



# **Pharmacognostic Properties of *Quisqualis indica* Linn: Against Human Pathogenic Microorganisms: An Insight Review**

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. Author BSB is working as a Junior Research Fellow in this project. He was involved in searching literature and has written the review. Author SD has carefully checked the manuscript. Author TH compiled and edited the article throughout all stages. All authors read and approved the final manuscript.*

## **Article Information**

DOI: 10.9734/EJMP/2020/v31i2030369

### Editor(s):

- (1) Dr. Paola Angelini, University of Perugia, Italy.  
(2) Prof. Marcello Iriti, University of Milan, Italy.

### Reviewers:

- (1) Borgonovo Gigliola, University of Milan, Italy.  
(2) Erisnaldo Francisco Reis, Unifaveni Dom Alberto, Brazil.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/66214>

**Review Article**

**Received 22 October 2020**  
**Accepted 28 December 2020**  
**Published 31 December 2020**

## **ABSTRACT**

India has a large repository of medicinal plants that are used in traditional medical treatments. Several medicinal plants are useful for treating common ailments and some of the plants include Amla (*Emblica cinalis*), Ashoka (*Saraca asoca*), Aswagandha (*Withania somnifera*), Tulsi (*Ocimum sanctum*), Sarpa Gandha (*Rauwolfia serpentina*), Sandalwood (*Santalum album*), Indian birthwort (*Aristolochia indica* L.), Brahmi (*Bacopa monnieri*), Neem (*Azadirachta indica*), Vringraj (*Eclipta alba*), Ghrhit kumara (*Aloe vera*), Harida (*Terminalia chebula*) and Madhumalati (*Quisqualis indica*), Catnip (*Nepeta cataria*), Cayenne pepper (*Capsicum annum*), Sage (*Salvia officinalis*); etc. *Quisqualis indica* commonly known as the Madhu Malati, is a vine with red flower clusters and is found in abundance in India. It shows a wide range of remarkable medicinal properties. Over the last two decades, large scale research has been conducted to identify bio-active constituents of *Quisqualis indica* therapeutic prospects. This review summarizes the pharmacognostic properties of *Quisqualis indica* Linn. Against human pathogenic microorganisms. Several authors have reviewed the medicinal properties of *Quisqualis indica* Linn. but our review summarizes the anti-

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bacterial, anti-inflammatory, anti-oxidant, anti-pyretic, anti-helminthic, anti-diarrheal, anti-hyperglycemic, anti-microbial, anti-fungal and immuno-modulatory properties. It would be useful to students, academicians, microbiologists, as it reduces the need for detailed searching. It serves the purpose of quick reference.

**Keywords:** *Pharmacognostic properties; Quisqualis indica Linn; human pathogenic microorganisms; review.*

## 1. INTRODUCTION

India is one of the prosperous countries in the world in terms of bio-diversity having 15 agro-meteorological zones.

It is estimated that there are around 17,000-18,000 species of flowering plants and about 7000 are being used in folk and documented alternative medicinal therapy namely Ayurveda, Yoga, Unani, Siddha and Homoeopathy (AYUSH System of Medicine).

Medicinal plants are found from Himalayan to marine regions and desert to rain forest ecosystems. These plants provide livelihood and health security to a large section of Indian population and also are a major means of resource for the herbal and traditional medicine production/ manufacturing unit [1]. Due to vast diversity of plant species around the world, the crude herb extract has long been sustained as basic of herbal medicine [2].

Majority of the healers/practitioners of the traditional systems of medicine prepare formulations by their own procedure and disburse to the patients. About 70 percent of rural community in India, depends on the traditional medicines whereas around 40 percent of people in the Western countries, use the herbal medicine as a therapy for the various diseases. Increased adverse reactions, side effects and high cost of the modern medicines are some of the factors that have led to the increased enthusiasm in traditional medicines. Several governmental agencies are encouraging the researchers to develop plant based drugs for treatment of various medical conditions. Majority of rural people in developing as well as developed countries use these medicines for their basic health care where modern medicines are used predominantly [3,4].

Meanwhile countries with community based ancient understanding of medicinal plants and its products, heterogeneity existed with the character and content of the drug diverge in to

traditional Chinese medicine (TCM), traditional Japanese medicine (kampo), Korean Chinese medicine, jamu (Indonesia), phyto-therapy and homeopathy in Europe, Ayurveda in India and alternative medicines in America [5,6,7].

Traditional medicine, as defined by the World Health Organization, is the entirety of the information, expertise, patterns based on the theories, beliefs and experiences native to different civilizations whether comprehensible or not, used in the up keep of health as well as in the prohibition, detection, recovery or therapy of physical disability and mental disorders.

The alternative medicines in the traditional systems are derived from herbs, inorganic and biological matter while for the preparation of herbal drugs, plants of medicinal values are used. In India, plants have been used since ancient times as medicine and an important component of the health care system.

Traditional therapeutic medicine, phytomedicine, biological medicine or herbal medicine all defines the plant having medicinal properties which are the only source used to treat diseases in ancient time and act as the backbone of traditional medicine [8].

Phytochemical is defined as the biological active compound obtains from different parts of the plant that play a role in plant growth or defense against antagonist, micro-organisms or predators. Phytochemical practicing continuing today because of its biomedical property, traditional believes among the people, increasing cost of brand name drug and different aftermath of allopathy drugs [9, 10]. Over past 100 years, the use of chemically synthesized drugs had a great impact on health care system around the world. Industrialization in developed country and the process of treating illness on short span made synthetic drug prior to traditional drugs in last two decades. In developing countries, 50-60% of traditional medicines are used. The low per capita index, slower economic growth, affordable price of herbal medicines, adverse

side effects of synthetic drugs, more often correlate with the patient's belief, reassure a preference for more personalized health care and allowing greater social approach to health information, when traditional medicine is inefficient in the treatment of diseases such as advanced cancer and infectious diseases are some of the reasons for using traditional medicine over synthetic one.

