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REVIEW

Lawsonia inermis (L.): A perspective on anticancer potential of Mehndi/Henna

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Abstract— Incidence of cancer is growing swiftly worldwide and sparse supply of anticancer drugs; unaffordable cost and its lethal effect have shown the way to adopt complementary and alternative medicine for the treatment and/or prevention of cancer. The isolation of anti-cancer alkaloids vinblastine, vincristine and podophyllotoxins during 1950s prompts research on anticancer agents from plant origins. *Lawsonia inermis* (L.) popularly known as Mehndi or Henna, is a cosmetically renowned plant of the oriental region possesses diverse pharmacological activity including anti-carcinogenic, antimicrobial, anti-inflammatory, analgesic, antipyretic, hepatoprotective, anti-tuberculostatic. In search of new anticancer drugs from natural sources many researchers have reported anticancer and chemopreventive properties of Henna extracts/compounds in their pre-clinical studies. Lawsone, one of the major constituent of henna, is used as a starting material in the synthesis of a variety of clinically valuable anticancer drugs such as atovaquone, lapachol and dichloroallyl lawsone. This plant contain other chemicals such as isoplumbagin, apigenin, apigenin glycosides, luteolin, luteolin-7 glucosides, p-coumarin and lupeol among which many are reported for their cytotoxicity and chemopreventive activity against different type of cancer cell. Here in this review, we are reporting a palingenesis of information regarding anticancer potential of Mehndi/Henna. We have included maximum available information from its *in vitro* and *in vivo* studies by referring different websites, text-books, notes, and articles, abstract, summary and consulting worldwide accepted scientific databases. The present review recapitulates some important findings on the anticancer potential of Mehndi/Henna and to a great extent more work has to be undertaken to explore its novel target(s). Future investigation on novel molecules from Mehndi/Henna may offer great hope for discovering new cancer chemotherapeutic and/or chemopreventive agents from this miraculous plant.

Keywords— Anticancer, chemoprevention, Henna, Lawsone, *Lawsonia inermis*, phytochemistry.

INTRODUCTION

The prevalence of cancer is speedily growing worldwide and rank second after cardiovascular diseases targeting both developed and developing countries. Limited supply of anticancer drugs, unaffordable cost of treatments, and lethal adverse effect of several available drugs have shown the way to adopt complementary and alternative medicine for the treatment and/or prevention of cancer (Cragg et al., 1997; McClellan et al., 2011). Almost twenty five percent of the modern medicine used today originates from plants and the examples include taxol from *Taxus baccata* (Yew), vincristine and vinblastine from *Catharanthus roseus* (Sadabahar), podophyllotoxin from *Podophyllum peltatum* (Mayapple), aspirin from *Sahennax* species (Willow bark), digitalis from *Digitalis purpurea* (Foxglove), pilocarpine from *Pilocarpus jaborandi* (Jaborandi or Indian hemp). Since the dawn of civilization, plants are essential element of human society and used extensively in folk medicine for the treatment of innumerous ailments. Since then several species of plants have become a part of various indigenous system of treatment such as Ayurveda, Unani, Siddha and Homeopathy collectively known as AYUSH. Plants, rich in secondary metabolites and essential oils have been studied during the last few decades for potential source of drug. Today, it is ballparked that a

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propos of 70-95 % people dwelling in developing nation relies on traditional medicines for their primary health care (Dahanukar et al., 2000). Drugs from plant origin posturing to become source for medicine have led to an unexpected augmentation in the number of herbal industries (Kirtikar and Basu, 2005). The isolation of anti-cancer compounds such as vinblastine, vincristine from *Catharanthus roseus* and podophyllotoxins from *Podophyllum peltatum* in 1950s promoted the researchers to explore anticancer agents from plant sources (Cassady and Douros, 1980; Cragg and Newman, 2005; Shoeb, 2005). Out of the available anticancer drugs in the market, two-third is either of natural origin or simple modification of the natural product (Cragg et al., 1997).

