

Phytochemical analysis and effects of Haridra (*Curcuma longa*) on diabetes mellitus (Madhumeha)

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Abstract- Diabetes mellitus (Madhumeha) is a chronic metabolic disorder characterized by persistent hyperglycemia due to impaired insulin secretion, insulin action, or both. Traditional medicinal systems such as Ayurveda describe Haridra (*Curcuma longa* Linn.) as a drug with *Prameha-hara* (anti-diabetic) properties. Haridra is one of an important dravya described in Ayurveda. It is used clinically externally as well as internally for the treatment of variety of ailments. Haridra is most popular among Indian women to improve the texture and lustre of the skin. It is used in religious functions of Hindus since centuries. Drugs containing Tikta, Katu Rasa like Haridra, is specially indicated in the management of Prameha/Madhumeha. Acharya Vagbhata has praised it, as a drug of choice in the treatment of diabetes mellitus. Recently Turmeric has received a lot of attention from all section of scientific communities in the field of health care system and

pharma-ceutical industry, regarding its anti-diabetic, antioxidant, hepato-protective, anti-inflammatory, anti-carcinogenic and antimicrobial properties. The present research article focuses exclusively on preliminary phytochemical screening of *Curcuma longa* rhizome extracts, their qualitative testing, observed results, and discussion of how these phytochemicals contribute to anti-diabetic activity. The study highlights the relevance of phytochemical screening as a foundational step in identifying bioactive constituents responsible for anti-diabetic effects.

Introduction

Diabetes mellitus is a rapidly increasing global health problem associated with severe complications such as neuropathy, nephropathy, retinopathy, and cardiovascular disorders. In Ayurveda, Madhumeha is classified under *Prameha* and is associated with derangement of *Kapha* and *Vata* doshas along with impaired *Agni* and *Medo dhatu*

metabolism. Herbal drugs play a crucial role in the management of Madhumeha due to their multi-targeted action and fewer side effects.

Haridra (*Curcuma longa* Linn.), belonging to the family Zingiberaceae, is widely used as a spice and medicinal plant (Sharma, 2005; Srinivasan, 2007). Classical Ayurvedic texts describe Haridra as *Tikta* and *Katu rasa*, *Ruksha guna*, and *Ushna virya*, making it beneficial in metabolic disorders. Modern scientific studies attribute its pharmacological activities to the presence of diverse phytochemicals. Therefore, phytochemical screening of *Curcuma longa* extracts is essential to understand the basis of its anti-diabetic potential (Harborne, 1998; Kokate, 2010).

The Sanskrit word Haridra literally means the drug which improves the complexion of the skin. In India, it is popularly known as Haldi (turmeric). In Atharvaveda (Shaunakiya recession 1-22), it was mentioned that the food of rice pap mixed with turmeric should be given to a patient of Hariman (Yellowness/Jaundice). In Atharvaveda (Pipalada recession P.I. 16.1) four plants were mentioned, turmeric is one of them, named as Oshadhi. In Ayurvedic texts, its various synonyms describing its virtues like Kanchani -renders golden tinge to the skin, Nisha- beautiful like a starry night, Harita- yellow, Varavarni- imparts color to the skin etc. The great sage Charaka has categorized it under Lekhaneeya Varnya Vishaghna Kushthaghna.

Sushruta has classified it under Stanya Shodhaka Mahakashaya. Later on, many Ayurvedic texts have categorized it as Kandughna, Kamala nashaka, Shonita sthapana and Sirovirechana.

In the classical texts of Ayurveda (C.S. Ci.-6/26, 27, 38, 39, S.S. Ci.-6/20, 1118, 9, Su. 13/11, A.S. Ci. -14/12, 18, 25, A.H.D. -40/48), Haridra is clearly mentioned for the treatment of Prameha/Madhumeha alone or in combination with other preparations. Drugs containing Tikta, Katu Rasa like Haridra is specially prescribed in the management of Prameha/ Madhumeha. Acharya Vagbhata has described it as the drug of choice in the treatment of diabetes mellitus. A large number of synonyms were given in the lexicons of Indian Pharmacopoeia. These synonyms were based either on the pharmacological action of the drug or on its morphology.

Botanical description of Haridra

Common Name : Indian Saffron or Turmeric.

Botanical Name : *Curcuma longa*

Synonym : Curma domes.,

Family : Zingiberaceae

Flowering and Fruiting Time : from October to December

Propagation : Tubers of previous crop are planted 6-8 cm deep at distance of 30 to 40 cm in April August.

Useful parts : Rhizome and Some-time flowers.

