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# EXPLORING CITRUS JAMBHIRI: TRADITIONAL USES, PHYTOCHEMISTRY, AND POTENTIAL APPLICATIONS

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## ABSTRACT

Citrus occupies an important place in the fruit economy of the country. *Citrus Jhambhiri* also known as *Jambira Nimbu* in Sanskrit which is indigenous and medium to large tree and belonging to the family Rutaceae. Major production areas of *citrus jambhiri* are India (40 to 45%), China (20 to 25%), Brazil (10 to 15%), Egypt (5 to 10 %), Mexico (5 to 7 %), and Spain (2 to 5%). This is mainly grown in tropical and subtropical climates. In addition to its agricultural significance, *Citrus jambhiri* is also recognized for its medicinal properties. The present study deals with *Citrus Jambhiri* plant, it is a minor type of citrus fruit, which makes up a percentage of the world's citrus production. *Citrus jambhiri* is a rich blend of flavonoids, phenolics, and essential oils provide a variety of pharmacological advantages. Although traditional and exploratory scientific studies have shown promise, more research is required to completely evaluate its therapeutic potential and mechanisms. Here in this review we have discussed pharmacogenetic characteristics, Pharmacological uses etc., were discussed broadly.

**KEYWORDS:** Citrus jambhiri, Rough lemon, Ethnopharmacology, Flavonoids, Phenolic compounds.

## INTRODUCTION

*Citrus jambhiri*, commonly referred to as rough lemon, is a species belonging to the Rutaceae family and is primarily found in South Asia, although its cultivation has spread to various tropical and subtropical regions worldwide. This species is characterized by its rough, thick-skinned fruit, which typically exhibits a high AB acidity level. The fruit is generally small to medium-sized, with a yellow to greenish hue when ripe, and is often regarded as inedible due to its sour taste. However, it has several practical applications, particularly in the agricultural sector. One of the key attributes of *Citrus jambhiri* is its use as a root stock for grafting other citrus varieties.[1] Its robustness and adaptability to a wide range of soil types make it an ideal choice for improving the resilience and yield of grafted citrus trees. The plant demonstrates significant resistance to various pests and diseases, including citrus tristeza virus, which poses a considerable threat to citrus production globally. This resistance enhances the sustainability of citrus farming, particularly in regions vulnerable to such threats. In addition to its agricultural significance, *Citrus jambhiri* is also recognized for its medicinal properties. Traditional medicine systems in some cultures utilize extracts from its leaves and fruit for treating ailments, reflecting its potential in phytotherapy.[2] The essential oils derived from the leaves and fruit are of interest for their antimicrobial and antioxidant properties, further expanding its potential applications. Research into *Citrus jambhiri* has increased in recent years, focusing on its genetic diversity, phytochemical composition, and the potential benefits of incorporating it into breeding programs.[3] Understanding its genetic makeup could unlock pathways for developing new citrus varieties that combine desirable traits such as disease resistance, drought tolerance, and improved fruit quality. In summary, *Citrus jambhiri* serves as a vital species in both agricultural and medicinal contexts. Its adaptability, resilience, and potential health benefits position it as a significant contributor to sustainable citrus production and a resource for further scientific exploration. Continued research is essential to fully harness its capabilities and integrate it into modern agricultural production.

*Citrus jambhiri*, or rough lemon, is native to South Asia, particularly in regions like India and Pakistan. It thrives in subtropical and tropical climates and is commonly found in home gardens, orchards, and wild habitats. The tree is characterized by its thorny branches, large, elongated leaves, and small, acidic fruits. Rough lemon is resilient and adaptable, able to grow in various soil types, although it prefers well-drained, fertile soils. The plant is often used as a root stock for other citrus varieties due to its resistance to certain diseases and pests. Its cultivation is widespread in many parts of the world, and it plays a significant role in local

agriculture and traditional medicine.[4] The leaves, fruit, and peel of *Citrus jambhiri* are utilized for various purposes, including culinary uses, essential oil extraction, and herbal remedies. This plant's medicinal properties, including its anti-spasmodic effects, are gaining recognition, making it a valuable resource for both traditional and modern medicine.