Lawsonia inermis L. (Lythraceae), a monotypic genus, popularly known as '*Mehndi*' or '*Henna*' is renowned as a cosmetic as well as medicinal agent in the Oriental parts of the world since time immemorial. The plant extracts and purified constituent of henna in folklore accounts for a variety of activities including antibacterial (Malekzadeh, 1968), antifungal (Tripathi et al., 1978), antioxidant and immunomodulatory (Hsouna et al., 2010; Mikhaeil et al., 2004), hepatoprotective (Anand et al., 1992), analgesic, anti-inflammatory and antipyretic (Ali et al., 1995), and cytotoxic (Ali and Grever, 1998). The bactericidal and fungicidal action of this plant has been attributed through its tanning effect (Wessjohann et al., 2003) and it has been confirmed that henna is neither an allergen nor a carcinogen (Nayak et al., 2007). The key coloring agent present in henna leaves is a red-orange pigment lawsone (2-hydroxy-1, 4-naphthoquinone) (Al-Tufail et al., 1999; Lekouch et al., 2001), which makes this plant useful for dying of hair, as well as to color palms, fingers, fingernails and soles (Cartwright, 2006; Hanna et al., 1998). Lawsone is also a suitable reagent for the detection of latent fingermarks on paper, as contact evidence in criminology (Khan and S., 2010). Lawsone (2-hydroxy-1, 4-naphthoquinone) is a starting material in the synthesis of many clinically useful anticancer compounds such as atovaquone, lapachol and dichloroallyl lawsone (Pradhan et al., 2012).

In Ayurveda and Unani medicine, Henna has been considered as a source of non-toxic therapeutic agent for blood tonic, cancer, infectious disease, inflammation, tuberculosis, tumors and wounds when; given as single preparation of henna decoction or extract or as blended with other molecules. Translation of Henna compounds and its derivatives to modern drug discovery strategy results to potential new molecule for specific therapeutic agents. The description of lawsone derivatives in our review offers agreeable substantiation for the usefulness of some of these molecules against certain type cancers. It is worthy to notice that lawsone itself has significant antioxidant and anti-inflammatory activity that could be major characteristic of numerous anticancer phytochemicals.

Although Mehndi/Henna extracts and constituents are reported for its pharmacological properties but little attention has been paid to explore its anticancer potential. Therefore, in this review we prepared a palingenesis of information regarding anticancer reports on mehndi/henna by providing maximum available information from its *in vitro* and *in vivo* studies.

INFORMATION RETRIEVAL

Imperative information for the compilation of review was acquired from published literature in form of abstracts, articles, books, notes, peer reviewed papers, summary, texts etc. by using key words '*Lawsonia inermis*', 'Mehndi and/or 'Henna as anticancer agent', 'anticancer activity of mehndi/henna', 'cytotoxicity of mehndi/henna', 'Extracts/compounds in Mehndi/henna as anticancer agent' 'Anticancer/cytotoxicity activities of mehndi/henna extract and essential oil', 'Mehndi/henna and cancer cell lines', 'Mehndi/henna and cancer/tumor', 'chemopreventive properties of mehndi/henna'. Also a comprehensive bibliographic search on Mehndi/henna was carried out during March 2013-March 2014 exploring the worldwide accepted scientific databases of NISCAIR, SCIELO, PUBMED, SCOPUS, INFLIBNET, Sci-Finder, Science Direct and Google Scholar. Compilation of the information retrieved was done arbitrarily for the preparation of palingenesis of the review under the appropriate headings.

