Traditional utilization and pharmacology of *Cinnamomum glanduliferum*: a review on current research status

Shaiphali SAXENA¹*, Pasumarti B. RAO²

¹Government Post Graduate College, Department of Botany, Manila 263667, District Almora, Uttarakhand, India; defalsaxena1192@gmail.com

²G.B. Pant University of Agriculture & Technology, Department of Biological Sciences, College of Basic Sciences & Humanities, Pantnagar-263145, Uttarakhand, India; pasumartib658@gmail.com

Abstract

*Cinnamomum glanduliferum* (Wall.) Meisn from Lauraceae, commonly referred to as ‘Nepal camphor tree’ or ‘false camphor tree’, is mainly known for its spice qualities and aromaticity. The pleasant aroma mainly develops due to the presence of valuable phytoconstituents in the form of terpenes and volatile hydrocarbons conferring the plant species a camphor substitute. Bulk of studied researches on *C. glanduliferum* segregated and not well documented. This study however attempted to congregate the fragmented data based on the ethnomedicinal, pharmacological and biochemical properties along with the other miscellaneous data. Results authenticated sparse documentation on the ethnomedicinal, pharmacological and biochemical properties of *C. glanduliferum* thus pointed to the untapped information on the various potentials of the plant. Exploring its sustainable utilization, pharmacological, biochemical and nutraceutical potentials are recommended.

**Keywords:** biological and pharmacological activities; *C. glanduliferum*; ethnomedicinal properties; genome; patents; phytoconstituents; taxonomic classification

Introduction

The genus *Cinnamomum* is coming from ‘kinnamomon’ (Greek), which means both the ‘sweet wood’ and ‘spice’. In 1760, this genus was mentioned, for the first time, by Schaeffer. There are about 250 to 300 species of this genus worldwide, 26 species from India, out of which 12 species are concentrated to the north-eastern parts of India (Ranasinghe et al., 2012; Singh et al., 2013; Kumar et al., 2019). The leaves of the genus are extensively utilized for essential oil production and in the form of food spices as the leaves upon crushing emit spicy odour with good taste (Prasad et al., 2009). Previously, several biochemical, pharmacological and ethnobotanical research studies have been accomplished on different species of the genus. Surprisingly, the research information on *Cinnamomum tamala* concerning its pharmaceutical and biochemical potential is inestimable. However, the research work done on *C. glanduliferum* is very sparse hitherto.
*Cinnamomum glanduliferum* (Wall.) Meisn is distributed in India (Assam, Tripura, Arunachal Pradesh, Meghalaya and Uttarakhand), Bhutan, China, Nepal, Malaysia, Tibet and Myanmar, and is considered to be the native of tropical Himalayan regions of India and Nepal (Figure 1). In India, the plant is found at an elevation of 1200-2500 m in both the plains and hills, and named as ‘Gondroroi tree’. All parts of the plant are aromatic due to the presence of essential oils enriched with cineole, nerolidol, borneol, pinene, terpeniol, camphor, etc. as major phytochemicals (Azab et al., 2017; Zhao et al., 2019; Geethakumary et al., 2021). The plant wood possesses d-camphor, a good substitute of Sassafras, while the leaf essential oil having cineole emits camphor-like odour (Baruah and Nath, 2006). In the United States of America, the approximate market price for its oils falls under 10 to 20 USD per kilogram for the purpose of pesticides (Jianget et al., 2012). The plant species having forest habitat is though kept under the ‘least concern’ category of IUCN Red Data Book in the year 2019 but it is continuously being declined in the occupancy areas (https://iucnredlist.org; Liu and Liu, 2019; Geethakumary et al., 2021).

**Study purpose**

The previous research information on the ethnomedicinal, biochemical and pharmacological properties *C. glanduliferum* is fragmented, scarce and not well-documented. This review was geared towards the compilation of the ethnomedicinal, pharmacological and biochemical properties of *C. glanduliferum* thus along with other miscellaneous information.