The plant and their secondary metabolite for therapeutic use have a long ancestral history in both traditional and modern medicines. A study conducted by National Center for Biotechnology information on 2015 along with World Health Organization (WHO) reported that worldwide, 50% to 60% people depend on herbal materials for better treatment. The consumer's expenses on herbal supplements increased to a high of USD 7.452 billion in 2016. WHO emphasizes the need to spot medicinal plants with newer, cheaper and better agents [11].

The Global Herbal Medicine Market [12], by category, is segregated into 4 categories namely Herbal pharmaceuticals, Herbal dietary supplements, Herbal functional foods and Herbal beauty products. Among the above categories the herbal pharmaceutical section led the market with USD 50,972.4 million in 2017 which is about 36.95% of market share.

With regard to form, the global herbal medicine market is segmented into 5 types namely extracts, powders, capsules, tablets and syrups.

With regard to source, the global herbal medicine market is segmented into 6 classes namely leaves, fruit, roots, barks, whole plant and others (combinations of various plant parts). Among the sources, the leaves section led the global herbal medicine market with a share of USD 51,495.2 million in 2017. A data shared by govt. of India during the period of 2015-2016, value added products of cost \$358.60 million, which was 0.5% of the global herbal market export by AYUSH.

Due to the adverse effects of synthetic drug and efficacy of traditional medicine in treating chronic diseases with fewer side effects focused is being on the plant descended products. In last two decades, the consumption of herbal medicine boost consistently throughout the world as an auxiliary treatment for other health problems like heart diseases, diabetes, cancer and other persistent illness. The use of plant derived

product which contain many secondary metabolite and others phytochemical with low cost extraction lay the groundwork of prominence research uncovering plant derived chemicals. With increasing multi-drug resistance and anti-microbial resistance around the globe, the plant extract incorporate with modern technique slowly but surely fabricate its footprint in revolutionizing the aspect of modern medicine.

Medicinal plants are useful to keep on hand treating common ailments and some of the plants include Amla (*Embllica cinalis*), Ashok (*Saraca asoca*), Aswagandha (*Withania somnifera*), Tulsi (*Ocimum sanctum*), Sarpa Gandha (*Rauwolfia serpentina*), Sandalwood (*Santalum album*), Indian birthwort (*Aristolochia indica L.*), Brahmi (*Bacopa monnieri*), Neem (*Azardirchata indica*), Vringraj (*Eclipta alba*), Ghrhit kumara (*Aloe vera*), Harida (*Terminalia chebula*) and Madhumalati (*Quisqualisindica*), Catnip (*Nepeta cataria*), Cayenne pepper (*Capsicum annum*), Sage (*Salvia officinalis*), etc.

Among all of these plants, *Quisqualis indica* shows a wide range of remarkable medicinal potential. Over the last two decades, large scale research has been conducted to identify bio-active constituents of *Quisqualis indica* therapeutic prospects.

*Quisqualis indica* is found in gardens, bushes or secondary forests of the Philippines, India and Malaysia more commonly in the Asian continent. It is a creeper with bunch of red flowers and famously known as the *Combretum indicum*, Rangoon Creeper and Chinese honeysuckle. Other names for the plant include *Quiscual* (in Spanish), *Niyog-niyogan* (in Filipino of family *Combretaceae* or *Terminalia*, Regionally known as Marathi - Madhu Malati and Vilayati chambeli, Rangunachavel, Hindi - Madhumalti and Rangoon-ki-bel, Bengali - Modhumalati and Sandhyamalati, Gujarati - Barmasinivel, Kannada - Rangoon Kempumalle, Punjabi - Lal Malti, Tamil - Irangunmalati, Telugu - Radha Manoharam and Ettaguttilativva, Manipuri - Parijat, Filipino - Niyog-niyogan, Spanish - Quiscual and China - Shih-chun-tzu. The Rangoon Creeper is a ligneous creeper cultivated as an ornamental plant growing from 2.5 meters to up to 8 meters. The leaves are elliptical with opposite arrangement grow from 7 to 15 centimeters. The fragrant star shaped flowers are tubular and their color appears white at night and turns pale pink to red at day break.



Fig. 1. Shows the leaves and flowers of *Quisqualis indica* L

## 2. PLANT PROFILE

Kingdom : Plantae  
 Division : Mangoliophyta  
 Class : Mangoliophyta  
 Order : Myrtales  
 Family : Combretaceae  
 Genus : Quisqualis  
 Species : *Quisqualis indica*

### 2.1 Cultivation and Collections

This evergreen plant has vigorous growth requiring strong support and grows abundantly on favorable conditions as it does not require deep and embedding roots. It needs an area with sunlight, regular watering and afternoon shade to keep the soil moist and a support stand for the creeper to grow on. The scarlet Rangoon creeper is a common, popular, ornamental garden climber grown in the tropics is indigenous to Africa. This creeper is often found as a hedge plant covering boundary walls. It can sustain itself in well draining and pH adaptable soil conditions.

### 2.2 Habitat and Distribution

Although native to tropical Asia continent, i.e., Bangladesh, India, China, Malaysia, Philippines

and Thailand but nowadays, it is widely cultivated throughout the tropics and subtropics, mainly as an ornamental plant.

### 2.3 Dendrological Characteristics and Identification Features

This ligneous vine with few varieties can be distinguishable by the colour of flower and size of the leaves. The plant can reach up to 9 m in general but can reach up to 21 m in the wild. The flower with 5-7 petals, terminal or axillary inflorescences, simple and often compound spikes blooms in bunches, especially in the summer season. The leaves ranges from 7 to 15 cm are elliptical with opposite arrangement, a rounded base and an acuminate tip. The fruit of this plant is nearly ellipsoidal, 2.5-3 cm long with 5 sharp, longitudinal angles or wings. [13,14,15].

### 2.4 Microscopic Characteristics

Mayank et al (2018) analyzed the microscopic characteristics of upper epidermis, lower epidermis, parenchymatous cell, colenchymatous cell trichomes, xylem and phloem [16]. Physiochemical analysis and quantitative microscopy of leaves are shown in Table 1 and Table 2.