PHYTOCHEMISTRY

Noticed by researchers, Mehndi/Henna got its popularity due to presence of a unique chemical named lawsone. Other group of molecules reported from this plant include quinones, phenylpropanoids, flavonoids, terpenoids, phenolics, fatty acids, carbohydrates, proteins, tannins, alkaloids, xanthones, coumarin, glucosides, naphthoquinone, saponins, triterpenoids, sterols and dioxin derivatives. Some potent bioactive like isoplumpagin (a naphthaquinone from bark), lupeol, 30-norlupan-3-ol-20-one, betuhennan, betuhennanic acid and n-tridecanoate (bark), phenolic glycosides, lawsoniaside, β -sitosterol and stigmasterol (leaves) have been reported from Mehndi/Henna plant (Bhardwaj et al., 1980; Bhardwaj et al., 1978; Chakrabortty et al., 1980; Gupta et al., 1992 ; Gupta et al., 1993 ; Takeda and Fatope, 1988), 24-beta ethyl cholest-4-en-3-beta-ol have also been reported from the roots of henna (Gupta et al., 1992). The seeds of Mehndi/Henna contain ~7.5 % viscous oil possessing palmitic, behenic, arachidic, stearic, oleic and linolenic acids (Aggarwal et al., 1959; Handa et al., 1997). Bioactivity guided fractionation of methanolic seed extract lead to isolation of two new triterpenoids lawnermis acid and its methyl ester (Siddiqui et al., 2005). The leaves of Mehndi/Henna also contains apigenin-7-glucoside, apigenin-4-glycoside, luteohennan-7-glucoside luteolin-3-glucoside (Chakrabartty et al., 1982). The essential oil of *Lawsonia inermis* seeds contains about 23 components revealed in GC-MS analysis. The prin-

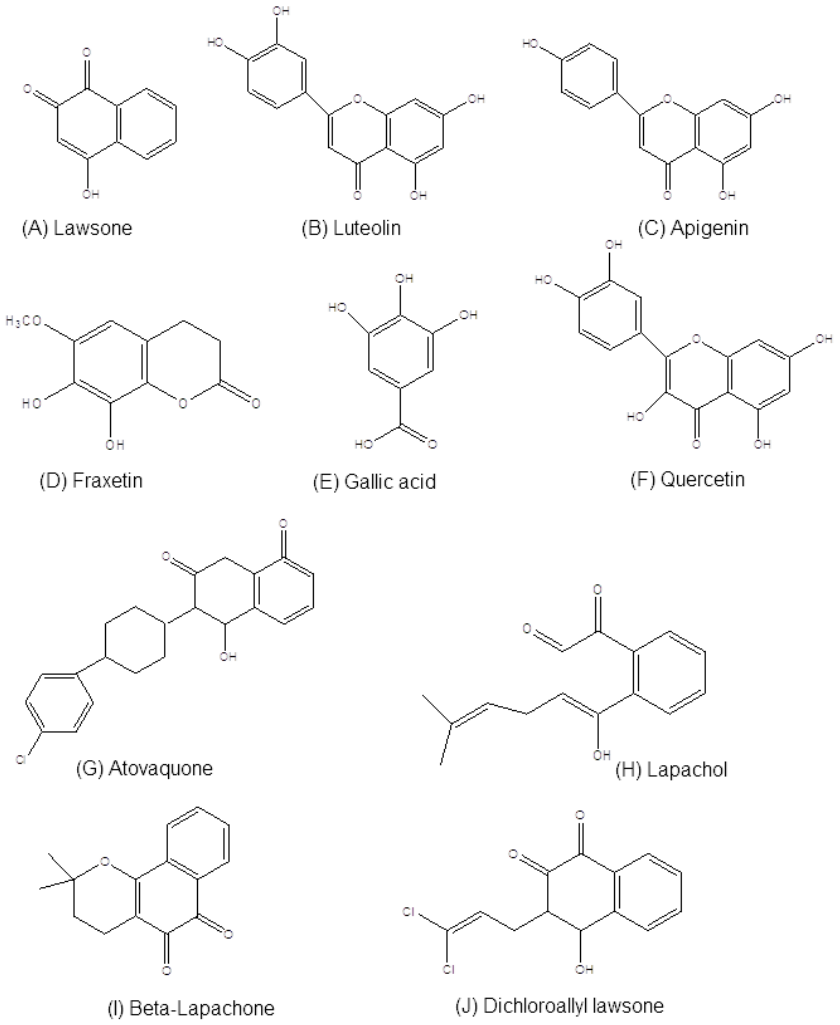

Figure 1. Reported anticancer molecules from *Lawsonia inermis* and some derivatives of lawsone. (A) Lawsone, (B) Luteolin, (C) Apigenin, (D) Fraxetin, (E) Gallic acid, (F) Quercetin, (G) Atovaquone, (H) Lapachol, (I) β-lapachone, (J) Dichloroallyl lawsone.

cipal components were Tridecane (7.7%), phytol (10.30%), Hexadecane (14.88%), Tetradecane (16.77%), Heptadecane (23.48%) (Rahmat et al., 2006). Structures of the reported anticancer molecules from *Lawsonia inermis* and some of the derivatives of lawsone is given in **Fig. 1**.

