



# IJPPR

INTERNATIONAL JOURNAL OF PHARMACY & PHARMACEUTICAL RESEARCH  
An official Publication of Human Journals

ISSN 2349-7203



Human Journals

**Review Article**

August 2023 Vol.:28, Issue:1

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## *Citrus medica* L.: A Comprehensive Review of Botany, Phytochemistry, and Medicinal Properties



**IJPPR**  
INTERNATIONAL JOURNAL OF PHARMACY & PHARMACEUTICAL RESEARCH  
An official Publication of Human Journals



ISSN 2349-7203

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**Submitted:** 25 July 2023  
**Accepted:** 18 August 2023  
**Published:** 30 August 2023

**Keywords:** Citron, *Citrus medica* L., Phytochemicals, Pharmacological Properties

### ABSTRACT

Throughout history, plants have served as valuable sources of safe and effective medicines, with herbal remedies being widely used for maintaining good health in various cultures. The use of natural products with medicinal properties dates back to ancient times when substances derived from minerals, plants, and animals formed the basis of medicinal treatments. This preference for natural compounds was driven by the ease of obtaining pure substances and the ability to modify their structures to create more potent and safer drugs. Additionally, pharmaceutical companies recognized the commercial potential of these natural resources. Citrus fruits, in particular, have been widely consumed and appreciated for their nutritional value. Among the citrus species, *Citrus medica* L., frequently recognized as Citron, has been extensively useful within traditional Indian medicine. Different parts of the Citron plant have various medicinal properties. For instance, its leaves are known for their sleep-inducing effects and have historically been considered an antidote for various types of poisons. The fruit itself possesses analgesic, anticancer, and antiulcer properties, while the peel exhibits several characteristics, such as hypoglycemic, anti-cholinesterase, hypocholesterolemic, hypo-lipidemic, antimicrobial, as well as anthelmintic activities. Furthermore, the seeds of Citron have been found to have anti-diabetic, hypocholesterolemic, hypolipidemic, and estrogenic actions. Beyond its medicinal applications, Citron holds significant economic value due to its edible and nutritious fruit, useful wood, latex, and bark, providing livelihood support to local communities. To encourage further research and broaden the scope of its therapeutic applications, the authors conducted a comprehensive bird view of *Citrus medica* L.'s chemical composition and biological characteristics. This research seeks to motivate fresh ideas in the field of medicine and maximize the potential benefits of this remarkable plant.



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## INTRODUCTION

*Citrus medica* L., generally identified as Citron or *Citrus medica*, is an ancient and remarkable plant belonging to the Rutaceae family [1]. With a rich history dating back millennia, this botanical marvel has played an integral role in various cultures as a significant culinary, medicinal, and religious symbol [1]. The plant's diverse range of uses, distinctive appearance, and aromatic properties have captivated human interest for generations [1].

*Citrus medica* L. is a perennial evergreen shrub or small tree, typically reaching a height of 5 to 10 meters. It boasts a symmetrical, round crown with glossy green leaves and thorny branches [2]. The compound leaves consist of ovate to elliptical leaflets, bearing aromatic glands on the leaf surface. The flowers are fragrant, solitary or clustered, and possess five white or pale pink petals. The fruit of *Citrus medica* L., usually referred to as the citron or Buddha's hand, is unique in shape, resembling a large, segmented, and often finger-like citron [2].

It is thought that *Citrus medica* L. emerged in Southeast Asia's eastern areas, which include sections of Malaysia, China, and India [3]. Over centuries of trade and exploration, it spread to other parts of the world, including the Mediterranean region in addition to the Middle East. Today, It has been upgraded in various subtropical and tropical regions worldwide, including parts of the Americas, Africa, and Australia [3].

*Citrus medica* L. holds a significant position in various ancient civilizations. Historically, it is thought to be one of the original citrus fruits, along with the mandarin and pomelo. The plant was first cultivated in ancient China, where it was admired as a representation of wealth, joy, and fertility. Subsequently, Citron found its way into the sacred texts of multiple religions, including Hinduism, Buddhism, Judaism, and Christianity, and became an essential part of various religious rituals and ceremonies [1, 3].

*Citrus medica* L. has a diverse range of applications in culinary and medicinal domains. In traditional cuisine, the citron's aromatic rind is used as a flavoring agent in various dishes, desserts, and beverages, imparting a unique, tangy flavor [2]. Furthermore, the citron's pulp and juice are utilized in medicinal preparations, owing to its rich composition of bioactive compounds, such as flavonoids, limonoids, and vitamins [2].

In traditional medicine, *Citrus medica* L. has been employed to treat a wide array of health conditions. Its extracts have shown potential as antioxidant, anti-inflammatory, and

antimicrobial agents. The citron's essential oil is also valued for its therapeutic properties, being used in aromatherapy to alleviate stress, anxiety, and digestive discomfort [3].