![Figure 1. The map showing extant of *C. glanduliferum* in the world and occurrence in India](image)

**Strategy of Literature Search**

The information for the present review was compiled by searching previous studies conducted on the reference plant species from December, 2021 to January, 2022 (Figure 2). The accessible primary and secondary research study sources of 31 years were searched and reviewed using Google Scholars (http://scholar.google.com).
Taylor and Francis (https://tandfonline.com/), Science Direct (http://www.sciencedirect.com), Wiley online library (https://onlinelibrary.wiley.com/), MDPI (https://www.mdpi.com/), PubMed (https://pubmed.ncbi.nlm.nih.gov/), NCBI (https://www.ncbi.nlm.nih.gov/), Google Patents (https://patents.google.com/), European Patents (https://www.epo.org/) , United States Patent and Trademark Office (https://www.uspto.gov/) and Indian Patent Office (https://ipindia.gov.in/advanced-search.htm?keysrch) published from 1991 to 2022. The validation of plant species name was done by accessing The Plant List (2013). Searches were made using the following keywords- *Cinnamomum*, *C. glanduliferum*, taxonomic classification, medicinal properties, patents, phytoconstituents, biological and pharmacological activities. The research data about *C. glanduliferum* in English was limited and some work was inaccessible. Hence, for obtaining the additional research information on the plant species, manual search option was adopted by using cited references, websites and other sources of included papers. The searched data were included on the basis of the presence of reference plant species name and English language, while excluded due to the duplication and other languages. After that, the full titles and abstracts were read for further article screening and again the search studies were excluded due to the absence of the keywords and full text articles. Consequently, the remaining searches were selected and kept for the present review analysis.

**Figure 2.** Strategy of searching the literature

**Taxonomy and Botanical Description**

Kingdom: Plantae  
Clade: Tracheophytes  
Clade: Angiosperms  
Clade: Magnoliids  
Order: Laurales
Family: Lauraceae
Genus: Cinnamomum
Species: C. glanduliferum

*Cinnamomum glanduliferum* (Wall.) Meisn. is an accepted name with five synonym namely *Camphora glandulifera* (Wall.) Nees, *Cinnamomum cavaleriei* H. Lév., *Machilus dominii* H. Lév., *Machilus mekongensis* Diels and *Laurus glandulifera* Wall. (also, a basionym) according to The Plant List and International Plant Name Index (The Plant List, 2013; IPNI, 2021). Subglaibrous leaves are alternate with 1.5-3 cm petiole, elliptic to lanceolate (6-15 × 4-6.5 cm). Panicle (4-10 cm) is axillary with 2-4 cm glabrous peduncle and 1-2 mm short pedicels. Flowers (3mm) are small, fragrant, inconspicuous, yellowish with sparsely white 6-lobed perianth. First and second whords of stamens have complanate filaments, ovate filament-sized introrse anthers with only 9 fertile stamens. Each stamen of the third whord contains two cordate short-stalked glands near the base with oblong and extrorse anthers (1mm). Triangular staminodes are 3 including pubescent stalk (<1 mm). Ovary is ovoid (1.2 mm), glabrous with slender style (1.2 mm) and 3-lobed discoid stigma. Fruits are globose (1 cm diameter) and black drupes. Flowering occurs during March to May and fruiting in July to September (WFO, 2022).

**Plastid Genome**

Approximately 152715 bp (base pair) long chloroplastidian genome of *C. glanduliferum* comprises a long single copy (LSC) of 937617 bp (70.60%), a small single copy (SSC) of 18870 bp (14.23%), and a pair of inverted repeats (IR) of 20114 bp (15.17%) with 39.1% G+C content (Figure 3). This plastome construction shows its phylogenetic relationship with *C. bodinieri* under the genus *Cinnamomum* (Zhao et al., 2019).

![Figure 3. A hypothetical structure of plastid genome of *C. glanduliferum*](image)

**Plant as a Host**

The host plants in the sericulture have crucial role for maintaining the quality and quantity of the silk produced. According to the previous studies, *C. glanduliferum* has been a great host for the polyphagous or non-mulberry silkworms (Tikader and Kamble, 2010). The plant has been reported to rear the larvae of *Antheraea assama* (muga silkworm of Assam) on its leaves. The rearing duration (29 days) and effective reproductive rate (60.00%) of larvae on the plant were significantly higher as compared to the other studied plant species namely *Machilus bombycina* (25 days and 57.40%) and *Liisaea polyantha* (25 days and 52.00%)
(Ram and Samson, 1991). The plant is also reported to rear *Samia ricini* (ersilkworm) as a tertiary host (Das *et al.*, 2020).