Doses : Powder, 1-3 gm., Juice 10-20 ml

Phytochemical Analysis of *Curcuma longa*

The phytochemical screening of the *C. longa* rhizome extract showed the presence of several bioactive compounds including alkaloids, tannins, phenolic compounds, terpenoids, saponins, flavonoids, cardiac glycosides, and fixed oils / fatty acids. This remarkable phytochemical diversity contributes to the multitude of pharmacological activities and therapeutic potential associated with turmeric. Alkaloids are well known for their antimicrobial, analgesic, and antioxidant properties, play a crucial role in the traditional use of turmeric for treating various infectious diseases and inflammatory conditions. The presence of tannins and phenolic compounds, which exhibit potent antioxidant, anti-inflammatory, and antimutagenic effects, may contribute to the anticancer properties attributed to turmeric.

The **terpenoid** class, encompassing the curcuminoids (curcumin, demethoxycurcumin, and bisdemethoxycurcumin), has garnered significant attention for its anticancer, anti-inflammatory, and neuroprotective activities. These bioactive compounds may be responsible for the observed therapeutic effects of turmeric in various chronic diseases, including cancer, inflammatory disorders, and neurodegenerative conditions. **Saponins**, known for their ability to enhance immune function and exhibit hypocholesterolemic effects, may contribute to the traditional use of

turmeric in promoting overall health and well-being. **Flavonoids**, another class of polyphenolic compounds present in the extract, possess remarkable antioxidant, anti-inflammatory, and anticancer properties, further enhancing the therapeutic potential of turmeric.

The diverse phytochemical composition of *C. longa* rhizomes provides a strong scientific rationale for its widespread traditional use in various therapeutic applications and highlights the potential for further exploration and development of novel therapeutic agents derived from this plant source. The DPPH free radical scavenging assay is a widely accepted and reliable method for evaluating the antioxidant capacity of various compounds. In various studies, the *C. longa* rhizome extract exhibited a concentration-dependent increase in radical scavenging activity, reaching a maximum of around 81% at the highest concentration tested (3 mL). This potent antioxidant activity can be attributed to the unique chemical structure of curcumin, the principal bioactive compound present in the extract.

Curcumin's remarkable antioxidant potential is attributed to its ability to donate hydrogen atoms and electrons efficiently, thereby neutralizing free radicals and reactive oxygen species (ROS). The presence of methoxy, phenoxy, and carbon-carbon double bonds in the curcumin molecule facilitates this process, enabling the formation of relatively stable

phenoxy radicals and preventing further oxidative damage to cellular components. Additionally, curcumin has been reported to chelate metal ions, which can catalyze the formation of free radicals through the Fenton reaction. By sequestering these metal ions, curcumin prevents the generation of harmful free radicals, further contributing to its overall antioxidant activity. Moreover, curcumin exhibits indirect antioxidant mechanisms by modulating the activity of transcription factors like nuclear factor erythroid 2-related factor 2 (Nrf2). Nrf2 regulates the expression of various antioxidant enzymes, including superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx). By activating the Nrf2 signaling pathway, curcumin can enhance the levels of these enzymes, thereby strengthening the body's endogenous antioxidant defense system against oxidative stress.

The phytochemical constituents present in the methanolic extract were more in number than that of ethanolic extract which may be due to more extracting capacity of some specific phytochemicals like phenol, phlobatannin etc. In various studies, phytochemical constituents alkaloids, steroids, tannins, saponins, flavonoids, phenol, carbohydrates, cardiac glycosides, phytosterol, protein, anthocyanin, coumarin, emodins, diterpenes, amino acids, phlobatannin, leucoanthocyanin, anthraquinone, chalcones, terpenoids were analysed. In the methanolic

extract saponin, protein and amino acids, coumarin and phlobatannin were absent. In the ethanolic extract phenol, phlobatannin, protein, amino acids, coumarin and diterpenes were absent.

Ayurvedic Pharmacodynamics of Haridra

Rasa : Tikta, Katu-bitter and pungent.

Guna : Ruksha, Laghu

Veerya : Ushna

Vipaka : Katu

Prabhava : anti-diabetic, anti-dermatitis, digestant and haemopoietic.

Dosha Karma: Kapha Vatahara and Pitta shamaka.