Table 1. Quantitative microscopy of leaves of *Quisqualis indica*

Parameters	Results
Vein islet number (1 mm <sup>2</sup> leaf surface)	26.4
Vein termination number (1 mm <sup>2</sup> leaf surface)	52.4
Stomatal number (1 mm <sup>2</sup> leaf surface on lower epidermis)	96.32
Stomatal number (1 mm <sup>2</sup> leaf surface on upper epidermis)	70.45
Stomatal index	23.8
Palisade ratio	4.36

**Table 2. Physiochemical analysis of leaves of *Q.indica***

Parameters	Results
Total ash	7.84
Water soluble ash	3.4
Acid-insoluble ash	1.2
Water extractive value	60.1
Ethanol extractive value	19.9
Loss on drying	7.8
Swelling index	2.4
Foaming index	<100

### 2.4.1 Analytical analysis and methods used for bioactive compounds extraction isolation and purification

#### 2.4.1.1 Extraction of plant material

The powder material of different parts of the plant was subjected for extraction using Soxhlet apparatus with various solvents based on polarity for about 24hr. as per protocol of Sashidharn et al (2011) [17]. The percent yield of various extracts was calculated by the following formula:

Percentage yield = Weight of extract (g) / Weight of dry powder (G) × 100

#### 2.4.2 Isolation and purification

Based on chromatographic technique the isolation and purification of plant products were carried out by one or combination of several fractional procedures. The most useful technique in phytochemical isolation includes thin layer chromatography (TLC), column chromatography (CC), gas chromatography- mass spectroscopy (GC-MS), and high-performance thin-layer chromatography (HPTLC).

### 2.5 Column Chromatography

An analytical technique which is used for separating molecular mixture based on affinities of the solute between the two immiscible phases.

As the compounds moves through the column at different rate which allow them to separate according to their adsorption capacity for the adsorbent present in stationary phase. Bairagi et al (2012) performed column chromatography to isolate the phytoconstituents from the petroleum extract of leaves and flower of *Q.indica* for triterpenoids and methanolic extract for flavonoids and tannins [18].

#### 2.5.1 High-performance thin layer chromatography

Based on the classical principle of Thin-layer chromatography (TLC) / adsorption chromatography, an extension to TLC is High-performance Liquid Chromatography (HPTLC). Thin layer and smaller particle size significantly increases detection sensitivity and analysis speed. HPTLC can estimate the concentration of component although TLC can only separate components. Mayank et al. (2018) and team performed HPTLC for urosolic acid and lupeol with toluene: ethyl acetate: formic acid (8: 2: 0.1) v/v/v solvent system on methanolic extract of *Q.indica* and found that the amount of Lupeol was found to be 0.011% while Urosolic acid was 0.018% [16]. In accordance with eluting power of solvent with polarity different type of solvent system used in HPTLC for analyzing diverse phytochemicals shown in Table 3.

**Table 3. Shows different Solvent System for Thin-layer Chromatography (TLC)**

Extract	Solvent System/Mobile Phase
Methanol	Chloroform: Methanol: Petroleum Ether ( 9.7 : 0.2 : 0.1 ) Toluene: Ethyl acetate: Formic acid (8:2:0.1)
Methanol (leaf)	Toluene : Ethyl Acetate : Formic Acid (2.5: 1 : 1) Ethyl Acetate : Methanol : Water : Toluene (10 : 1.5 : 1.3 : 2)
Methanol (flower)	Toluene : Ethyl Acetate : Formic Acid (2.5 : 1 : 1) Ethyl Acetate : Methanol : Water : Toluene (10 : 1.5 : 1.3 : 2)
Chloroform	Chloroform : Methanol (9.8 : 0.2)
Ethanol	Chloroform : Methanol : Water (9.5 : 0.4 : 0.1)
Petroleum ether(leaf)	Petroleum Ether : Ethyl Acetate (8 : 2)
Petroleum ether (flower)	Petroleum Ether : Ethyl Acetate (8 : 2)

## 2.5.2 Detection of phytochemicals

### 2.5.2.1 Fourier-transform infrared Spectroscopy (FTIR)

A vibrational technique that measures the absorbance, transmittance and reflectance of infrared radiation for identifying chemicals that is either organic or inorganic. It is based on the interaction between electromagnetic radiation and natural vibration of the chemical bonds among atom that compose the matter [18,19]. Sutar et al (2020) performed characterization of isolated compounds by spectral data based on frequency of absorption and found different spectra of isolated compound. Peak observed at around 3000-3700  $\text{cm}^{-1}$  is due to O-H stretching vibrations of the peptide linkage. Peak observed at 2700  $\text{cm}^{-1}$  and at 3300  $\text{cm}^{-1}$  is due to asymmetric C-H stretching vibrations, and peak centered at 1200 - 1500  $\text{cm}^{-1}$  indicates the presence of proteins and it typically indicates the presence of O-H bends of poly peptide linkage. Band observed at 900-1300  $\text{cm}^{-1}$  corresponds to the C-O stretching mode. At around 800-830  $\text{cm}^{-1}$  peak is due to the presence of C-H bend out of plane [20].

### 2.5.2.2 Gas chromatography- mass spectroscopy (GC-MS) analysis

A combination of two analytical techniques that combine the feature of gas chromatography (GS) used to separate volatile and semi-volatile

compound with great resolution and mass spectroscopy (MS) gives details structural information so that they can be exactly identified and quantified according their mass-to-charge (M/Z) ratio.

Mass-to-charge ratio (M/Z) = Mass of Cation / Charge of cation

Agarwal et al (2017) performed GC-MS analysis using aerial part of *Q.indica* with methanol, ethyl acetate and hexane extracts and found various compounds as shown in Table 4 [21].

### 2.5.2.3 Phytochemical screening, phytochemical analysis and quantitative microscopy

Depending upon the nature of the solvent, compound will travel different distance on plate. A good solvent system is one that moves all component of the mixture off the base line, but does not put anything on the solvent front. Most of the polar compound will not move in non-polar solvent. In contrast, polar solvent will usually move non-polar compound to the solvent front and push the polar compound off of the base line. Polar and Non-polar solvent extracts of leaves, flowers, aerial parts, roots and shoots of *Q. indica* recorded presence of different types of phytochemicals with preliminary screening tests and with different solvent extract, which would be useful in the detection of bioactive principle in drug discovery as shown in Table 5, Table 6, Table 7 and Table 8.