ANTICANCER/CYTOTOXICITY ACTIVITIES OF *LAWSONIA INERMIS* EXTRACT AND ESSENTIAL OIL

An assortment of anticancer activities of *Lawsonia inermis* extracts, essential oil, lawsone and its derivatives have been summarised in **Table 1**. In addition, description of anticancer studies is provided under the following headings:

In vitro study on different cancer cell lines

Discovery of oncogene and apoptotic pathway represents a breakthrough for understanding the molecular and genetic basis of cancer and are considered as one of the most valuable targets for anticancer drug discovery programme, endeavouring the selectivity of new drugs towards cancer cell and sparing the normal ones (Pierotti et al., 2000). Study conducted on human liver cancer cell line (HepG2) demonstrated induction of the apoptotic phenomena by essential oil and leaves extract of Mehndi/Henna at a concentration of 20 and 30 mg/mL. The induction was evidenced by number of apoptotic bodies, DNA fragmentation and chromatin condensation in the treated groups (Endrini et al., 2011). Essential oil from the leaves of Mehndi/Henna also exhibited strong cytotoxicity on HepG2 with an IC_{50} value of 24μg/mL in MTT assay (Rahmat et al., 2006). Similarly, *in vivo* exper-

iment of Roshnah *et al*., (1998) revealed that Henna reduces chemical-induced hepatocarcinogenesis in rat model. Likewise, chloroform extract of Mehndi leaves showed cytotoxicity on HepG2 and MCF-7 (hormone-dependent breast cancer cell line) with an IC_{50} value of 0.3 and 24.8μg/mL respectively. The effect of Mehndi/Henna extract on expression of c-myc gene was also studied and it was observed that the gene was not expressed in cell (HepG2 and MCF-7) treated with 20 and 30μg/mL of crude extract (Endrini et al., 2007). The expression of the c-myc is indicative of early response during cell proliferation and it has been found to be frequently over expressed in a variety of tissues and cultured cancer cell lines (Saito et al., 1991). From the study, it was concluded that cytotoxicity was mediated by the down regulation of c-myc expression and it was also observed that the extracts did not exhibit any activity on normal, Caco-2 (colon cancer) and MDA-MB-231 (breast cancer) cell lines (Endrini et al., 2007).

***In vivo* study in different tumour model of rodent**

Ozaslan *et al.* (2009) explored the effect of Mehndi/Henna powder on cancerous cells and observed that intracellular free radicals and hydrogen peroxide level was escalated but hydrogen ion concentration was reduced which leads to the stimulation of apoptosis as a consequence of oxidative effect. 0.3% aqueous solution prepared and administered to mice for 12 days twice in equal doses resulted in inhibition of Ehrlich Ascites Carcinoma progression with an increase of GSH and SOD level concluding the promotion of apoptosis due to oxidant effect (Ozaslan et al., 2009). Cancerous cells require more H^+ and intracellular concentration of H^+ in Henna powder treated group was decreased due to its oxidative effect. The ethanolic extract of Mehndi/Henna root connotes anti-tumoral activity in Swiss albino mice at a dose level of 180 mg/kg body weight administered for 15 days in DLA transplanted mice. The body weight, tumor volume, packed cell volume and viable cells were brought back to basal level which was comparable to vincristine (1mg/kg bw), a potent anticancer drug. The experimental finding of the study revealed the reversal of the immunological and pathological abnormalities like increased WBC, platelet, lymphocytes, ALT, AST, ALP, LDH & decreased level of Hb, RBC, PCV, monocytes and differential count in treated mice compared to control group. The hepatocytes of mice treated with Mehndi/Henna and vincristine were well developed with prominent nucleus and maintained sinusoidal space. The findings revealed that ethanolic extract of Mehndi/Henna increased the life span of DLA tumor bearing mice, enhanced the antioxidant status and reduced the lipid profile (Priya et al., 2011). Modulatory effect of Mehndi/Henna leaf extract on drug metabolising enzymes was investigated by Dasgupta *et al*., (2003). Effect of 200 and 400 mg/kg bw of 80% ethanolic extract of the fresh leaves on drug metabolizing phase I and phase II enzymes, antioxidant enzymes, glutathione content, lactate dehydrogenase and lipid peroxidation in the liver of 7 weeks old Swiss albino mice was investigated. Anti-carcinogenic potential of Mehndi/Henna leaf extract was also studied adopting the protocol of benzo (a) pyrene-induced forestomach and 7, 12 dimethylbenz (a) anthracene (DMBA)-initiated and croton oil-promoted skin papillomagenesis. Outcomes of the primary result reveals the 'duel-acting' nature of mehndi/henna leaf as only phase II enzyme activity was induced associated with detoxification of carcinogen in liver of mice whereas the activity of phase I enzyme was inhibited. Significant inhibition of tumor burden was observed in both the studied model and reduced tumor incidence was observed in both the doses signifying the cancer chemopreventive potential of mehndi/henna (Dasgupta et al., 2003).