Haridra in Ayurvedic Classics

In **Charaka Samhita** it is mentioned in Lekhneeya, Kushthaghna and Vishaghna Mahakashayas. It is indicated in for the treatment of Prameha, Kushtha, Pandu, Shotha, Krimi etc. It is enumerated in Tiktakandha and Shirovirechana Dravyas. In Cikitsasthana it is used for Samshodhana before taking Rasayana and as an ingredient of Brahma Rasayana and other Rasayana yogas in Prameha, Kushtha, Mahakushtha etc. It is frequently prescribed in Vishadosha Chikitsa, internally as well as externally. It is also used for Vamana and Virechana in combination with other drugs and as an ingredient of Anuvasna- Vasti.

In **Sushruta Samhita** it is mentioned in Haridradi gana, Mustadi gana, Lakshadi gana and Vidaryadi gana. In

vata sanshamana Varga and Kapha shamana Varga and in Tikta Varga. It promotes Àrogya, Bala, Medha and Ayu of infants. It is indicated in Prameha and also in Asthapana vasti. It is also used as Rasayana and also in the management of Sthavara and Jangama visha etc.

In **Ashtanga Sangraha** it is described as the best drug among Prameha hara Dravyas, (Haridra Pramehaharanam A.S.Su. 13/3). It is mentioned in Tikta skandha and is described as Katu, Tikta, Meha nashaka etc. It is mentioned in Lekhaneeya and Kushthaghana gaṇas, in Haridradi and Mustadigana. It is an ingredient of Atisthauyahara

Yogas, Vishanashaka Yogas. It is also used in Vaman Kalpa and in disease like Jvara, Raktapitta, Prameha, Pandu, and Kamala etc. It is an ingredient of Brahma Rasayana and other Rasayana yogas.

In **Ashtanga Hridaya** it is mentioned in Tiktavarga, Kaphanashaka varga, Haridradi gana and Mustadigana. It is used in Vishashamaka yoga, Atisthauyahara yoga and Dhooma-Dravyas. It is prescribed in Prameha and externally used in Vidradhi. It is regarded as the best drug in treating Prameha along with Amalaka, (“Meheshu Dhattrinise “(A.H. U. 40/48).

Table-1 Therapeutic Indications of Haridra in Ayurvedic text

Clinical conditions		Modern correlate	Textual References
1.	Prameha	Urinary Disorder and Diabetes	C.S. Ci.-6/26, S.S. Ci.-6/17-20, K.N., B.P.N., R.N., D.N.
2.	Tvagvikara	Skin Diseases	K.N., C.S. Ci. 12/39.
3.	Arsharoga	Haemorrhoids	C.S. Ci.-14/52, B.P. 5/57
4.	Bhagandra	Fistula in ano	B.P.-50/31, C.D.- 46/26
5.	Pandu	Anemia	K.N., B.D.N., C.D., C.S. Ci. 6/53
6.	Visha	Allergy	K.N., D.N., G.N., 6/3/11, C.S. Su. 4
7.	Vrana	Ulcers	K.N., R.N., B.P.N., D.N.
8.	Ashmari	Urinary calculus	Vangasena Aśmarī-48, B.P.-37/48
9.	Kamala	Jaundice	C.S. Ci.-16/53, A.V.S. 1.22, A.H. Ci. 16/44
10.	Shleepada	Filariasis	C.D.-42/12, B.P.-45/14, V.M.-42/14
11.	Vatavyadhi	Neuropathies	V.D. -12-2/15
12.	Kasa	Cough	S.B.M.- 4/393.
13.	Mashurika	Chickenpox	C.D.- 45/9
14.	Vyanga	Chloasma	R.R.S.- 24/45
15.	Visarpa	Anthrax/Erysipelas	C.D.- 55/139, V.M.- 57/97
16.	Stanapeeda	Pain in the breast	B.P.- 70/74
17.	Medoroga	Obesity	B.P.- 39/72
18.	Chippa and Kunakha	Infection of nails	B.P.- 61/75, V.M.- 27/18
19.	Netrabhishyanda	Conjunctivitis	C.D.- 59/58
20.	Arbuda Apachi	Tumors	K.N., C.D.- 41/60

21.	Shwasa Kasa Hikka	Dyspnoea, cough, Hiccough	S.B.M.- 4/375, 376
22.	Nadi vrana	Sinus	B.R.- 50/3
23.	Atisara	Diarrhoea	A.H.Su.-15/35
24.	Peenasa	Rhinitis	D.N.-Guduchyadi Varga -54, 55,56
25.	Vatarakta	Gout	B.P. Ci. - 29-79.
26.	Pama	Scabies	C.D.- 50/47

Pharmacological Studies on Haridra

Extensive pharmacological investigations on *Haridra* (*Curcuma longa*) and its active constituents—primarily **curcumin**, **turmerin**, and **tetrahydrocurcuminoids (THC)**—demonstrate a wide spectrum of biological activities validated through **in vitro**, **in vivo**, and some **clinical studies**.