**Table 4. Shows the detected phytochemicals in different solvent extract of *Q. indica***

Compounds		
Methanol extract	Ethylacetate extract	Hexane extract
Diethylphthalate	Dodecane	Pentadecane
Isobutyl-o-phthalate	Heptadecane	Famesene
Methyl isohexadecanoate	Famesene	Famesane
Methyl Linolelaidate	Phytol	6-methyl octadecane
Phytol	Octacosane	Heptadecane
Methyl tetradecanoate, 12-Me	Trans squalene	Methyl hexadecanoate
7,10,13-Hexadecatrienal	Pentatriacotane	Methyl palmitate
Trans Squalene	Gama-tocopherol	Methyl linolate
1-Dotriacontanol	Tetratetraacotane	Phytol
Nerolidol isomer	Viamin E Acetate	Methyl stearate
Tocopherol	Stigmasterol	Octacosane
Viamin E Acetate	Heptacosane-1-chloro	Pentatriacotane
Stigmasterol		Stigmasterol
Viridiforol		Viamin E Acetate
Cycloartenyl Acetate		Tetratetraacotane
		Gama-tocopherol
		Trans Squalene

**Table 5. Shows the active constituents present in the parts of *Quisqualis indica* Linn**

S.No.	Parts of the plant	Secondary metabolite or phytochemicals
1	Flower	Alkaloids, Phenols, Flavonoids, Saponins, Tannins
2	Leaf	Torpenoids, Flavonoids, Saponins, Tannins, Alkaloids
3	Root	Cardiac glycosides, Reducing Sugars, Torpenoids, Flavonoids, Saponins, Tannins, Alkaloids
4	Stem	Cardiac glycosides, Reducing Sugars, Torpenoids, Flavonoids, Saponins, Tannins, Alkaloids

**Table 6. Shows the preliminary screening tests for the detection of phytochemicals**

Phytochemicals	Name of test
Alkaloids	Mayer's Test
	Drangendroff's Test
	Hager's Test
	Wagner's Test
	Molisch's Test
Carbohydrates Reducing sugar	Fehling's Test
	Benedict's Test
	Foam Test
Saponin	Forth Test
Phytosteroids	Salkowski Test
	LibermannBurchard's Test
Phenols	Ferric Chloride Test
	Lead Acetate Test
Tannins	Ferric Chloride
	Lead Acetate Test
Flavonoids	Alkaline Reagent Test
	Killer-Kallani Test
	Millon's Test
Cardiac glycosides	Ninhydrin Test
	Salkowski Test
Protein & amino acids	Sport Test
	Saponification Test
	Ruthium Red Solution
Gum & mucilges	

#### 2.5.2.4 Diversification of phytochemical properties through pharmacognostical studies

Phytochemicals extracted from different parts of the plant individually or mixed with other ingredients as remedy to different ailments like anti-flatulence, coughs, diarrhea, body pains, anthelmintic, toothache, stomach pain, cold, skin parasites, and rickettsia and cardiovascular system. The seeds of *Quisqualis indica* and its related species, *Quisqualis fructus* and *Q. chinensis*, have a compound, quisqualic acid, which is linked to excito-toxicity (cell death) and is an agonist for the  $\alpha$ -amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid) AMPA receptor, a kind of glutamate receptor in the brain [21]. Pharmacognostical studies have reported different properties of phytochemicals as immune-modulatory, anti-microbial, anti-oxidant,

anti-pyretic, anti-helminthic, anti-rheumatic, anti-viral, anti-fungal, anti-inflammatory, anti-staphylococcal and anti-septic as depicted in Table 9. Table 5 shows the active constituents present in the parts of *Quisqualis indica* Linn. Its seeds and leaves are used for anti-gelmintozone tool against tapeworm as well as a sedative. The leaf extracts of *Q. indica* Linn. contain phytochemicals such as quinone, flavonoids, Tannin, Phenolic, Saponin compound and coumarin. Due to availability of this plant throughout the season and quickly flourishing nature, it is used for making herbal medicine.

#### 2.6 Anti-Microbial Activity

With the discovery of penicillin, the hope of treating infectious diseases came true. However, in last two decades with the increased mass production and distribution, the susceptibility to

antibiotics tends towards the potential effect of anti-microbial resistance (AMR). The multifactorial antimicrobial resistance to a great extent depends on interaction of bacteria, environmental factor and host characteristics eventually reflect a problem in the treatment of pathogenic microbes, and this has led to uncover the new chemical structure to vanquish the above snag [22,23]. Anti-microbial agent diversified into anti-bacterial, anti-fungal, anti-viral and anti-parasitic based on the sort of microorganisms it retaliates is shown in chart 1. Fatima et al (2015) investigated the anti-microbial potential of *Quisqualis indica* bark against various microbial species, and it was found to have good anti-microbial property [24]. Several authors have tested the anti-microbial and anti-fungal activity by using agar plate diffusion assay for *E. coli* and *P. aeruginosa*, *B. subtilis* and *S. aureus* and fungal strains *A. niger* and *A. oryzae* and found ethanol root extract against *B. subtilis* having maximum zone of inhibition while chloroform and ethanol root extract had displayed varying potential against the fungal strains [25, 26, 27].