**Ethnomedicinal and Traditional Uses**

The Hill Miri and Tagin tribes of Arunachal Pradesh use *C. glanduliferum* bark with rice and *Solanum nigrum* leaves for preparing starter culture prepared within 7 to 10 days that can be stored up to 6 months (Shrivastava *et al.*, 2012). About 5mL of stem bark and leave juice is given thrice a day for treating cough in Mizoram (Sharma *et al.*, 2001). The roots of *C. glanduliferum* are used treat toothache, wounds and diabetes, while the leaves are used in the management of cough, cold as well as carminative, analgesic, astringent, antiseptic, anti-rheumatic and stimulant. The plant bark relieves kidney troubles and hook warm expulsion. The kernel fat of fruits is utilized for industrial purposes, while the seeds help in medicating toothache, cold, cough, taeniasis, body ache, joint pain, muscular swelling and spasm. Its timber is used for household purposes and furniture making such as cabinet, decoration and plywood manufacturing (Greeshma *et al.*, 2006; Shu *et al.*, 2008; Doley *et al.*, 2009; Joshi *et al.*, 2016; Kumar and Kumari, 2019). The decoction from crushed fruits of *C. glanduliferum* comprises the antipyretic and insect repellent qualities (Xiong *et al.*, 2020).

**Pharmacological and Clinical Studies**

*Anti-inflammatory and Gastroprotective Activity*

Azab *et al.* (2017) investigated the gastroprotective and anti-inflammatory activities of essential oil extracted from green branches and leaves of *C. glanduliferum* by ethanol-induced gastritis and carrageenan-induced Wistar rat paw-oedema methods, respectively. The volatile oil doses at 250, 500 and 1000 mg/kg concentrations significantly suppressed the gastritis by reducing the nitric oxide content (32, 37 and 41 μM nitrate/g) and lipid peroxidation inhibition (1.15, 1.11 and 1.04 nmol/g). The volatile oil from leaves with 4 hrs treatment on rat reduced the paw volume (93.75±1.3, 81.6±3.3 and 69.14±1.9%) and oedema inhibition (59.8, 47.65 and 55.6%) at 250, 500 and 1000 mg/kg doses, respectively at significant level. Further, the anti-inflammatory inhibition was confirmed by inhibition of COX-2 activity (73.8, 50.7 and 21.4 nmol/min/mL) PGE2 concentration (2.95 ± 0.2, 2.45 ± 0.15 and 1.75 ± 0.015 pg/mL) for the same concentrations.

*Antimicrobial and anticancer potential*

In cytotoxicity test via brine shrimp lethality assay, the LC50 (μg/mL) values for *C. glanduliferum* leaf and bark ethanol extracts were reported to be 87 and 110.3 (Maridass, 2008). Singh *et al.* (2013) assessed the antimicrobial activity of *C. glanduliferum* essential oil against ten foodborne microbial strains. The best minimum inhibitory concentration (μg/mL) was exhibited against *Aeromonas salmonicida* (1.72) > *Escherichia coli* and *Pseudomonas aeruginosa* (3.43) > *Micrococcus luteus* (6.86) > *Staphylococcus aureus* (11.66) and > *Erwinia herbicola* (13.73).

Mohamed *et al.* (2016) investigated the antibacterial activity of *C. glandulifera* leaf essential oil against six bacterial pathogens. The plant essential oil exhibited highest antibacterial potential than other studied plant species with minimum inhibitory concentration (μg/mL) as 0.49 (for *Staphylococcus aureus* and *Klebsiella pneumoniae*) > 0.98 (for *Streptococcus pneumoniae* and *Escherichia coli*) > 3.9 (for *Methicillin-Resistant Staphylococcus aureus*).