Anticancer Activities of Lawsone and Its Derivatives

Lawsone (2-hydroxy-1, 4-naphthoquinone) a key molecules of mehndi/henna is being used as starting material in the synthesis of variety of clinically valuable anticancer drugs such as Atovaquone, Lapachol and Dichloroallyl lawsone (Pradhan et al., 2012). Lawsone and juglone inhibit the growth of HCT-15 (human colon cancer cells) by blocking the S-phase of cell cycle observed during flow cytometric study. Furano-1, 2- naphthoquinone synthesised from 2-hydroxy-1, 4-naphthoquinone and chloroacetaldehyde, blocked the growth of A549 (lung cancer cells) by mediating G(2)/M cell cycle arrest and promoting apoptosis (Kamei et al., 1998). Induction of the apoptosis was escorted by up-regulation of Bax and down-regulation of Bcl-2. In addition, the compound also affected EGFR phosphorylation, JAK2, STAT3, and STAT5 activation, and brings about activation of p38 MAPK and c-Jun NH_2-terminal kinase (JNK) stress signals (Su et al., 2010). In another study on Furano-1, 2- naphthoquinone, Chien and Co-worker (2010) reported suppression of EGF receptor phosphorylation and activation of PI3K/Akt in Ca9-22 (oral cancer cells). Interrupted mitochondrial membrane potential, release of cytochrome C, activation of caspases 3 and 9 fetched apoptosis in Ca9-22 cells *via* inactivation of the EGF receptor (Chien et al., 2010).

Amino-derivatives of lawsone and lapachol were found to be cytotoxic against Ehrlich carcinoma and human K562 (leukemia cells). Allyl-amine derivatives of lawsone and lapachol were found potent cytotoxic with an IC_{50} values of 23.89 and 16.94 μM respectively (da Silva et al., 2002). Dichloroallyl lawsone, an analog of the lapachol, and acivicin inhibit the biosynthesis of nucleotide and showed anticancer activity against certain experimental tumor models (Kemp et al., 1986). Dichloroallyl lawsone is an important chemotherapeutic agent causes cardiac toxicity in the rhesus monkey (McKelvey et al., 1979).

Chemopreventive Properties in Skin Cancer

Mehndi/Henna leaf powder and lawsone significantly exhibited inhibition (>88%) of EBV-EA activation induced by the tumor promoter 12-O-tetradecanoylphorbol-13-acetate (TPA) in Raji cells (human cell line from hematopoietic origin, produces an unusual strain of Epstein-Barr virus which transforms cord blood lymphocytes and induce early

Table 1. Reported anticancer/cytotoxicity mechanism of *Lawsonia inermis* extracts, Lawsone and its derivatives.