Antioxidant Activity

- Curcumin, turmerin, and tetrahydrocurcuminoids exhibit **strong antioxidant properties**, effectively inhibiting lipid peroxidation and protecting DNA and cellular membranes.
- Turmerin showed up to **80% protection** against oxidative injury without cytotoxicity.
- THC demonstrated stronger antioxidant effects than curcumin, enhancing endogenous antioxidant enzymes (SOD, catalase, GPx, glutathione).

Anti-inflammatory and Anti-spasmodic Effects

- Curcumin and its analogues significantly reduced inflammation by

inhibiting edema in experimental models.

- Certain curcuminoids (demethoxycurcumin, bisdemethoxycurcumin) showed **stronger anti-inflammatory activity** than curcumin.
- Curcumin exhibited **spasmolytic**, depressant, and transient hypotensive effects.

Anti-diabetic and Metabolic Effects

- Curcumin and THC significantly reduced **blood glucose**, **glycosylated hemoglobin**, and improved **insulin levels** in diabetic animal models.
- Restoration of carbohydrate metabolic enzymes and normalization of gluconeogenesis were observed.
- Activation of **PPAR- γ** by curcuminoids and sesquiterpenoids contributes to hypoglycemic action.
- Protective effects against **diabetic complications** such as nephropathy, cataract, oxidative stress, and impaired wound healing were demonstrated.

Antimicrobial, Antiviral, and Anticancer Properties

- Exhibited **antibacterial activity**, though weaker than standard antibiotics.

- Curcumin showed **cytotoxic effects** against lymphoma cells and growth inhibition in cell cultures.
- Demonstrated **antiviral activity**, including trials in AIDS patients.
- Neuroprotective and anti-amyloid effects (e.g., Calebin-A) suggest potential in neurodegenerative disorders.

Material and Methods

Plant Material and Preparation of Extracts

Fresh rhizomes of *Curcuma longa* were collected, authenticated, washed, shade-dried, and coarsely powdered. The powdered material was subjected to extraction using different solvents such as aqueous, ethanol, and methanol to obtain crude extracts. The extracts were concentrated and stored in airtight containers for phytochemical analysis.

Relationship of Phytochemical Screening of Haridra (*Curcuma longa*) with Anti-Diabetic Activity

Phytochemical screening of Haridra (*Curcuma longa* Linn.) reveals the presence of several bioactive secondary metabolites such as flavonoids, phenolic compounds, alkaloids, terpenoids, saponins, glycosides, and steroids (Harborne, 1998; Kokate, 2010). These phytochemicals are reported to play a significant role in the management of diabetes mellitus through multiple biochemical and physiological mechanisms.

Flavonoids and phenolic compounds exhibit strong antioxidant activity, which is particularly important in diabetes mellitus, where oxidative stress leads to pancreatic β -cell dysfunction and insulin resistance (Srinivasan, 2007; Kumar et al., 2017). By scavenging free radicals, these compounds protect pancreatic β -cells and improve insulin sensitivity, thereby helping in the regulation of blood glucose levels.

Alkaloids identified during phytochemical screening are known to enhance insulin secretion from pancreatic β -cells and inhibit carbohydrate-digesting enzymes such as α -amylase and α -glucosidase, leading to reduced intestinal glucose absorption and better post-prandial glycemic control (Kumar et al., 2017).

Terpenoids and steroids present in turmeric contribute to anti-diabetic activity by improving lipid metabolism, reducing insulin resistance, and enhancing glucose uptake in peripheral tissues (Srinivasan, 2007). These effects are crucial in type 2 diabetes mellitus, where dyslipidemia and insulin resistance are common pathological features. Saponins play a vital role in delaying glucose absorption from the gastrointestinal tract and improving glucose utilization, which helps in lowering hyperglycemia (Pandey and Tripathi, 2014). Glycosides detected in Haridra extracts have also been reported to exhibit hypoglycemic activity by modulating hepatic glucose production and improving insulin action (Kumar et al., 2017).

Thus, phytochemical screening is an important tool in anti-diabetic research as it helps identify the presence of bioactive compounds responsible for glucose-lowering, antioxidant, and insulin-sensitizing effects. The synergistic action of these phytochemicals provides scientific validation for the traditional Ayurvedic use of Haridra in the management of Madhumeha (Sharma, 2005).