In recent years, scientific interest in *Citrus medica* L. has surged, leading to extensive research into its potential medicinal applications. Studies have revealed promising outcomes in relation to the plant's antioxidant and anticancer properties. The manifestation of numerous bioactive composites has garnered attention from the pharmaceutical industry, with ongoing investigations into the development of novel drugs and nutraceuticals derived from *Citrus medica* L [1-3].

As we embark on this captivating journey into the world of *Citrus medica* L., it becomes evident that the Citron plant is much more than just a fruit-bearing shrub; it symbolizes an intricate fusion of botany, history, culture, and science. This review seeks to provide a comprehensive understanding of this remarkable plant's various facets, unearthing the hidden gems that lie within its history, utilization, and potential for the future. With a keen focus on the latest research and discoveries, we aim to shed light on the many wonders of *Citrus medica* L., revealing the secrets that have enchanted civilizations for centuries.



**Figure 1: *Citrus medica* L. Plant**

## Beginning and Supply

The ancient citrus species known as the citron is thought to have originated in India, specifically found in valleys around the eastern Himalayas. There is evidence suggesting that the largest cultivated citrus species originated from a few familial types, which include citron, pomelo, mandarin, and, to a lesser extent, papedas and kumquat. Citron typically undergoes self-pollination, leading to a high level of genetic homozygosity. Interestingly, in citrus hybrids, the citron serves as the male parent rather than the female one. However, archaeological confirmation for citrus fruits is restricted, as it is unlikely for seeds or pollen to be commonly preserved in archaeological findings [1-3].

## Propagation

*Citrus medica* L., commonly known as citron, is typically propagated through a method called rooting. Rooting involves using cuttings from the plant to create new ones. A cutting refers to a section of the plant that is used for propagation and can recreate the missing part of the original plant. When it comes to stem cuttings, there are different classifications based on the stage of growth: hardwood cuttings, semi-hardwood cuttings, softwood cuttings, and herbaceous cuttings. However, in the case of propagating *Citrus medica* L., the semi-hardwood technique is commonly employed [4-7].



**Figure 2: Fruit and Seed of *Citrus medica* L. Plant**

## Plant Profile

**Name:** *Citrus medica* L.

**Synonyms:** Citron, Wild Lemon, Bijapura, Limbu, Nimbu

**Kingdom:** Plantae

**Subkingdom:** Tracheobionta

**Super division:** Spermatophyta

**Division:** Magnoliophyta

**Class:** Magnoliopsida

**Order:** Sapindales

**Family:** Rutaceae

**Genus:** Citrus

**Species:** Medica L

### **Phytochemical Properties**

(Table 1) presents the phytochemical properties of different parts of *Citrus medica* Linn. The fruit decoction contains alkaloids, flavonoids, phenols, carbohydrates, and mucilage. The peels, or rind of the fruit, contain alkaloids, flavonoids, steroids, phenols, and carbohydrates. Meanwhile, the leaves of the plant comprise alkaloids, flavonoids, steroids, and glycosides [8-10]. Specific flavonoids found in the fruits include hesperidin:3,5,6-trihydroxyl-4,7-dimethoxy flavone and 3,5,6-trihydroxy-3',4', 7-tri methoxy flavones [11,12]. On the other hand, the peel is informed towards containing coumarins, limettin, scoparone, scopoletin, and umbelliferone, while the seeds contain limonin, limonol, and nomilinic acid [13, 14]. In the leaves, Gurdip et al. identified the foremost ingredients in the leaf oil as citronellal, citronellol, limonene, citronellyl acetate, isopulegol, and linalool [15]. These phytochemicals in *Citrus medica* Linn, contribute to its potential medicinal and aromatic properties.

The essential oils extracted from the leaves and peels of *Citrus medica* Linn are complex mixtures comprising numerous compounds, with many present in trace amounts. Table 2 and Table 3 present the foremost ingredients found in the essential oils of peels as well as leaves, respectively. It is important to note that there is considerable variation in the chemical composition of these essential oils across diverse varieties of *Citrus medica*. In the case of the Bangladesh variety, erucylamide and isolimonene are identified as the furthestmost significant

in addition to primary constituents in both the leaf and peel oils. Interestingly, these two compounds have not been reported in any other oils of *Citrus medica*, indicating that the Bangladesh variety stands out in this regard. This unique chemical composition makes *Citrus medica* from Bangladesh a promising resource for separating natural erucylamide and isolimonene [16].

Furthermore, the higher amount of erucylamide and isolimonene in the leaf and peel oils of *Citrus medica* from Bangladesh suggests potential medicinal applications due to their fungicidal properties [17]. Given their antifungal activity, these essential oils may hold promise for medicinal purposes. In summary, the essential oils derived from *Citrus medica* Linn., leaves, and peels exhibit a wide array of chemical components, and the specific composition varies among different varieties. The presence of erucylamide and isolimonene in high concentrations in the Bangladesh variety highlights its significance as a potential source for natural compounds with medicinal properties.

