascertain the anti-tumor effect of henna leaves in mice induced with tumor. The extract of *Lawsonia inermis* was dosed at 10mg/kg to tumor bearing-mice. The result showed increased in the percentage mean survival period of the tumor bearing

mice. The total number cancerous cells reduced significantly. It further showed a reduction in glutathione levels in the test on comparing with the control. The study concluded that the extracts increase the pH levels and possibly may be responsible for the inhibition of tumor cell which is bio-transformed by henna plant extract (Zumrutdaet *al.*, 2008; Ozaslanet *al.*, 2009).

Similar research conducted by Priya *et al.* (2011) on the anti-cancer efficacy of *L. inermis* extracts in the tumor induced mice. The outcome revealed an increased in mean life span and survival time of the mice. The result further showed that *Lawsonia inermis* possesses anticancer activities and can be used in the exploration of a novel drug for management and treatment of various tumors (Priya *et al.*, 2011). In another experiment conducted by Endriniet *al.* (2002) chloroform fraction of henna plant was used for MTT (succinate dehydrogenase) based cytotoxic assay for its anti-tumor action. The extract was tested on both normal and cancerous cell lines of hepatic cell. The outcome of the study showed henna extract brings about a significant reduction in the cancer cells (Endriniet *al.*, 2002).

Memory and behavioral enhancing potential: In folk medical practices, many plants have been used to improve the neurotropic activities of local people. Iyeret *al.*, (1998) conducted research to see the effect of different fractions of henna plant leaves on

anxiety, behavior and memory which is mediated via monoamine (MOA) neurotransmitters. This effect was quantified with the use of increase passive shock, plus maze and avoidance paradigms. The result showed that the acetone and ether fraction of the extract exhibited dominant neurotropic effect. The study concluded that henna plant possesses a stimulatory effect on behavior and memory which is mainly mediated via MOA neurotransmitters (Iyer *et al.*, 1998).

Safety evaluation and acute toxicity of *Lawsonia inermis*

Reports on most toxicological studies as a result of using of phytomedicine or herbs as medicine are mostly associated with liver toxicity. Other major organs that showed signs of toxicity includes the heart and its vessels, kidney and nervous system. Toxic effects affecting pregnancy leading to mutagenicity and carcinogenicity are well common and have been reported in many journals warranting enormous biological experiments so as standardized the safety test before proceeding to the chemotherapeutic study of any plant. Many reports from the literature have confirm that henna plant showed various pharmacological activities such as hepatoprotective, analgesic anti-inflammatory, antibacterial and antioxidant potential thereby showing that its safety and drug source (Yan *et al.*, 2000).

Mudi *et al.* (2011), embark on a study to test the lethal dose of the aqueous extract of henna plant in rats in order to confirm its safety and toxicity. Rats were administered different doses of the aqueous extract (0.3g/mL-1) at different volume doses intraperitoneally. The result showed various toxic signs such as dizziness among others. Abortion is observed in pregnant females especially in the groups treated with higher dosage but the groups treated lower dosage and the control remained active and healthy without showing toxic signs. The outcome further showed that there was no death recorded in all of the treated groups and delayed toxicity was noticed. They pointed out that intraperitoneal administration of henna may be used for abortion even though slightly toxic but it is considered generally safe for chemotherapeutic potential when used at normal dose (Mudi *et al.*, 2011).

Another researcher Abdelgadir *et al.*, 2010, reported that there was a significant toxicity in male rats dosed with seeds of henna plant at various dosages. The damage to the vital organs was evidence and exemplified by hemorrhages, congestion, fatty changes and necrosis of various vital organs especially at higher dosage. He pointed out that the extract was not toxic when given lower concentrations (Abdelgadir *et al.*, 2010).

Probable Side Effects of *Lawsonia inermis*

It was reported by Aguwa 1987, that the leaves of *Lawsonia inermis* has abortion tendency thus, henna should not be used during pregnancy and lactation. The widespread use of it as a dye has led to many individuals experiencing allergic reactions and these reactions can also be as a result of p-phenylenediamine used to obtain black color. Hypersensitivity to it can last a lifetime, and once individual have become sensitive or allergic to it, any use of synthetic coloring agents may become life threatening (Skenderi *et al.*, 2003).

DISCUSSION

The world is now a global village and there has been a growing notion in substituting synthetic drugs with natural sources such as plant materials as the high incidence of global death rate estimated to be 90% is associated with synthetic drug toxicity. Another big problem facing the entire world is the issues of drug resistant by the pathogen against the modern synthetic drugs. Herbs are the direct replacement to conventional drugs with their synergistic effects for treating both infectious and metabolic diseases of human and animals.

Exploration of various literatures revealed that many parts of *Lawsonia inermis* possess wide spectrum of ethno-pharmacological action and due to

these great potentials, it can be used as a drug in phytomedicines. Various compounds or phytoconstituents are available in this multifunctional plant, thereby enabling it in the treatment of arrays diseases in different part of the body system.

Lawsonia inermis has industrial values where it can be employed as dyes, staining agent and anti-corrosive agent. It possesses medicinal activities which may be used as antibacterial, antiviral, antimycotic, antimicrobial, antidiabetic, contraceptives, anthelmintic among others.

Judging by these various therapeutic activities of this important and miraculous plant; it deserves special attention and consideration by scientists, chemist, pharmacologist and other researchers in various fields in order to develop different drug from this underexploit plant.

A drug development programme should be undertaken to produce a unique and modern drug from constituent of *Lawsonia inermis*. Various reports have shown that crude extracts from leaves of *Lawsonia inermis* have ethno-medicinal applications from ancient time, there is need for modern drugs development following extensive investigation of its bioactivity, mechanism of action, pharmacotherapeutics and toxicity.

Conclusively, there should be further assessment in order to explore the hidden potentials of *Lawsonia inermis*

and its therapeutic applications for both human and animal welfare.

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