Experimental Procedure for Phytochemical Screening

Each extract (aqueous, ethanolic, and methanolic) was subjected to individual qualitative chemical tests using standard protocols described in pharmacognosy literature (Harborne, 1998; Kokate, 2010). About 1–2 mL of each extract was taken in clean test tubes and treated with specific reagents for the detection of different phytochemical groups.

For alkaloids, the extract was acidified with dilute hydrochloric acid and treated separately with Mayer's and Wagner's reagents; the formation of a cream or reddish-brown precipitate indicated a positive result, as described by Harborne (1998). Flavonoids were identified by the appearance of a pink or red coloration upon addition of magnesium turnings followed by concentrated hydrochloric acid (Shinoda test), according to standard procedures outlined by Kokate (2010).

Phenolic compounds and tannins were detected by the development of a blue-green or dark coloration upon addition of ferric chloride solution, following the method suggested by Harborne (1998). Saponins were identified by persistent froth formation after vigorous shaking of the aqueous extract, as reported by Pandey and Tripathi (2014). Glycosides were tested using Keller–Killiani reaction, where a brown ring at the interface indicated the presence of cardiac glycosides (Kokate, 2010).

Terpenoids were confirmed by the formation of a reddish-brown coloration in the Salkowski test, while steroids were identified by a green or bluish coloration in the Liebermann–Burchard test, following standard phytochemical methods (Harborne, 1998; Pandey and Tripathi, 2014). Carbohydrates were detected by the appearance of a violet ring at the junction of two liquids in Molisch's test (Kokate, 2010).

All experiments were carried out in triplicate to ensure reproducibility, and observations were recorded carefully based on visible color changes or precipitate formation.

Results

The preliminary phytochemical screening of *Curcuma longa* rhizome extracts revealed the presence of several bioactive constituents. The results are summarized in **Table-2**.

Table-2 Extraction of phytochemical screening of *Curcuma longa* rhizome

Phytochemical Constituents	Aqueous Extract	Ethanollic Extract	Methanolic Extract
Alkaloids	+	+	+
Flavonoids	+	+	+
Phenols & Tannins	+	+	+
Saponins	+	-	-
Glycosides	-	+	+
Terpenoids	+	+	+
Steroids	-	+	+
Carbohydrates	+	+	+

(+ = Present, - = Absent)

Discussion

Phytochemical screening serves as a crucial preliminary step in identifying bioactive compounds responsible for therapeutic effects (Harborne, 1998; Pandey and Tripathi, 2014). The presence of flavonoids, phenolic compounds, alkaloids, terpenoids, and glycosides in *Curcuma longa* extracts strongly supports its traditional use in diabetes mellitus.

Flavonoids and phenolic compounds are well-known for their antioxidant properties, which play a significant role in reducing oxidative stress-induced pancreatic β -cell damage in diabetes (Kumar et al., 2017; Srinivasan, 2007). These compounds also improve insulin sensitivity and glucose uptake in peripheral tissues. Alkaloids are reported to enhance insulin secretion and modulate carbohydrate metabolism enzymes (Kumar et al., 2017).

Terpenoids and steroids contribute to anti-diabetic activity by improving lipid metabolism, reducing insulin resistance,

and protecting pancreatic tissue (Srinivasan, 2007). Saponins are known to inhibit intestinal glucose absorption and delay carbohydrate digestion, thereby controlling postprandial hyperglycemia (Kumar et al., 2017).

The synergistic action of these phytochemicals explains the multi-targeted anti-diabetic potential of *Curcuma longa* in Madhumeha.

Conclusion

The present study confirms that *Curcuma longa* rhizome contains diverse phytochemical constituents with proven relevance to diabetes management (Srinivasan, 2007; Sharma, 2005). Preliminary phytochemical screening reveals the presence of flavonoids, phenols, alkaloids, terpenoids, glycosides, and saponins, all of which contribute to anti-diabetic activity through antioxidant, insulin-sensitizing, and glucose-lowering mechanisms. Phyto-chemical screening thus provides a scientific basis for the traditional use of Haridra in Madhumeha

and forms a foundation for further anti-diabetic research using herbal extracts.

Haridra is an Ayurvedic classical drug having various pharmacological actions and it is used in the treatment of variety of physical and mental disorders since antiquity. In recent year Haridra has received a lot of attention from all the scientific communities in the field of health care system and pharmaceutical industry and to do extensive research, regarding its anti-diabetic, antioxidant, hepato-protective, anti-inflammatory, anti-carcinogenic and antimicrobial properties.

Disclaimer Statement

Authors declare that no competing interest exists. The products used for this research are commonly used products in research. There is no conflict of interest between authors and producers of the product.

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