## MORPHOLOGY

*Citrus jambhiri*, or rough lemon can grow up to 3-6 meters. Usually these are bushy appearance with a spreading canopy. The branches are often thorny and the leaves are ever green, alternate and ovate to elliptical in shape which measures about 5 to 10 cm in length. The flowers are small, white to pale purple and fragrant typically which measures 2 to 4 cm in diameter. The fruit is oval to round, averaging 5 to 10 cm in diameter, the skin is thick, bumpy and yellow when ripe, often with a rough texture.[5] The root system is extensive and fibrous, and enabling the tree to access water and nutrients from the soil effectively.[6]

## TAXONOMY

KINGDOM - Plantae

SUBKINGDOM - Tracheobionta

SUPERDIVISION - Magnolipophyta

CLASS – Magnoliopsida

SUBCLASS - Rosidae

ORDER - Sapindales

FAMILY - Rutaceae

GENUS - Citrus L

SPECIES - Citrus jambhiri Lush[7]

**Fig. No1: Rough Lemon.**

## ETHNOPHARMACOLOGY

Ethnopharmacology is the study of how different cultures use natural substances especially plant products for medicinal purposes. *Citrus jambhiri* has been used traditionally used to treat digestive issues such as indigestion, bloating, and constipation. The fruits high citric acid content aids digestion and stimulates appetite. It has been employed in folk medicine for their potential antibacterial and anti-fungal properties. Traditionally often utilize these to treat infections like skin aliments. It is believed to be beneficial in treating arthritis and other inflammatory diseases. It is used to relieve respiratory conditions, including coughs and bronchitis, by acting as a natural expectorant. *Citrus jambhiri* has mood-lifting properties, with essential oils derived from peel used in aromatherapy to reduce stress and anxiety. Many cultures has used *Citrus jambhiri* to ease menstrual cramps providing comfort during menstruation.[8]

## PHARMACOLOGICAL ACTIVITIES RELATED TO DIFFERENT CHEMICAL CONSTITUIENTS

*Citrus jambhiri* is rich in variety of bio active compounds, including flavonoids, limonoids, alkaloids, essential oils, ascorbic acid, and phenolic compounds, which collectively contribute to its diverse pharmacological activities. Its anti-oxidant activity is primarily attributed to flavanoids, vitamin c, and phenolic compounds, which scavenges free radicals and reduce oxidative stress, thus protecting cells from damage linked to chronic diseases like cancer and cardiovascular disorders. The anti-inflammatory properties are mainly due to flavanoids and essential oils, which inhibit inflammatory mediators such as cytokines and prostaglandins, modulating pathways like NF-kB to reduce inflammation.[9] *Citrus jambhiri* also exhibits anti-microbial activity through essential oils, especially against a wide range of bacterial and fungal infections.[10] Furthermore, its anticancer potential stems from flavanoids and limonoids, which induce apoptosis in cancer cells and inhibit tumor progression by modulating key signaling pathways.[11] Lastly, *Citrus jambhiri* shows anti diabetic effects, and anti oxidant effect, with compounds like naringin and hesperidin improving insulin sensitivity and reducing blood sugar levels.[12] These pharmacological activities suggest that *citrus jambhiri* could play a significant role in preventive and therapeutic strategies against several health conditions.

## OTHER PROPERTIES

Some *Citrus* flavonoids and their derivatives in the field of food technology are principally known for their ability to provide a bitter or sweet taste and as bitterness inhibitor. Naringin and neohesperidin convert into their corresponding flavones rhoifolin and neodiosmin leads to loss of bitterness.[13] Some other *Citrus* flavonoids are although tasteless, can alter the taste of fruit juice and other food products. For example, the addition of the flavone neodiosmin to citric juice can significantly reduce the threshold of the bitterness produced by limonin.[14]