## 2.7 Anti-Bacterial Activity

Anti-bacterial or Anti-microbial properties of molecule predominantly associated with the exterminating disease causing bacteria or virus without affecting the neighbor cell mass. According to the mode of response towards the microbes it's classified in two categories as bacteriostatic and bactericidal [28, 29]. Depending upon the time taken and percentage of population eradicate bactericidal may be highly active (kill > 90%) or intermediate (kill < 90%). Whereas bacteriostatic largely inhibit the growth of microbial population by inhibiting the toxic protein production, DNA replication or other aspect of bacterial cellular metabolism. But according to microbiological definition the bacteriostatic and bactericidal activity generally rely on the minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) [30,31]. Former is defined as the minimum concentration of antimicrobial agent that inhibits the visible occurrence of bacterial growth in 24 hour in specific media while the latter is defined as the minimum concentration of drugs that lessen the microbial population to 1000 fold. Anti-microbial drugs shows the bacteriostatic activity when the MBC to MIC ratio is greater than 4 and for bactericidal the MBC to MIC ratio is less than 4 [32]. Mukherjee et al (2017) investigated the anti-microbial activity of *Quisqualis indica* flower extracts using agar well diffusion method with

different solvent and found out that petroleum ether shows best anti-microbial activity for *Staphylococcus aureus* (*S. aureus*), *Escherichia coli* (*E.coli*), *Pseudomonas aeruginosa* (*P. aeruginosa*), *Bacillus subtilis* (*B.subtilis*) with MIC value of 27.0, 30.0, 38.0, and 40.0 µg/ml with the presence of phytochemical like alkaloids and phenol. They examined the anti-bacterial activity by performing agar well diffusion assay with petroleum ether, methanol: chloroform, dimethylsulphoxide and sterile distilled water extract of *Quisqualis indica* flower against *S.aureus*, *E.coli*, *P.aeruginosa* and *B.subtilis*. With secondary phytochemicals like alkaloids, steroids, flavonoids and phenols, petroleum ether extract showed the significant antibacterial activity against *S.aureus* and *E.coli* [33].

Kumar et al. (2014). performed an agar well diffusion assay with the flower extract of *Quisqualis indica* with solvent like methanol, ethanol and aqueous against some gram positive and gram negative bacteria *M.luteus*, *B.subtilis* and *E.coli*. Methanolic flower extract of *Quisqualis indica* showed notable zone of inhibition as compared to ethanol and aqueous extract with gram positive *M.luteus* [34]. Kiruthika et al (2011) studied methanol extracts of the flower *Quisqualis indica*, both in dry and wet form showed significant anti-bacterial activity against the microbes *K. pneumoniae*, *P. aeruginosa*, *P. mirabilis*, *E. coli*, Methicillin Resistant *Staphylococcus aureus* and *B. subtilis* [35]. Thakur et al (2017) looked in to the anti-bacterial activity of aerial fragment of *Quisqualis indica* with solvent like methanol, ethyl acetate and hexane in counter with four bacteria: *E. coli*, *K. pneumoniae*, *S.aureus* and *Staphylococcus pneumoniae*. While methanol and hexane extracts showed most effectual outcome against *E. coli* and *K. pneumoniae*, the least effective case was found with *S. aureus* and *E.coli* [36].

## 2.8 Anti-Inflammatory Activity

The anti-inflammatory activity proceeds with lessening the effect of inflammation by blocking signal to central nervous system. Two subtypes of anti-inflammatory drugs: corticosteroid and non-steroid anti-inflammatory drugs (NSAIDs) are useful for alleviating pain caused by inflammation. Corticosteroid as glucocorticoids and mineralocorticoids regulate the immunity by breaking fat, carbohydrate, protein and balancing the salt-water concentration inside the body [37,38]. Whereas non-steroid anti-inflammatory drugs block the enzyme cyclo-oxygenase (COX-



1) which is responsible for secreting prostaglandin that leads to production of other immunomodulator like leukotriene, Platelet activating factor (PAF), cytokines that are target site for anti-inflammatory drugs. Yadav et al (2011) assessed the anti-inflammatory activity of *Quisqualis indica* by using acute inflammatory models like acetic acid-induced vascular permeability and chronic models like cotton-pellet induced granuloma. Phytochemical analysis showed that hydro-alcoholic flower extract of *Quisqualis indica* contains plenty of polyphenol and flavonoid that inhibit prostaglandin synthesis [39].

## 2.9 Anti-Oxidant Activity

Anti-oxidant also known as free radical scavengers or reactive oxygen species are unstable molecules that body produces as a reaction to environment and other pressure to prevent slow damage to cell caused by free radicals. Based on source anti-oxidants are grouped in to endogenous (natural) or exogenous (artificial). Vitamins A, C and E, beta-carotene, lycopene, lutein, selenium, manganese, zeaxanthin are exogenous anti-oxidants while flavonoids, flavones, catechins, polyphenols and phytoestrogens are the types of anti-oxidants and phytonutrients found in plant-based products [40]. DPPH is a nitrogen based free radical that is converted into stable molecule diphenyl 1- picryl hydrazine. The reduction of DPPH by the extract carried out by transfer of hydrogen atom or electrons with reference to ascorbic acid. Percentage inhibition of DPPH free radical was calculated based on the control reading, which contained DPPH and distilled water without any extract using the following equation:

$$\text{DPPH Scavenged (\%)} = \frac{\text{Absorbance of control (A}_0\text{)} - \text{absorbance of test (A}_1\text{)}}{\text{absorbance of control (A}_0\text{)}} \times 100$$

Whereas Percentage inhibition of hydrogen peroxide was calculated based on the control reading, which contained sodium thiosulfate ( $\text{Na}_2\text{S}_2\text{O}_3$ ) with extract and hydrogen peroxide without any extract using the following equation:

$$\text{H}_2\text{O}_2 \text{ Scavenged (\%)} = \frac{\text{Volume of control (V}_0\text{)} - \text{Volume of test (V}_1\text{)}}{\text{Volume of control (V}_0\text{)}} \times 100$$

### 2.9.1 Reducing power assay

Based on the ability of reducing ferric ion to ferrous ion, the reducing power was monitored by measuring the formation of per's Prussian blue

at 700 nm. Substances with reduction potential react with potassium ferricyanide ( $\text{Fe}^{3+}$ ) to form potassium ferrocyanide ( $\text{Fe}^{2+}$ ), which then reacts with ferric chloride to form ferric-ferrous complex that has absorption capacity of 700nm. With the increasing volume of sample and standard concentration, the reducing capacity of standard and hydro alcoholic extracts increases.