**Table 1: Physiochemical properties of Plant**

Phytochemicals	Fruit	Peels	Leaves
Alkaloids	Present	Present	Present
Flavonoids	Present	Present	Present
Tannins	Absent	Absent	Absent
Terpenoids	Absent	Absent	Absent
Steroids	Absent	Present	Present
Glycosides	Absent	Absent	Present
Phenols	Present	Present	Absent
Carbohydrates	Present	Present	Absent
Mucilage	Present	Absent	Absent

**Table 2: Major constituents from the Leaf part of the plant**

Sr. No.	Name of Constituents	Availability in Leaf (%)
1	Erucylamide	28.43
2	Limonene	18.36
3	Cital	12.95
4	Mehp	8.96
5	2,6-Octadien-1-ol, 3,7-dimethyl-acetate	5.23
6	6-Octenal, 3,7-dimethyl	4.39
7	1,2-Cyclohexanediol, 1-methyl-4-(1-methyl phenyl)	3.98
8	Methoprene	3.51

**Table 3: Major constituents from the Fruit part of the plant**

Sr. No.	Name of Constituents	Availability in Fruit (%)
1	Isolimonene	39.37
2	Limonene	23.12
3	Cital	21.78
4	$\beta$ -Myrcene	2.70
5	Neryl acetate	2.51
6	Neryl Alcohol	2.25

### Traditional Uses

*Citrus medica* L. is widely utilized in traditional medicine systems not only in India but also in various other countries. The plant's different parts hold significant importance and find various essential uses. Below are some of the primary applications of *Citrus medica* L. in traditional medicine.

### Flowers

The flowers of *Citrus medica* L. have several valuable medicinal properties. They are known to act as antidepressants, provide astringent effects to the bowels, increase appetite, and help alleviate vomiting. Additionally, these flowers have been found to be effective in treating numerous situations for example tumors, asthma, cough, in addition to hiccups [18].

### **Roots**

The roots of *Citrus medica* L. possess valuable anti-parasitic properties and are commonly employed in traditional medicine to address constipation and tumors. They are known for their effectiveness in treating stomachaches, relieving vomiting, and providing relief from renal stones. Additionally, the roots are believed to be beneficial in managing dental issues, particularly toothaches [18].

### **Peels**

The peel of the *Citrus medica* L. fruit possesses a pungent and sharp quality and is rich in oils, making it a stimulant. When frozen, the peel is utilized as an anti-dysentery treatment and is taken towards reducing bad breath. The essential oil derived from the peel has been the subject of studies for its potential antibiotic properties. In its fresh form, the peel is utilized as a stomachic, stimulant, expectorant, and tonic [19, 20].

### **Seeds**

The seeds of *Citrus medica* L. have a pungent taste and are considered non-digestive. They generate significant heat in the body and act as stimulants and tonics. Additionally, they are known for their anti-inflammatory properties. In traditional practices aimed at conception, five seeds are ground and consumed with cow milk every morning for a month. Furthermore, these seeds are utilized as anti-parasitic agents [18].

### **Shoots**

A decoction produced from the wild plant's branches has been utilized to help boost appetite, relieve stomachaches, and get rid of intestinal worms [19, 20].

### **Leaves**

After childbirth, a mixture of leaf juice from *Citrus medica* L., Polygonum, and Indigofera is consumed. The combination of these leaves is used as an antispasmodic remedy. Additionally, the leaves of *Citrus medica* L. are consumed as a vegetable to address issues related to the liver [21].



## **Fruits**

The fully ripe fruit of *Citrus medica* L. has a pleasant combination of sweet and sour tastes. It acts as a stimulant and is easily digestible. The fruit is considered tonic and is believed to provide relief from leprosy. It can be utilized as a sore throat treatment, cough, asthma, and hiccups management. Furthermore, the fruit is beneficial for throat health, and its juice is known to alleviate earache [18].

## **Pharmacological Properties of Plant**

### **Analgesic Action**

In the hot plate technique, all three dosages (1, 2, and 4 ml/kg) of *Citrus medica* Linn fruit decoction showed effectiveness. However, in the tail immersion method, only the doses of 2 and 4 ml/kg were found to be effective, while the 1 ml/kg dose did not show efficacy in evaluating centrally acting drugs' analgesic effects. Notably, the 4 ml/kg dose of *C. medica* Linn decoction exhibited pain inhibition comparable to diclofenac sodium injection in both hot plate and tail immersion methods. This study confirms the conventional usage of *C. medica* Linn decoction as a pain-relieving. The observed pain-relieving action of *C. medica* Linn is likely attributed to its flavonoids and phenolic composites, which are known to possess analgesic properties [22].