### Limonoids

Limonoids are secondary metabolites in all *Citrus* fruits tissue and occur as limonoid glycosides.[15] Limonoidaglycones, in particular limonin have been known and studied in relation to the development of "delayed bitterness" in *Citrus* juices due to the hydrolysis of the corresponding glycosides.[16] Limonoids exhibits a wide range of biological activities including, antioxidant activity[17], antibacterial, anti-fungal, antiviral and cytotoxic activities.[18] In vivo animal tests have been shown that *Citrus* limonoids induce glutathione Stransferase activity and inhibit fore stomach, oral, lung, skin and colon tumors in animals. *In vitro* studies with human breast cancer cells have been shown limonoids to be potent inhibitors of proliferation of estrogen receptor.[19] Limonin could contribute to the cholesterol lowering effect of *Citrus* juice.[20] Nomilin as an agent having anti-obesity and anti-hypoglycemia effects that are likely to be mediated through the activation of TGR5[21] limonin and nomilin in plant products is a significant indicator of the pest control. *Citrus* limonoids (Limonin, nomilin and obacunone) which are obtained from seeds of *Citruslimon* showed antifeedent activity against *Spodopetrafrugiperda* thus confirming their probable role as chemical defense agents in *Citrus*herbivore interactions.[22-25]

### Coumarins

*Citrus*also contain bio active compounds coumarins with potential health promoting properties. *Citrus* oils contain Bergpetan. *Citrus* oils are the biggest contributors to furocoumarin content in fragranced products.[23] UV irradiation is effective in activating essential oils and in particular bergapten. This phototoxicity may be considered as a treatment option in some cases of lentigomaligna. Some coumarins have been shown to possess following activities: Antimicrobial, Antibacterial, Anti-mutagenic, Anti-platelet aggregating, Antioxidant, Anti-inflammatory, Anti Carcinogenic, Rodenticidal activity.[24]

## CHEMICAL CONSTITUENTS

**Essential oils:** The main compounds in *Citrus jambhiri* essential oils include Limonene, Sabinene, beta-myrcene, alpha-terpineol,1,3-tetradecadiene, linalool, Saturated fatty acids, unsaturated fatty acids, oxygenated sesquiterpenes, sesquiterpene hydrocarbons and monoterpenes.[25,26,27] **Minerals:** The peel content (18.35%), moisture content (23.75%), and ash content (2.04*%). Citrus jambhiri* are also a good source of **vitamin C**, which provides 64% of the daily value in a 100g reference amount. Also contains flavanoids, which are antioxidants that can help prevent diseases and boost health.[28,29,30]

**Table No 1: The chemical constituents present in Citrus Jhambhiri.[31,32,33,34]**

| S. No | Chemical constituent | Composition |
|---|---|---|
| 1 | alpha- terpinol | 8.03% |
| 2 | lemonol | 7.67% |
| 3 | citral | 7.00% |
| 4 | 4-terpineol | 6.52% |
| 5 | n-hexadecanoicacid | 4.70% |
| 6 | caryopheliene | 4.58% |
| 7 | beta- bisabolena | 4.01% |
| 8 | alpha- bergamotene | 3.75% |
| 9 | precocene-1 | 3.33% |
| 10 | 1-nonanol | 0.89% |
| 11 | citronellol | 4.38% |
| 12 | decanal | 1.97% |
| 13 | alfol-10 | 1.73% |
| 14 | perillal | 1.30% |
| 15 | neryl acetate | 3.19% |
| 16 | geranyl acetate | 2.44% |
| 17 | acetic acid, chloro-decyl ester | 0.64% |
| 18 | humulene | 1.07% |
| 19 | isocarveol | 0.23% |
| 20 | eicosanoic acid | 0.14% |
| 21 | oleic acid | 3.07% |
| 22 | phytol | 0.23% |
| 23 | dipal mitin | 0.68% |
| 24 | octa decanoic acid | 3.04% |
| 25 | alpha-mono stearin | 1.00% |
| 26 | 4-pentadecyne, 15-chloro | 0.80% |
| 27 | cyclohexane, 2-etheny l - 1, 3, 3 - trimethyl | 3.80% |
| 28 | allyl trisulphide | 0.31% |
| 29 | perillyl acetate | 0.65% |
| 30 | p-menth-3-ene, 2-isopropanyl-1-vinyl-, (1s, 2r) - (-) - | 1.77% |
| 31 | carvone | 2.11% |
| 32 | Cyclohexane, 1-ethenyl-1-methyl-2, 4-bis (1methylethenyl)-, [1s-(1. alpha. 2. beta., 4. Beta.)]- | 1.07% |
| 33 | beta-copaene | 3.09% |