Taha and Eldabshan (2017) assessed the antimicrobial and anticancer potential of *C. glanduliferum* bark essential oil. The bark oil showed better minimum inhibitory concentration (μg/mL) against *Escherichia*
coli (0.49) < Bacillus subtilis (0.98) < Geotricum candidum (1.95) < methicillin-resistant Staphylococcus aureus (7.81) and = Pseudomonas aeruginosa (7.81), while maximum zone of inhibition (mm) against Mycobacterium tuberculosis (43.25±1.5) > Escherichia coli (25.3±1.0) and > Bacillus subtilis (22.4±0.58). The anticancer potential of bark oil showed cytotoxicity IC_{50} (µg/mL) against HCT-116 (human colon carcinoma cell line) HepG2 (human hepatocellular carcinoma cell line) and MCF-7 (human breast carcinoma cell line) as 9.1, 42.4 and 57.3, respectively.

**Insecticidal property**

The insecticidal potential of *C. glanduliferum* essential oil against third instar *Trichoplusia ni* larvae (cabbage looper) was studied by Jiang et al. (2012). The mortality rate (%) for the topical application method at 200 µg/larva was 80.8 (LD_{50} = 76.0 µg/larva) and for fumigation bioassay at 50 µL/L was 100.0 (LC_{50} = 29.7 µL/L).

**Phytochemistry**

From our review, *C. glanduliferum* contains total of 76 different kinds of phytoconstituents belonging to various classes summarized in Table 1. Class wise, about 36.84% monoterpenes (19-46), 35.53% sesquiterpenes (50-76), 13.16% hydrocarbons (9-18), 5.26% alcohols (1-4), 3.95% aldehydes (5-7), 3.95% phenylpropenes (47-49), and 1.32% fatty acids (8) are present; while about 70.48% leaf, 13.33% stem, and 16.19% bark have been used for the essential oil extraction to characterize its phytoconstituents.

**Table 1. List of phytoconstituents reported in C. glanduliferum**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Compound</th>
<th>Part Used</th>
<th>M.F.</th>
<th>M.W.</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2-propen-1-ol</td>
<td>L</td>
<td>C_{3}H_{6}O</td>
<td>58.08</td>
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<tr>
<td>2</td>
<td>2-methyl-3-buten-2-ol</td>
<td>L</td>
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<tr>
<td>3</td>
<td>2-methyl-2-propenal</td>
<td>L</td>
<td>C_{4}H_{6}O</td>
<td>70.09</td>
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<tr>
<td>4</td>
<td>3-methyl-1-penten-3-ol</td>
<td>L</td>
<td>C_{8}H_{14}O</td>
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<tr>
<td>5</td>
<td>Dodecanal</td>
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<td>C_{12}H_{26}O</td>
<td>184.32</td>
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<td>6</td>
<td>Cinnamic aldehyde</td>
<td>L</td>
<td>C_{9}H_{8}O</td>
<td>132.16</td>
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<td>7</td>
<td>Tetradecanal</td>
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<td>8</td>
<td>Linoleic acid</td>
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<td>9</td>
<td>(E)-Phytol acetate</td>
<td>L, S</td>
<td>C_{22}H_{36}O_{2}</td>
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<tr>
<td>11</td>
<td>Sabinene</td>
<td>L, S, B</td>
<td>C_{16}H_{16}</td>
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<td>12</td>
<td><em>trans</em>-sabinenehydrate</td>
<td>L</td>
<td>C_{10}H_{16}O</td>
<td>154.25</td>
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<tr>
<td>13</td>
<td><em>cis</em>-sabinenehydrate</td>
<td>L</td>
<td>C_{10}H_{16}O</td>
<td>154.25</td>
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<tr>
<td>14</td>
<td>Eugenol</td>
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<td>C_{10}H_{15}O</td>
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<tr>
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<td>Propanoic acid</td>
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<td>16</td>
<td>(E)-2-pentenal</td>
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<td>17</td>
<td>2,6-octadien-1-ol</td>
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<td>C_{8}H_{14}O</td>
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<tr>
<td>18</td>
<td>Benzyl benzoate</td>
<td>L</td>
<td>C_{13}H_{12}O_{2}</td>
<td>212.25</td>
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</table>