### 2.9.2 Total antioxidant capacity

Based on a spectrophotometric assay the total antioxidant capacity was calculated by phosphomolybdenum method. Phosphate present in the sample formed a complex with added molybdenum followed by reduction of the phosphomolybdenum complex with thiourea in aqueous sulphuric acid medium.

$$\text{Percentage (\%)} \text{ of inhibition: } \frac{\text{Control OD (A}_0\text{)} - \text{Sample OD (A}_1\text{)}}{\text{Control OD (A}_0\text{)}} \times 100$$

Maha A. El-Shazly et al (2016) evaluated the anti-oxidant activity of *Quisqualis indica* via 1,1'-diphenyl-2-picraylhydrazyl free radical (DPPH), phosphomolybdenum and reducing power anti-oxidant assays, also qualitatively via dot-blot DPPH staining assays. Free radical scavenging concentrations (SC50) of DPPH ranged from 24.38 to 72.10 $\mu\text{g/ml}$  against ascorbic acid as standard (SC50 equal to 7.45), while petroleum Ether and dichloromethane ( $\text{CH}_2\text{Cl}_2$ ) shows no activity, the high activity was recorded for Ethylacetate fraction [41]. Afify et al (2016) found that the water extract of *Quisqualis indica* flower show highest scavenging activity against DPPH radicals. Ethanol extract of *Quisqualis indica* flowers shows high scavenging activity of hydroxyl radicals and low scavenging activity for nitric oxide [42]. Bose et al (2009) showed that ethylacetate extract of *Quisqualis indica* leaf had best scavenging activity for hydroxyl radical and aqueous extract was best for both nitric oxide and hydrogen peroxide scavenging [43]. Chatterjee et al (2019) measured the anti-oxidant activity through 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid (ABTS) and hydrogen peroxide ( $\text{H}_2\text{O}_2$ ) radical scavenging assay by using disc diffusion method found that aqueous extract of leaf and flower shows maximum scavenging activity than ethylacetate extract [44].

## 2.10 Immuno-Modulatory Activity

Immuno-modulator is the substances that have capacity to stimulate, suppress or modulate

**Table 7. Shows the phytochemical analysis of leaves and flowers extract of *Q.indica***

Secondary metabolites	POLAR and non-polar solvent extract of plant									
	PEEL	CEL	MEL	AQEL	EEL	AQEF	MEF	PEEF	HAEF	MEAP
Alkaloids	+	+	+	+	+	+	+	+	+	+
Reducing sugar	—	+	+	+	+	—	—	—	+	—
Flavonoids	+	+	+	+	+	+	+	+	+	+
Saponin	—	—	+	+	—	+	+	—	+	+
Phenolic compound	—	+	+	+	—	+	+	—	+	—
Tannin	—	+	+	+	+	—	—	—	+	+
Protein & amino acid	+	+	+	+	+	—	—	—	+	+
Glycosides	—	—	+	+	+	+	+	—	+	+
Fat & oils	—	—	+	+	+	—	—	—	+	—
Carbohydrates	+	—	+	+	+	—	—	—	+	—
Terpenoids	—	—	+	+	+	+	+	—	—	+

+ = Represent presence of Metabolite  
 PEEL: Petroleum Ether Extract of Leaves  
 CEL: Chloroform Extract of Leaves  
 MEL: Methanol Extract of Leaves  
 AQEL: Aqueous Extract of Leaves  
 MEAP: Methanolic Extract of Aerial parts of Leaves  
 - = Represent absent of Metabolite  
 EEL: Ethanolic Extract of Leaves  
 AQEF: Aqueous Extract of Flower  
 MEF: Methanolic Extract of Flower  
 PEEF: Petroleum Ether Extract of Flower  
 HAEF: Hydroalcoholic Extract of Flower

**Table 8. Shows the phytochemical analysis of shoots and roots extract of *Q.indica***

Secondary metabolites	POLAR and non-polar solvent extract of plant									
	PEES	CES	AES	EES	AQES	NHES	AQER	EER	CER	NHER
Alkaloids	+	+	—	—	+	—	—	—	—	—
Tannins	—	+	—	+	—	—	—	+	+	+
Saponin	+	+	—	—	+	+	+	—	—	—
Flavonoids	+	—	—	—	—	+	—	—	—	—
Terpenoids	—	—	—	—	—	+	+	+	+	+
Reducing sugar	—	+	—	+	—	+	+	+	+	+
Cardiac glycosides	+	+	—	—	—	+	+	+	+	+

+ = Represent presence of Metabolite  
 PEES – Petroleum Ether Extract of Shoot  
 AES – Acetone Extract of Shoot  
 AQES – Aqueous Extract of Shoot  
 AQER – Aqueous Extract of Root  
 CER – Chloroform Extract of Root  
 - = Represent absent of Metabolite  
 CES – Chloroform Extract of Shoot  
 EES – Ethanol Extract of Shoot  
 NHES – N-Hexane Extract of Shoot  
 EER – Ethanol Extract of Root  
 NHER – N-Hexane Extract of Root

**Table 9. Shows the parts of *Q. indica* put to use as medicinal basis**

S.No.	Parts of plant	Pharmacognostical properties
1	Flower	Anti-microbial, Antibacterial, Anti-inflammatory, Anti-oxidant, Immuno-modulatory
2	Leaf	Anti-bacterial, Anti-oxidant, Anti-helminthic, Anti-pyretic, Anti-diarrheal, Anti-hyperglycemic
3	Root	Anti-microbial, Anti-fungal