### **Hypoglycemic and anticholinesterase activity**

Free radicals' contribution to oxidative damage is linked to the initiation and development of a number of chronic illnesses, like diabetes and Alzheimer's disease. Researchers have studied the n-hexane extract of Diamante citron peel, which is rich in monoterpenes and sesquiterpenes, and found that it exhibits significant antioxidant activity based on various assays, including the DPPH test,  $\beta$ -carotene bleaching test, and bovine brain peroxidation assay. Additionally, the Diamante citron peel extract has demonstrated hypoglycemic activity and an anticholinesterase effect. These promising in-vitro actions of Diamante citron recommend its potential use in the management of diabetes and Alzheimer's disease [23].

### **Anticancer action**

Certain fruits and vegetables are recognized for their potential anti-cancer properties due to their rich content of antioxidants, including phenols, vitamin C, vitamin E,  $\beta$ -carotene, and lycopene. Among these foods, Citrus fruits, in particular, stand out as one of the most

intriguing options. To evaluate the anti-cancer effects of *Citrus medica* Linn, researchers conducted a study using the vital capacity test and the Ames test. The Ames test involved the use of *Salmonella typhimurium* to assess the anti-mutagenic and anti-cancer properties of the chemicals present in the fruit. The research findings revealed that both half-ripe and ripe fruit juices demonstrated anti-cancer and anti-mutagenesis effects. Interestingly, the half-ripe fruit juice exhibited greater effectiveness in this regard compared to the ripe fruit juice [24].

#### **Anti-diabetic, hypocholesterolemic and hypolipidemic activity**

The petroleum ether extract of *Citrus medica* Linn seeds showed a notable dose-dependent decrease in fasting blood glucose, serum cholesterol, serum triglycerides, and LDL, in addition to VLDL levels after 15 days of administration at dosages of 200 and 400mg/kg. The 200 mg/kg/day dose did not affect HDL levels, but the 400mg/kg/day dose substantially improved HDL levels in diabetic rats. This indicates that *C. medica* Linn seeds possess substantial anti-diabetic, hypocholesterolemic, and hypolipidemic properties [25]. Similarly, the extract from *Citrus medica* L. cv Diamante peel demonstrated in vivo metabolic effects in mice, leading to a reduction in plasma glucose concentration, as well as decreased levels of plasma cholesterol and triglycerides. These findings highlight the potential of *Citrus medica* L. as a new resource with functional characteristics for the development of food or nutraceutical products [26].

#### **Insulin secretagogue activity**

The study evaluated the security, hypoglycemic, as well as anti-diabetic effects of *Citrus medica* L. var. *Sarcodactylis* (Finger citron) in Sprague-Dawley-SPF rats and Wister DIO rats. The study confirmed the insulin secretagogue effect by doing a kinetic examination of the hypoglycemia patterns seen throughout intraperitoneal blood sugar tolerance along with insulin glucose sensitivity testing. According to the research, finger citron fruits, which include insulin secretagogue and weight-loss benefits, may be especially helpful for people with type 2 diabetes mellitus [27].

#### **Anti-helminthic activity**

In an in-vitro investigation, the petroleum ether extracts of *Citrus medica* L. leaves demonstrated a dose-dependent anthelmintic action, comparable to the effects of Piperazine citrate. The plant has been established to possess anthelmintic properties contrary to Indian adult earthworms (*Pheretima posthuma*). Although the precise mechanism underlying its anti-

helminthic effect is yet unknown, it is thought to be connected to the parasites' suppression of glucose intake and glycogen formation. Additionally, *Citrus medica* L. may activate nicotinic cholinergic receptors in the worms, leading to either persistent depolarization or hyperpolarization. Finding the compound that gives *Citrus medica* L. its anthelmintic properties will require more investigation [10]. Moreover, alcoholic extracts from the rind of *Citrus medica* L. also exhibited moderate in-vitro anthelmintic activity against human *Ascaris lumbricoides* [28].

### **Antimicrobial activity**

Plant-based antimicrobials have great restorative capabilities, offering a lower risk of side effects compared to synthetic antimicrobials. It is essential to continue exploring plant-derived antimicrobials to meet the growing need for effective treatments. In this regard, the ethanolic extract of *Citrus medica* peels was investigated for its in-vitro antibacterial action utilizing the agar cup method. The study revealed that the peel extract exhibited effectiveness against various bacterial strains, including *Staphylococcus aureus*, *Proteus vulgaris*, *Klebsiella pneumonia*, *Escherichia coli*, *Bacillus subtilis*, and *Pseudomonas aeruginosa*. To fully harness the potential of *Citrus medica* L. peel extract as an antibacterial agent, further research is required to identify the specific antibacterial compounds present in the extract. Additionally, studying its complete spectrum of efficacy against various bacterial diseases is crucial. The broad-spectrum activity of the peel extract against common bacterial pathogens presents an exciting opportunity to discover novel antibacterial substances with clinical efficacy [9].