**Monoterpenes**

<p>| | | | |</p>
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<td>19</td>
<td>p-cymene</td>
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<td>C_{10}H_{16}</td>
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<tr>
<td>20</td>
<td>(E)-(\beta)-ocimene</td>
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<td>C_{10}H_{16}</td>
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<td>21</td>
<td>Geraniol</td>
<td>L</td>
<td>C_{10}H_{18}O</td>
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<td>22</td>
<td>Linalool</td>
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<td>23</td>
<td>(\beta)-pinene</td>
<td>L, S, B</td>
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<td>(\beta)-myrcene</td>
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<tr>
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<td>(\alpha)-terpinene</td>
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<tr>
<td>26</td>
<td>(\alpha)-pinene</td>
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<tr>
<td>42</td>
<td>Carvone</td>
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<td>Myrtenal</td>
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<td>α-thujene</td>
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<td>cis-pinocarveol</td>
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<td>3-allyl-6-methoxyphenol</td>
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<td>48</td>
<td>Methyl isoeugenol</td>
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<td>49</td>
<td>Elemicin</td>
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<td>(E)-nerolidol</td>
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<td>52</td>
<td>α-humulene</td>
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<td>β-selinene</td>
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<td>Guaiol</td>
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<td>α-selinene</td>
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<td>56</td>
<td>Germacrene D-4-ol</td>
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<td>57</td>
<td>Alloaromadendrene</td>
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<td>Calarene</td>
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<td>60</td>
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<td>63</td>
<td>Naphthalene,1,2,3,4,4a,7-hexahydro</td>
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<td>Viridiflorol</td>
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<td>C_{15}H_{24}</td>
</tr>
<tr>
<td>74</td>
<td>d-cadinene</td>
<td>L</td>
<td>C_{15}H_{24}</td>
</tr>
<tr>
<td>75</td>
<td>α-muurolene</td>
<td>L</td>
<td>C_{15}H_{24}</td>
</tr>
<tr>
<td>76</td>
<td>α-cadinol</td>
<td>L</td>
<td>C₁₃H₂₀O</td>
</tr>
<tr>
<td>----</td>
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<td>---</td>
<td>---------</td>
</tr>
</tbody>
</table>

**Note:** Part used: L= leaf, S= stem, B= bark; M.F.= molecular formula; M.W.= molecular weight.

**Source:** Baruah and Nath, 2006; Liet al., 2013; Singh et al., 2014; Jian et al., 2016; Taha and Eldahshan, 2017; Kumar et al., 2019

**Patents Filed**

The patents help in conserving the innovative research works done by the inventors or applicants so that they can have proper rights to protect their inventions, knowledge and novel researches by excluding other people to exploit them (Saxena, 2020). The following patent text (containing title, application number, inventor, publication date and reference) is clearly indicating that all the patents applications filed on *C. glanduliferum* belong to the field of medicines and pharmacology. Moreover, these patents reports are very recent (from 2011 to 2017) and have Chinese origin. All the patent applications filed till now are mentioned hereunder.

1. **Title:** *Cinnamomum glanduliferum* seed oil-containing lotion capable of moisturizing and caring skin and preparation method thereof.
   **Application number:** CN104434636A
   **Inventor:** Qing 2015a
   **Publication date:** 25-03-2015

2. **Title:** Natural moisturizing cream containing Yunnan camphor treeseed oil.
   **Application number:** CN104323955A
   **Inventor:** Qing 2015b
   **Publication date:** 04-02-2015

3. **Title:** Tibetan incense and preparation method thereof.
   **Application number:** CN104600587A
   **Inventor:** Zhaxi wangmu and Luobu, 2015
   **Publication date:** 29-07-2015

4. **Title:** Purely-natural facial cleanser capable of deeply decontaminating and controlling oil and preparation method thereof.
   **Application number:** CN104434639A
   **Inventor:** Qing 2015c
   **Publication date:** 25-03-2015

5. **Title:** Traditional Chinese medicine composition for treating wind-cold tightening superficies type cold.
   **Application number:** CN104984125A
   **Inventor:** Huaying 2015
   **Publication date:** 21-10-2015
6. Title: Healthcare tea and making method thereof.
   Application number: CN105148150A
   Inventor: Shaozhong, 2015
   Publication date: 16-12-2015
   Reference: https://worldwide.espacenet.com/patent/search/family/054789411/publication/CN1051481

7. Title: Saffron crocus dissolved medicine and preparation method thereof.
   Application number: CN102078479A
   Inventor: Zhang, 2011
   Publication date: 01-06-2011
   Reference: https://worldwide.espacenet.com/patent/search/family/044084803/publication/CN1020784