| | | |
|---|---|---|
| 34 | beta-sesquoiphellandrene | 0.22% |
| 35 | squallene | 0.57% |
| 36 | nerolidyl acetate | 2.27% |
| 37 | dodecanoic acid | 0.15% |
| 38 | spathulenol | 0.45% |
| 39 | viridiflorol | 0.42% |
| 40 | alpha-bisabolol | 0.65% |
| 41 | farnesol | 0.15% |
| 42 | (e)-stilbene | 0.35% |
| 43 | 3-methyldiadamanthane | 0.21% |
| 44 | 2,6,10 trimetnyl-2,6,9,11-dodecatetraenal | 0.45% |
| 45 | Sphiro [androst-5-ene-17,1'-cyclobutan]-2'-one, 3-hydroxy-, (3.beta.,17.beta.)- | 0.08% |
| 46 | methyl 16-hydroxy-hexadecanoate | 0.06% |
| 47 | (6e)-nerolidol | 0.64% |
| 48 | 9,9 dimethoxybicyclo [3.3.1] nona-2,4-dione | 0.51% |
| 49 | 2-4-diflorobenzene,1-benzyloxy | 0.29% |
| 50 | dipalmitin | 0.68% |
| 51 | palmitin,2-mono | 2.15% |
| 52 | oleic acid chloride | 1.21% |

## QUANTIFICATION TECHNIQUES

### Flavonoids

It involves various analytical techniques, with High-performance liquid chromatography [HPLC] being the most widely used due to its high sensitivity, specificity, and capacity to separate complex mixtures. HPLC allows for the identification and quantification of specific flavanoid compounds like quercetin, kaempferol, and hesperidin, using UV detection at specific wavelength (typically between 254 nm and 360 nm). Another popular method is **spectrophotometry**, which, through the aluminium chloride colorimetric assay, estimates the total flavonoid content by measuring the total flavonoid content by measuring the absorbance at around 415-430 nm. This method is quick and cost-effective but only provides an estimate of the total flavanoid content rather than individual compounds. **Thin layer chromatography (TLC)** is a simpler, more affordable method that allows for the separation and visualization of flavanoid compounds, through it is less sensitive and precise compared to HPLC. **Capillary electrophoresis (CE)** offers high resolution and sensitivity, separating flavanoids based on their charge and size, while **Liquid chromatography- Mass spectrometry (LC-MS)** is a highly advanced technique combining chromatography with mass spectrometry to provide detailed structural information and quantity flavanoids with unparalleled accuracy. Each technique has its advantages, with HPLC and LC-MS offering the most precise and comprehensive analysis for flavonoids profiling in *Citrus jambhiri*.[35,36,37]

**Formula: C=cV/m**

Where, C=Total flavonoid content

c = Concentration

V = Volume of extract

m = Mass of extract

**Limonoids:** Quantification of limonoids is typically performed using High performance liquid chromatography (HPLC), which separates and identifies specific limonoids, and Gas chromatography- mass spectrometry (GC-MS), which offers high sensitivity for volatile compounds. Spectrophotometry can also be used for preliminary quantification, though it is less specific. Over all, limonoids in *Citrus jambhiri* represent an important class of phytochemicals with significant health-promoting potential, making their analysis crucial for both nutritional and pharmaceutical applications.[38]

**Formula:** Accuracy = ([experimental mass-theoretical mass]x theoretical mass-1x 1000000) ppm.

**Coumarins:** Quantifying coumarins typically involve **High performance liquid chromatography (HPLC),** which separates and identifies specific coumarin compounds and **Gas chromatography-Mass spectrometry (GC-MS),** which offers high sensitivity for detecting volatile derivatives. Spectrophotometry can be also used for general quantification. The health-promoting effects of coumarins, including their ability to reduce oxidative stress, inflammation, and microbial activity. Make them valuable for both nutritionally and medicinally. Their presence in *citrus jambhiri* highlights their fruits potential as a source of beneficial bio active compounds.[39]