### **Antiulcer activity**

The aqueous extract of *Citrus medica* Linn, fruits demonstrated a significant reduction in ulcer scores, percentage of ulcers, and ulcer index in rats with ethanol-induced ulcers. The antiulcer outcome of *C. medica* is attributed to the existence of flavonoids among its constituents, as polyphenolic compounds are known for their antioxidant properties and gastroprotective effects. These findings were further supported by histopathological observations, which revealed reduced mucosal ulceration, reduced inflammatory infiltration in the mucosa, and less edema in the submucosa in the groups pretreated with the extract as contrasted with the untreated group. In conclusion, the fruit extract of *Citrus medica* Linn., exhibits antiulcer activity, thus validating its traditional use as a remedy for ulcers [29].

### Estrogenic activity

The petroleum ether extract of *Citrus medica* leaves, when orally administered at a dose of 400mg/kg body weight, led to an increase in uterus weight and exhibited estrogen-like activity in ovariectomized rats. It demonstrated substantial estrogenic action ( $P < 0.05$ ) at this particular dose. This suggests that the extract from *Citrus medica* leaves could serve as an innocuous and natural resource of estrogenic action, potentially beneficial for postmenopausal women [30]. Furthermore, the estrogenic and anti-estrogenic actions of the petroleum ether extract from *Citrus medica* seeds were investigated in albino rats. The results strappingly indicate the extract's potent estrogenic properties, which could be utilized as an antifertility agent [31].

### Research carried out in *Citrus medica* L.

The seeds roots, and leaves of the plant were investigated for their potential antibacterial and antioxidant effects against harmful bacteria that affect humans. The researchers used an agar diffusion assay to determine the antibacterial activity and employed the DPPH assay to assess the antioxidant properties of the extracts. Additionally, they analyzed the total phenolic and flavonoid fillings of the extracts and identified specific compounds like alkaloids, saponins, and tannins.

- The researchers examined the Fruit Juice of the plant to investigate the degradation kinetics of antioxidants and modifications in concentration throughout storage. The findings indicated that the degradation of ascorbic acid for the period of storage monitored a first-order kinetics pattern. Initially, the total phenolic content decreased in the first few weeks of storage, nevertheless over time, it exhibited a gradual increase [32].
- Researchers conducted a comparative analysis of the fruit extracts from *Citrus wilsonii* Tanaka and *Citrus medica* L. to explore their chemical and biological properties. Using an HPLC coupled with a diode array detector, they quantified the constituents present in each extract. The results revealed that *Citrus wilsonii* Tanaka had the highest concentration of naringin, whereas *Citrus medica* L. contained the most significant amount of nomilin [33].
- The researchers utilized the essential oil extracted from the fruit to investigate changes in constituents and antioxidant activity at different stages of development. The composition of certain components, such as  $\alpha$ -thujone, 3-carene,  $\alpha$ -pinene,  $\beta$ -pinene, and  $\gamma$ -terpinene,

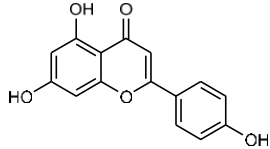
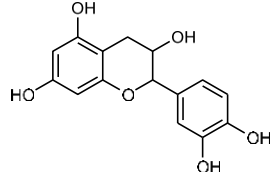
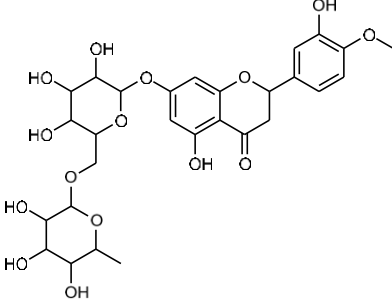
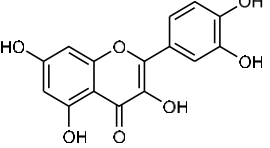
exhibited notable variations during the ripening stages. As the fruit matured during the harvesting period, the antioxidant activities of finger citron essential oils diminished [34].