**Chart 1. Anti-microbial Activity**

Solvent extract	Anti-microbial activity of leaf	Anti-microbial activity of flower
Aqueous extract	<i>S. aureus</i> <i>B. Subtillus</i> <i>Alternaria porri</i> [33]	<i>E.coli</i> [33]
Methanol extract	<i>E. coli</i> <i>B. Subtillus</i> [34]	<i>M.luteus</i> [34]
Petroleum ether extract	<i>B. Subtillus</i>	<i>S. aureus</i> <i>Escherichia coli</i> [33]
Ethyl acetate extract		<i>Escherichia coli</i> [36]
Hexane extract	<i>S.pneumoniae</i> [36]	

immune responsiveness may be innate or acquired arm of immunity response. Categorically immuno-modulator are as follows: immuno-stimulators stimulate the non-specific system including granulocytes, macrophages, complement, certain T-lymphocytes and different effector substances. Immuno-suppressants occur due to environmental or chemotherapeutic factors in order to reduce resistance against infections and immune-adjuvants enhance the potency of the vaccines through regulating cellular (Th1) and humoral (Th2) immunity [45]. Plant derived immune-modulator includes glycosides, flavonoid, alkaloid, coumarins, saponins, thiosulfates and polysaccharides. Yadav et al (2011) through phytochemical screening observed that the flower extract of *Quisqualis indica* possess flavonoids, tannin, phenolics compound, terpenoids and saponin and its hydroalcoholic extract was successfully administered for enhancing phagocytic activity of macrophage, differential leukocytes count and total WBC. The antibody independent hypersensitivity or delayed type of hypersensitivity response shows considerable activity by a higher dose *Quisqualis indica* by stimulating haemopoetic system [46].

### 2.11 Anti-Helminthic Activity

Anti-helminthic are group of anti-parasitic drugs that are used to eliminate the parasitic worm without affecting the host. Based up on the dimension of its effect it grouped in to broad spectrum and narrow spectrum anti-helminthic drugs [47]. Hai et al (2019) demonstrated the anti-helminthic activity of *Quisqualis indica* seeds

against ascarides, flukes, and *E. coli* strains by calculating the lethal dose (LD) at LD 50 and LD 100. With shorter LD 50 and LD 100 time the seed extract showed resilience effects against Ascariasis [48].

Sarma et al (2015) compared the anti-helminthic activity of different extracts of *Quisqualis indica* leaves on Indian earthworm with standard reference to albendazole 60 mg/ml and found that maximum activity was shown by methanolic extract when compared to the aqueous extract at the same concentration [49].

### 2.12 Anti-Pyretic Activity

Thermoregulation is a homeostasis process following a circadian with varying temperature ranging from low of 36.48°C in the morning to a high of 36.98°C in the afternoon. The pre-optic area consists of anterior part of hypothalamus (POAH) and septum is the essential for maintaining thermoregulation at a set point. Pyrogenic cytokines, namely as interleukin-1 $\beta$  (IL-1 $\beta$ ), tumor necrosis factor (TNF) and interleukin-6 (IL-6) act directly on the hypothalamus to stimulate a febrile response [50,51]. Inflammation in the body evoke the release of some modulators in the POAH area notably Prostaglandin E2. COX-1 and COX-2 are two sets of enzyme help in synthesizing prostaglandin E2 from arachidonic acid. COX-1 regulates the proper homeostasis by generating prostanoid whereas COX-2 induced by the pyrogenic cytokines to evoke febrile response during inflammation. Anti-pyretic drugs reduce fever by decreasing inflammatory responses at

the peripheral sites of tissue inflammation and in the thermoregulatory sites of central nervous system (POAH). These drugs enhance the production of anti-inflammatory molecules like adenosine and aspirin-triggered lipoxins which lower the thermoregulatory set point by blocking production of prostaglandin E2 by COX-2. Singh et al (2010) showed the anti-pyretic activity of *Quisqualis indica* methanolic leaves extract against brewer yeast induced pyrexia model in wistar rats. With reference to aspirin 150 mg/kg methanolic extract of 150 mg/kg and 200 mg/kg showed anti-pyretic activity by a deviation of temperature ranges  $38.40 \pm 0.075$  to  $37.44 \pm 0.0638$  and  $38.99 \pm 0.140$  to  $37.49 \pm 0.038$  at  $P < 0.01$  levels [52].

### 2.13 Anti-Diarrheal Activity

Diarrhea is the frequent passage of loose watery liquid defecation with persistent bowel movement due to an infection caused by variety of bacterial, viral and parasitic organisms in the intestine. Food intolerance, lactose intolerance, food allergy, an adverse reaction to a medication, viral infection, bacterial infection, an intestinal disease, a parasitic infection, gallbladder or stomach surgery and malnutrition are the primary causes of diarrhea among people of developing country. The most dreadful threat posed by diarrhea is dehydration with water and electrolyte (sodium, chloride, potassium and bi-carbonate) imbalance inside the body. The profound effect of dehydration is rated based on symptoms into a scale of three as severe dehydration, some dehydration and no hydration without any symptoms. Whereas diarrhea is clinically graded in to acute watery diarrhea that lasts several hours or days and includes cholera, acute bloody diarrhea, also known as dysentery and persistent diarrhea that lasts 14 days or longer. The most effective way to treat diarrhea is rehydration through ORS (oral rehydration salt), zinc supplement [53]. Singh et al (2013) analyzed the anti-diarrheal activity of petroleum ether leave extract of *Quisqualis indica* using castor oil induced diarrhea test and charcoal induced gastrointestinal motility test in Albino wistar rats. The petroleum ether extract of the plant at a dose level of 100 mg/kg and 200 mg /kg and the total wet faeces produced was 15.32 and 12.45 as compared to castor oil 21.16, whereas the percentage of inhibition of castor oil induced diarrhea was 27.59% and 32.23%, respectively. The presence of phytochemicals like tannins, alkaloids, flavonoids, sterols and tri-terpenes components in the *Quisqualis indica* Linn. plant

have played a role as an emerging anti-diarrhea plant species with potent and comparable results [54].