**Formula:** Coumarin content (mg/kg) = x X 10mg/kg

**Essential oils:** For accurate quantification, **Gas chromatography (GC) and Gas chromatography- Mass spectrometry (GC-MS)** of the most commonly employed techniques, offering precise identification and measurement of the various volatile compound in the oil. The essential oil of *citrus jambhiri* is not only valued for its pleasant fragrance but also for its potential health benefits, making it an important bio active extract in the citrus family.[40]

**Formula:** DENSITY; **d =m/v**

Where'd= density

m = mass

v = volume

Yield; **Rou=(M/Bm) x100**

Where, M=mass of extracted oil

Bm =initial plant biomass

**Phenolic compound:** Quantification is often done using **High performance liquid chromatography (HPLC)**, which separates and identifies individual phenolics, or the folio-ciocalteu method, a calorimetric assay that estimates the total phenolic content by measuring absorbance at a specific wavelength. These phenolic compounds are not only important for their health beneficial but also contributes to the characteristic flavour and aroma of *citrus jambhiri*, making them a valuable component of the fruits chemical profile.[41]

**Formula: C=cV/m**

Where, C=Total phenolic content

c = concentration

V = volume of extract

M = mass of extract

**Alkaloids:** Quantified through techniques like **Thin layer chromatography (TLC)** for semi quantitative analysis, or **High performance (HPLC)** and **Gas chromatography- Mass spectrometry (GC-MS)** for more precise identification and quantification. Despite their lower prevalence in citrus, alkaloids could contribute to the fruit's bioactivity, adding to its overall medicinal potential.[42]

**Formula:S C=A-b/m**

Where, C=concentration of alkaloid

A= area under the peak

b =Y- intercept of the calibration curve

m =slope of the calibration curve

**Side Effects:** *Citrus jambhiri*, or rough lemon, is generally considered safe for most people when consumed in moderate amounts. However, there are potential side effects and considerations to be aware of some individuals may experience allergic reactions, such as skin rashes or respiratory issues, after consuming or handling the fruit. High acidity can lead to stomach upset, heartburn, or acid reflex, especially in sensitive individuals. Citrus oils, including those from *Citrus jambhiri*, can increase skin sensitivity to sunlight, potentially leading to sunburn or skin irritation. Citrus fruits may interact with certain medications,

particularly statins and some anti-hypertensives. It's important to consult a healthcare provider if you're on medication. The high acidity of the juice can erode tooth enamel if consumed in large quantities or not followed by proper oral hygiene. *Citrus jambhiri* may have mild diuretic properties, leading to increased urination, which can cause dehydration if fluid loss.[43-46]

## CONCLUSION

This review shows us different details about the plant *Citrus jambhiri.* The *citrus jambhiri* is a raw material that can be used in different forms. This review shows the following details of *citrus jambhiri; Citrus jambhiri* is an important species within the citrus family, valued for its hardness, 1culinary uses and role in agriculture. Understanding its existence and promoting its cultivation can contribute to sustainable practices and biodiversity conservation. The morphology of *citrus jambhiri* showcases its adaption to various environments, making it a resilient species within the citrus family. Its distinct physical characteristics contribute to its utility in agricultural and horticulture. Understanding the taxonomy of *citrus jambhiri* is essential for its conservation, cultivation and utilization in agriculture and horticulture, as well as for the broader study of citrus genetics and breeding. It holds significant ethnopharmacological value, with a rich history of use in traditional medicine and growing interest in its therapeutic potential. The chemical composition of citrus jambhiri underscores its potential health benefits making it valuable in both culinary and medicinal contexts. Various Iextraction methods can be employed to isolate valuable compounds from *Citrus jambhiri*, each with its advantages and specific applications. While *Citrus jambhiri* offers several health benefits it should be taken in moderate range. If it is taken in high amount side effects may be shown.

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