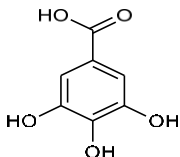
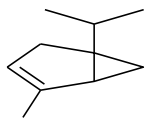
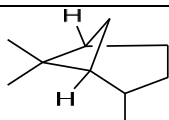
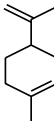
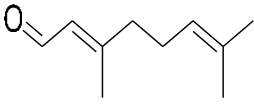
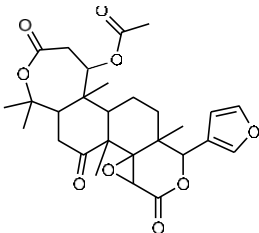
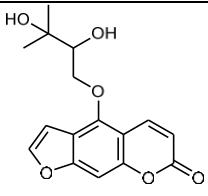
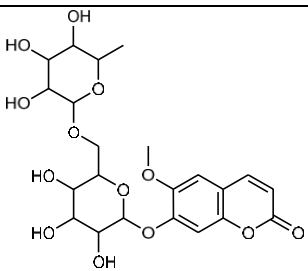
- The researchers investigated the potential antiulcer activity of the aqueous extract of the fruit on rats with ethanol-induced ulcers [35].
- The researchers tested the antimicrobial properties of the plant's fruit, juice, and ethanolic extracts obtained from its root, leaf, bark, peel, and pulp. They evaluated their effectiveness against various harmful microorganisms that can infect humans. These microorganisms included seven bacterial strains (*Bacillus subtilis*, *Staphylococcus aureus*, *Enterococcus faecalis*, *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and *Proteus vulgaris*), as well as two fungal strains (*Aspergillus flavus* and *A. niger*) and a yeast strain called *Candida albicans*. All the tested microorganisms were of clinical origin [29].
- The chemical composition, as well as the antioxidant, anti-inflammatory, and hypoglycemic properties of the plant's flowers, leaves, and fruits, were investigated at two different stages of maturity. The flowers and leaves exhibited the highest total phenol and flavonoid content among all the plant parts analyzed [36].
- The stem, root, and bark of the plant were utilized to identify bioactive compounds with anti-inflammatory properties using a bioassay-guided approach. This led to the discovery of a new coumarin called citrumelo-B, along with thirty known components. Among the anti-inflammatory compounds identified were xanthyletin, nordentatin, atalantoflavon, and lonchocarpol A, which exhibited strong nitric oxide (NO) reducing activity in microglial cells. These findings support the traditional use of *Citrus medica* L. var. *sarcodactylis* Swingle in Chinese medicine for treating allergic reactions and inflammation [37].
- Researchers studied the photo-induced cytotoxic activity of essential oils extracted from the peels of *Citrus bergamia* and *Citrus medica* L. cv. Diamante. The essential oils were obtained through hydro-distillation and analyzed using GC and GC/MS. In *Citrus medica* L. cv. Diamante, the most abundant compounds identified were limonene,  $\gamma$ -terpinene, citral, geranial,  $\beta$ -pinene, and  $\alpha$ -pinene [38].
- The essential oil extracted from the plant's fruits was analyzed, and the major components were found to be d-limonene (51.24%),  $\gamma$ -terpinene (33.7%),  $\alpha$ -pinene (3.40%), and  $\beta$ -pinene (2.88%). Through kinetic analysis of intraperitoneal glucose tolerance (IPGTT) and insulin-

glucose tolerance tests (IGTT), the study confirmed that the plant's insulin secretion had a significant hypoglycemic effect [27].

- The researchers examined the potential of the plant's peel extract to demonstrate antioxidative, anti-inflammatory, and analgesic properties [39].
- The essential oil extracted from the plant's leaves was analyzed for its physicochemical properties and its in vitro antifungal effects on storage fungi of *Arachis hypogaea* L. (groundnut) stored for 6 months, using the disc diffusion agar method. The researchers suggested that the oil could serve as an effective fumigant against storage fungi to preserve stored herb seeds. They highlighted its broad spectrum of activity, non-harmful effects on plants (non-phytotoxicity), and long-lasting efficacy in inhibiting fungi growth [40].

**Structure of some essential phytoconstituents from plant [27, 37-40]**

Phytoconstituents	Compound	Structure
Flavonoids	Apigenin	
	Catechin	
	Hesperidin	
	Quercetin	

	<b>Gallic acid</b>	
<b>Terpene</b>	<b><math>\alpha</math>-Thujene</b>	
	<b><math>\beta</math>-Pinene</b>	
	<b>Limonene</b>	
	<b>Citral</b>	
	<b>Nomilin</b>	
<b>Coumarins</b>	<b>Oxypeucedanin hydrate</b>	
	<b>Haploperoside A</b>	

## CONCLUSION

Over the past few years; there seems to have been an increase in curiosity in using plant-derived extracts as an alternative to conventional medicine, primarily due to concerns about potential adverse effects associated with conventional drugs. This review aims to summarize

the key chemical properties and pharmacological activities of *Citrus medica* L., exploring innovative methods for investigation to exchange knowledge about its therapeutic and nutraceutical properties. *Citrus medica* L. is an ancient wild crop from the citrus family, known for its diverse pharmacological and nutraceutical properties. Various parts of the plant contain phytochemicals that exhibit a range of beneficial activities. These include antioxidant effects, which offer protection against diseases like diabetes, cancer, hypercholesterolemia, and other chronic conditions induced by oxidative stress. Additionally, *Citrus medica* L. has shown antianxiety, antihypertensive, anti-thyroid, estrogenic, antiulcer, and CNS (central nervous system) effects. Furthermore, it has been associated with the prevention of anemia, insecticidal and repellent effects, as well as antifungal properties. Despite the vast potential of *Citrus medica* L. for human health, further research is needed to fully maximize its benefits and explore new possibilities for its application in medical and nutraceutical fields.