### 2.14 Anti-Hyperglycemic Activity

Diabetes, a group of metabolic disease and one of the most common non-communicable diseases prevailing in the world with characteristics of increased glucose level in blood as a result of insufficient insulin secretion or insulin resistance. It is one of the major causes of death in developed and newly industrialization country after cancer and cardio vascular diseases. Glycogenolysis and gluconeogenesis effectively result the overproduction of glucose leads to elevating the blood glucose level with curbing the binding insulin to its receptor in the cytoplasmic membrane [55]. With declining insulin production in the pancreatic  $\beta$  cell of Langerhans's vesicle fusion comes to a halt, jeopardizing the inward flow of glucose causing hyperglycemia. The calcium metalloenzyme  $\alpha$  - amylase which cannot work in the absence of calcium act as catalysis in the reaction involve hydrolysis of alpha-1,4 glycosidic linkages of the starch, amylopectin, amylose, glycogen resulting starch digestion. As starch cannot cross the blood-brain barrier amylase cleave the starch molecule in to smaller sugar helping flow of glucose in to the blood ensuring the conversion of glucose to glycogen in a normal healthy person [56]. In some cases due to immoderate activity of alpha amylase and reduced production of insulin which might leads to hyperglycemic condition. Verma et al (2018) looked in to the anti-hyperglycemic activity of ethanolic extract of *Quisqualis indica* leaves. With Gas Chromatography-Mass Spectrometry (GS-MS) analysis the ethanolic extract showed the presence of adequate amount phytochemicals like phytol, linolenic acid and penta-decanoic acid that has the capabilities of inhibiting  $\alpha$  - amylase and glucosidase [57].

#### 2.14.1 Effectiveness of *Q. indica*-AgNPs against malaria, filariasis vector and zika virus

Govindrajan et al (2016) analyzed the bio-physical and mosquitocidal activity of *Q. indica* using one pot biogenic fabrication of silver nanoparticle (AgNPs). Due to environment friendly properties of silver nano-particles, it serves as possible substitute for pyrethroids, carbamates and microbial agent [58]. AgNPs characterization was done by both microscopic (AFM, SEM, TEM and EDX) and spectroscopic

(UV, FTIR, XRD) technique. Synthesis of poly-dispersed AgNPs with spherical shape ranging 1-30nm was showed by microscopic technique. The crystalized structure was traced out by XRD. *Q. indica* synthesized AgNPs showed moderately toxic to non-target aquatic mosquito predator *Anisops bouvieri*, *Diplonychus indicus* and *Gambusia affinis* in contrast to the targeted mosquito larva. The acute toxicity of *Q. indica* extract and AgNPs was evaluated against Malaria, arbovirus and filariasis vector, *Anopheles stephensi*, *Ades aegypti*, *Culex quinquefasciatus* and found that *Q. indica*-AgNPs act as a eco-friendly tool in the fight against Zika Virus, Malaria and Filariasis vector.

#### 2.14.2 Assessment of cytotoxic activity of *Q.indica* copper-nanoparticle on B16F10 melanoma cell

Mukhopadhyay et al (2018) analysed the biophysical and cytotoxic activity of *Q.indica* flower extract by biofabrication of copper nanoparticle (QCuNPs) from copper acetate. By using MTT and Lactate dehydrogenase (LDH) assay on B16F10 melanoma cell of rat the cytotoxic potential of nano formulation was determined. Gene transcript analysis showed the upregulation of cascade dependent and cascade independent (AIF) apoptotic gene while proteomic study showed the abundance of apoptotic and cell cycle arrest protein in treated sample [59].

#### 2.14.3 Efficacy of *Q. indica* against hyperlipidemia

Sahu et al (2013) investigated the hypolipidemic activity of methanolic extract of aerial parts of *Q.indica*. Passive smoking hyperlipidemia was induced by putting one burning cigarette in a closed chamber and analyzed the blood serum level in UV at 505nm. Methanolic extract in a dose dependent manner shows striking effect on harmful lipid layer in blood serum by reducing low density lipoprotein (LDL), very low density lipoprotein (VLDL), cholesterol, triglyceride and rising high density lipoprotein (HDL) level in blood by inhibiting lipid peroxidation.[60].

### 2.15 Anti-Cancer Activity

Thomas et al (2008) and Birgid et al (2015) identified 25-o-acetyl-23,24-di hydro-cucurbitacin F as a cytotoxic constituent of *Q.indica* fractioned by chromatographic technique and elucidated the chemical structure by nuclear magnetic

resonance (NMR) and mass spectroscopy (MS). It reduces the cell viability by arresting the cell G<sub>2</sub>/M interface by decreasing cell cycle check point regulator cyclin B, cyclin A, CDK 1 and CDK 2 in a dose dependent manner. It was also found that in liposarcoma and rhabdomyosarcoma cells it induces apoptosis through caspase-3 dependent pathway. [61,62]

### 2.16 Improve Benign Prostatic Hyperlasia

Wijerathane et al (2017) studied the therapeutic efficacy of *Q.indica* extract on treating benign prostatic hyperplasia (BPH) in LNCaP human prostate cancer cell line and a testosterone induced BPH rat model. Cancer treated with *Q.indica* extract plus testosterone propionate (TP) and androgen receptor (AR) and prostate specific antigen (SPA) showed that TP-induced increases in AR and SPA expression in LNCaP cell were reduced by *Q.indica* treatment. In BPH rat expression of 5- $\alpha$ -reductase Mrna, prostate weight, TP-induced prostatic hyperplasis and proliferating cell nuclear antigen (PCNA), and cyclin D were significantly attenuated through anti proliferative and proapoptotic activities of *Q.indica* [63]. Dee-geon-kim et al (2020) studied the efficacy of *Q.indica* extract on low urinary tract symptoms and found that it mitigate the increase in urethral pressure which is the biggest practical symptoms of enlarged prostate [64].

## 3. CONCLUSION

Several authors have reviewed the medicinal properties of *Quisqualis indica* Linn. but our review focuses on the anti-bacterial, anti-inflammatory, anti-oxidant, anti-pyretic, anti-helminthic anti-diarrheal, anti-hyperglycemic, anti-microbial, anti-fungal and immunomodulatory properties.

It would be useful to students, academicians, microbiologists, as it reduces the need for detailed searching. It serves the purpose of quick reference. There is an urgent need to put the use of herbal remedies and other natural products into the correct medical perspective.

## DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for

any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

## ACKNOWLEDGEMENT

We thank ICMR for funding this project entitled, "Assessment of antimicrobial potentialities of *Quisqualis indica* L. against human pathogenic microorganisms".

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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