8. Title: Pre-operation anesthetic and preparation method thereof.
   Application number: CN105853519A
   Inventor: Li and Haiqing, 2016
   Publication date: 17-08-2016
   Reference: https://worldwide.espacenet.com/patent/search/family/056649903/publication/CN1058535

   Application number: CN105920140A
   Inventor: Fengsheng, 2016
   Publication date: 07-09-2016

10. Title: Traditional Chinese medicine composition for treating wind-cold-damp type entrapment syndrome of superior clunial nerves.
    Application number: CN106955310A
    Inventor: Xia, 2017
    Publication date: 18-07-2017
    Reference: https://worldwide.espacenet.com/patent/search/family/059480725/publication/CN1069553

11. Title: Traditional Chinese medicine preparation for treating children bronchial asthma and preparation method thereof.
    Application number: CN105288200A
    Inventor: Linben and Xiaofei, 2016
    Publication date: 03-02-2016

12. Title: Traditional Chinese medicine preparation for treating shoulder joint instability and preparation method.
    Application number: CN105796721A
    Inventor: Zebing and Bingxiu, 2016
    Publication date: 27-07-2016
    Reference: https://worldwide.espacenet.com/patent/search/family/056455932/publication/CN1057967

13. Title: Medicine used for treating infantile hip joint dropsy and preparation method thereof.
Application number: CN105031282A
Inventor: Yining 2015
Publication date: 11-11-2015

Application number: CN105664025A
Inventor: Lizhi, 2016
Publication date: 15-06-2016

15. Title: Oral-administration medicine treating anal cryptitis.
Application number: CN105267796A
Inventor: Fukui and Chunli, 2016
Publication date: 27-01-2016

Discussion

Astonishingly, a very few research studies have been conducted on the genomic, biochemical, ethno-botanical and pharmaceutical properties of C. glanduliferum, leading to the scarce and fragmented research status of the reference plant species despite of 31 years of researching on same plant according to this review. Furthermore, our review showed that most of the researches on C. glanduliferum were mostly focused on patents (34.88%), ethnomedicines (18.60%), phytoconstituent characterization (13.95%), geographical distribution (9.30%), antimicrobial studies (6.98%), sericultural practices (6.98%), cytotoxicity (4.65%), insecticidal activity (2.33%) and anti-inflammatory potential (2.33%). Most of the researches done on C. glanduliferum till date have been conducted among the years of 2011 to 2020 (Figure 4). C. glanduliferum can be one of the best host plants in the sericulture sectors in India for maintaining the quality and productivity of different types of silks. This quality may be due to the presence of valuable phytocompounds present in its leaves supporting the reproductive rate of the silkworms. Among the reported phytoconstituents of C. glanduliferum, monoterpenes and sesquiterpenes are maximum. Noticeably, the patent applications filed on C. glanduliferum are more in number as compared to their biological and pharmacological research studies. Moreover, all the patents, according the present review research, are owned by China. This can be due to the wild occurrence and availability of the plant species in China. Another possible reason of more Chinese patents may be the consequence of maximum attention paid on researches and related activities in the fields of medicines than other nations (Indian subcontinents) where the plant species is distributed. Now C. glanduliferum has also been introduced into the northeast Argentina according to the information searched on The Plants of the World Online (POWO, 2022).
Conclusions

The aromatic and medicinal plant species are largely viewed as valuable remedial sources. The present review on C. glanduliferum highlights its distribution, taxonomy, phylogeny, ethnobotanical, phytochemical and pharmacological aspects. The pharmacological activities conducted on C. glanduliferum show very recent findings (2008 to 2017), which need further attention to be studied by the future researchers. Although, the IUCN Red Data Book categorized the plant species as ‘least concern’ in the year 2019, but plant is facing the uninterrupted threats of being dwindled in its natural areas apparently due to the lack of adaptation ability of the plant, less genetic diversity, improper conservation and management strategies, and manual picking of its bark for spices and medicinal purposes. This action will surely lead the plant species towards vulnerability. So, the proper distribution strategies and deliberate introduction of the plant species are urgent appeal for sustaining its long-term survival.

Authors’ Contributions

Both authors read and approved the final manuscript.

Ethical approval (for researches involving animals or humans)

Not applicable.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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