#### **ACKNOWLEDGEMENT:**

The authors are thankful to Prof. Dr. Amol Chandekar & and Asst. Prof. Atul Tripathi for providing guidance to prepare this manuscript.

**CONFLICT OF INTEREST:** None

**AUTHOR CONTRIBUTION:** All authors contributed equally.

#### **REFERENCES**

1. Krug CA. Chromosome numbers in the subfamily Aurantioideae with special reference to the genus Citrus. Botanical Gazette. 1943;104(4):602-611.
2. Carvalho R, Soares Filho WS, Brasileiro-Vidal AC, Guerra M. The relationships among lemons, limes, and citron: a chromosomal comparison. Cytogenet. Genome Res. 2005;109(1-3):276-282.
3. Wu GA, Terol J, Ibanez V, López-García A, Pérez-Román E, Borredá C, Domingo C, Tadeo FR, Carbonell-Caballero J, Alonso R, Curk F. Genomics of the origin and evolution of Citrus. Nature. 2018;554(7692):311-316.
4. Platt T, Irwin B, Rao DS. Primary productivity and nutrient measurements on the spring phytoplankton bloom in Bedford Basin. Bedford Institute of Oceanography, Marine Ecology Laboratory. 1973.
5. Debnath S, Hore JK, Dhua RS, Sen SK. Auxin synergists in the rooting of stem cuttings of lemon (*Citrus limon* Burm). South Indian Horticulture (India). 1986;34:123-128.
6. Singh KK, Choudhary T, Prabhat K. Effect of IBA concentrations on growth and rooting of Citrus limon cv. Pant Lemon cuttings. HortFlora Research Spectrum. 2013;2(3):268-270.
7. Singh KK, Krishan C, Singh K. Propagation of citrus species through cutting: A review. J. Med. Plants Stud. 2018;6(1):167-172.
8. Negi SA, Vijay J, Melkani AB. Analgesic activity of fruit decoction of *Citrus medica* Linn. J. Pharm. Res. 2010;3(9):2119-21.
9. Kabra AO, Bairagi GB, Mahamuni AS and Wanare RS. In vitro Antimicrobial Activity and Phytochemical Analysis of the Peels of *Citrus medica*. Int. j. res. pharm. biomed. sci. 2012;3(1):34.