Type of extract/compound	Model/method of study	Type of cancer	Result	Probable mechanism	References
Ethyl acetate and petroleum ether extract of leaves	*In vitro*; cytotoxicity assay by (3H)-hypoxanthine incorporation assay	Breast cancer (MCF-7 cell lines)	Active against MCF-7 cell line at dose of 22 and 27 mg/mL	Not mentioned	(Babili et al., 2013)
Essential oil and chloroform leaf extract	*In vitro* cell viability assay by tryptan blue and tunel assay for apoptosis	Liver cell (HepG2)	Henna extract and essential oil lead to shrinkage of cell, condensed nucleus and also produced apoptotic bodies.	Induction of apoptosis	(Endrini et al., 2011)
Ethanolic root extract	*In vivo*; Dalton's lymphoma ascites model in swiss albino mice at dose of 180 mg/kg bw	Lymphatic cancer	Significant antitumor activity	Due to antioxidant activity and reduced the lipid profile	(Priya et al., 2011)
Henna leaf powder	*In vivo*; Ehrlich ascites tumour model in swiss albino mice at dose of 0.3% w/w	Gluteal sarcoma	Lawsonia inermis suppresses tumour and delayed survival time in mice.	Promotion of apoptosis due to oxidant effect by enhancing interacellular level of H_2O_2 and free raicals.	(Ozaslan et al., 2009)
Leaf extract	*In vitro*; exposure of broad spectrum light on human leukaemia cell-line HL60 at dose of 20 μg/mL	Human promyelocytic leukemia cells	Significantly effective in protection of phototoxicity	Not mentioned	(Ong et al., 2009)
Chloroform extract of dried leaves	*In vitro*; Microculture tetrazolium salt assay (MTT)	Liver (HepG2) and Human breast (MCF-7) cancer cell lines	Henna was found to be cytotoxic to liver cancer cell line and hormone dependent breast cancer cell MCF-7 (IC_{50} = 0.3 and 24.85 μg/mL respectively)	Cytotoxicity was found to be mediated by the down regulation of c-myc expression	(Endrini et al., 2007)
Essential oil from leaf	*In vitro* cell cytotoxicity assay by MTT	Liver (HepG2), breast (MDA-MB-231, MCF-7) and colon (CaCO2), cell lines	Strong cytotoxicity on HepG2 (liver cancer) cells with an IC_{50} value of 24 μg /mL	High antioxidant activity speculated due presence of terpenoids like phytol and hexahydrofernysyl acetone.	(Rahmat et al., 2006)
80% ethanolic leaf extract	*In vivo* by Benzo (a) pyrene-induced forestomach and 7,12 dimethylbenz (a) anthracene-initiated and croton oil-promoted skin papillomagenesis in swiss albino mice	Skin cancer	Chemopreventive potential of henna was confirmed by significant inhibition of tumor burden and reduction of tumor incidence in both the model.	Selective activation of Phase-II and inhibition of phase I metabolic enzymes. Naphthaquinone is the major constituen of henna and might be involved in induction of DT-diaphorase.	(Dasgupta et al., 2003)

antigens). In two-stage mouse skin carcinogenesis model, tumour incidence was decreased by 66% and multiplicity by 40% in Mehndi/Henna powder treatment and decreased tumour incidence by 72% and multiplicity by 50% were reported using UV-B radiation for initiation and TPA for tumour promotion. The tumour inhibitory tendency was sustained during the 20-week test period. Similar antitumor activities were observed when Mehndi/Henna (0.5 mg/ml)

Table 1. Reported anticancer/cytotoxicity mechanism of *Lawsonia inermis* extracts, Lawsone and its derivatives *(continued)*.