10. Bairagi GB, Kabra AO, Mandade RJ. Anthelmintic activity of *Citrus medica* L. leaves in Indian adult earthworm. Int. J. Pharmtech Res. 2011;3(2):664-667.
11. Khare CP, Indian Medicinal Plants, Springer: New York, USA; 2007.
12. The Wealth of India-Raw Materials, Vol. III, National Institute of Science Communication and Information Resources, New Delhi; 1992.
13. Govindachari TR, Suresh G, Gopalakrishnan G, Masilamani S, Banumathi B. Antifungal activity of some tetranortriterpenoids. Fitoterapia. 2000;71(3):317-320.
14. Bhatia SC, Perfumes and Cosmetics, 1<sup>st</sup> Ed, Vol. II, CBS Publishers and Distributors: New Delhi; 2001
15. Singh G, Singh OP. Chemistry of essential oils of Citrus species. Nat. Prod. Radiance. 2002:8-21.
16. Bhuiyan MN, Begum J, Sardar PK, Rahman MS. Constituents of peel and leaf essential oils of *Citrus medica* L. J. Sci. Res. 2009;1(2):387-392.
17. Panara K, Joshi K, Nishteswar K. A review on phytochemical and pharmacological properties of *Citrus medica* Linn. Int. J. Pharm. Biol. Arch. 2012;3(6):1292-1297.
18. Kirtikar KR, Basu BD. Indian medicinal plants. Vol. 3. International Book Distributors; 1999.
19. Joshi SK, Sharma BD, Bhatia CR, Singh RV, Thakur RS. The wealth of India's raw materials. Council of Scientific and Industrial Research Publication, New Delhi. 1992;3:270-281.
20. Morton JF. Fruits of warm climates. JF Morton; 1987.
21. Grosvenor PW, Gothard PK, McWilliam NC, Supriono A, Gray DO. Medicinal plants from riau province, sumatra, Indonesia. Part 1: uses. J. Ethnopharmacol. 1995;45(2):75-95.
22. Negi SA, Vijay J, Melkani AB. Analgesic activity of fruit decoction of *Citrus medica* Linn. J. Pharm. Res. 2010;3(9):2119-2121.
23. Conforti F, Statti GA, Tundis R, Loizzo MR, Menichini F. In vitro activities of *Citrus medica* L. cv. Diamante (Diamante citron) relevant to the treatment of diabetes and Alzheimer's disease. Phytoter Res. 2007;21(5):427-433.
24. Entezari M, Majd A, Falahian FA, Mehrabian S, Hashemi M, Ardeshiri LA. Antimutagenicity and anticancer effects of *Citrus medica* fruit juice. Acta Medica Iranica 2009;47(5):374-377.
25. Sah AN, Joshi A, Juyal V, Kumar T. Antidiabetic and hypolipidemic activity of *Citrus medica* Linn seed extract in streptozotocin induced diabetic rats. Pharmacogn. J. 2011;3(23):80-84.
26. Menichini F, Tundis R, Loizzo MR, Bonesi M, Liu B, Jones P, Persaud SJ, Mastellone V, Lombardi P, Houghton PJ, Avallone L. C. medica cv Diamante peel chemical composition and influence on glucose homeostasis and metabolic parameters. Food Chem. 2011;124(3):1083-1089.
27. Peng CH, Ker YB, Weng CF, Peng CC, Huang CN, Lin LY, Peng RY. Insulin secretagogue bioactivity of finger citron fruit (*Citrus medica* L. var. Sarcodactylis Hort, Rutaceae). J. Agric. Food Chem. 2009;57(19):8812-8819.
28. Raj RK. Screening of indigenous plants for anthelmintic action against human *Ascaris lumbricoides*: Part--II. Indian J. Physiol. Pharmacol. 1975;19(1).
29. Nagaraju B, Anand SC, Ahmed N, Chandra JN, Ahmed F, Padmavathi GV. Antiulcer activity of aqueous extract of *Citrus medica* Linn. fruit against ethanol-induced ulcer in rats. Adv. Biol. Res. 2012;6(1):24-29.
30. El-Alfy TS, Hetta MH, Yassin NZ, Rahman RF, Kadry EM. Estrogenic activity of *Citrus medica* L. leaves growing in Egypt. J. Appl. Pharm. Sci. 2012;2(8):180-185.
31. Sharangouda PS. Estrogenic activity of ethanolic extract of *Citrus medica* L. on immature albino rats. Int. Jr. Green Pharm. 2007;2:91-94.
32. Shojaemehr M, Alamholo M, Soltani J. Investigation of antibacterial and antioxidant activity of *Citrus medica* L extract on human pathogenic bacteria. Avicenna j. clin. Microbiol. infect. 2020;7(1):8-14.
33. Islam MZ, Dey P, Hoque MM, Monalisa K. Kinetics of antioxidants degradation and quality changes of citron (*Citrus medica*) fruit juice concentrate during storage. J. Microbiol. Biotechnol. Food Sci. 2020;10(2):230-234.
34. Zhao P, Duan L, Guo L, Dou LL, Dong X, Zhou P, Li P, Liu EH. Chemical and biological comparison of the fruit extracts of *Citrus wilsonii* Tanaka and *Citrus medica* L. Food Chem. 2015;173:54-60.
35. Wu Z, Li H, Yang Y, Zhan Y, Tu D. Variation in the components and antioxidant activity of *Citrus medica* L. var. sarcodactylis essential oils at different stages of maturity. Ind Crops Prod. 2013;46:311-316.

36. Sah AN, Juyal V, Melkani AB. Antimicrobial activity of six different parts of the plant *Citrus medica* Linn. *Pharmacognosy J.* 2011;3(21):80-93.
37. Menichini F, Tundis R, Loizzo MR, Bonesi M, Provenzano E, Cindio BD, Menichini F. In vitro photo-induced cytotoxic activity of *Citrus bergamia* and *C. medica* L. cv. Diamante peel essential oils and identified active coumarins. *Pharm. Bio.* 2010;48(9):1059-1065.
38. Chan YY, Li CH, Shen YC, Wu TS. Anti-inflammatory principles from the stem and root bark of *Citrus medica*. *Chem Pharm Bull (Tokyo)*. 2010;58(1):61-65.
39. Sood S, Bansal S, Muthuraman A, Gill NS, Bali M. Therapeutic potential of *Citrus medica* L. peel extract in carrageenan-induced inflammatory pain in rat. *Res. J. Med. Plant.* 2009;3(4):123-133.
40. Essien EP, Essien JP, Ita BN, Ebong GA. Physicochemical properties and fungitoxicity of the essential oil of *Citrus medica* L. against groundnut storage fungi. *Turk. J. Bot.* 2008;32(2):161-164.