Type of extract/compound	Model/method of study	Type of cancer	Result	Probable mechanism	References
Lawsone	*In vitro*; Inhibition of EBV-EA activation assay, and cell viability assay	Skin Cancer	Lawsone was found effective in reducing the effect of DMBA induced, TPA promoted mouse skin carcinogenesis. It also demonstrated chemopreventive potential against skin tumors induced by UV-B radiation, chemical carcinogen, DMBA and PON.	Inhibitor of TPA induced EBV-EA activation in cultures of Raji cells and suppress the tumor promotion.	(Kapadia et al., 2013)
	In vitro; Cytotoxicity assay on HCT-15 and flow cytometric anlysis	Colon cancer	IC_{50} = 12.5μg/mL was repored; anthraquinones with 2 or 3 OH groups were found to better than with no OH group	Inhibition of S-phase of cell cycle	(Kamei et al., 1998)
Furano-1, 2-naphthoquinone	*In vitro*; cell viability assay and flow cytometric detection	Lung cancer	Significant cytotoxicity of A549 cell and promote apoptosis	Cytotoxicity was mediated with the G2/M cell cycle arrest and apoptosis via inactivation of EGFR-mediated signaling pathway and up-regulation of Bax and down-regulation of Bcl-2	(Chien et al., 2010)
	In vitro; cell viability assay and flow cytometric detection	eukemia /*metabolter	Altered mitochondrial membrane potential, released of cytochrome C and activation of caspases 3 and 9.	Bring back apoptosis in Ca9-22 cells *via* inactivation of the EGF receptor	(Chien et al., 2010)
Atovaquone derivative	*In vitro*; MTT cytotoxicity assay on Du145 human prostate cancercell line	Prostate cancer	Showed significant cytotoxicity against and promote apoptosis in prostate cancer cell line	Tempted apoptosis via activation of pro-apoptotic caspases 9 and 3.	(Zhou et al., 2009)
Lapachol	Chick embryo chorioallantoic membrane model	Cervical cancer (HeLa cells)	At concentration of 400μg/ml, lapachol changes the protein profile and inhibited the invasiveness of HeLa cells in CAM model.	It reduces cancer metastasis in HeLa cells.	(Balassiano et al., 2005)
Dichloroallyl lawsone	Two-dimensional chromatographic procedure.	Mouse lymphocytic leukemia (L1210) cells	Powerful inhibitors of nucleotide bio-synthesis	It prohibited the conversion of UMP UDP by potent inhibition of dihydroorotate + orotat	(Kemp et al., 1986)

and lawsone (0.015 mg/ml) were applied topically on the back skin in the UV-B initiated/TPA promoted and peroxynitrite initiated/TPA promoted mouse skin carcinogenesis models (Kapadia et al., 2013).

A Case Study

Hand Foot Syndrome (HFS), the most frequent cutaneous adverse effect of capecitabine (a prodrug of 5-Florouracil) is manifested as acral erythema with swelling and dysesthesia of the palms and soles. It interferes significantly with normal daily activities of patients undergoing treatment with capecitabine. A breast cancer patient undergoing capecitabine treatment at the Department of Medical Oncology, Ondokuz Mayis University Medical School, Turkey complained about the presence of skin rashes on her feet but not in hands. Later she was diagnosed with HFS and it was observed that she had applied mehndi/henna on her hands which was an exciting case for the researchers. Following it as an example case, six patients with severe case of HFS were recommended to apply mehndi/henna on their hands. Astoundingly, after using mehndi/henna, whinges were reduced in 48 h and disappeared in one week (Yucel and Guzin, 2008).

CONCLUSIONS

Despite being used as a cosmetic agent in the Oriental regions of the world to dye hair and in body art, Mehndi/Henna holds several cytotoxic and chemopreventive agents in its possession. The present review recapitulates some important findings on the anticancer potential of Mehndi/Henna and to a great extent more work needs to be embark on to explore its novel target(s). Phytochemistry of Mehndi/Henna needs a broader study for the isolation of novel compounds and pharmacological studies on suitable models and clinically established cancer biomarkers will help to identify pioneering chemotherapeutic and/or chemopreventive agent. Future investigation on these aspects of Mehndi/Henna may offer great hope for the discovery of new anticancer agents from this miraculous plant.

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ABBREVIATIONS

AYUSH: Ayurveda, Yoga & Naturopathy, Unani, Sidha and Homeopathy Medicine; IC_{50}- 50 percent inhibitory concentration; GSH: Glutathione; SOD: Superoxide dismutase; DLA: Dalton lymphoma ascitis; WBC: White blood cells; ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; ALP: Alkaline phosphatise; LDH: Lactate dehydrogenase; Hb: Haemoglobin; RBC: Red blood cells; PCV: Packed cell volume; PON: Peroxynitrile.

Competing interests

The authors declare that they have no competing interests.

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