**TERMINALIA CHEBULA: SUCCESS FROM BOTANY TO ALLOPATHIC AND AYURVEDIC PHARMACY**

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**ABSTRACT**

*Terminalia chebula* (TC) is a unique herb having various therapeutic potentials as anti-inflammatory, antioxidant, anticancer, and digestant. It belongs to family Combretaceae. In the present review, an attempt has been made to decipher classification, chemical constituents, therapeutic uses, and patents that have been reported for TC. Various pharmacological activities of TC that make it as potential medicine and its Ayurvedic formulations are highlighted.

**Keywords:** *Terminalia chebula*, Anti-oxidant, Anti-cancer, Ayurvedic formulations, Anti-oxidant.

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**INTRODUCTION**

*Terminalia chebula* (TC) is a unique herb that is used from ancient time since Charak. It is used in many herbal formulations like Triphala. It is used as anti-inflammatory and digestant [1-3]. In recent years, an extract of TC has been reported for having anticancer and antioxidant properties [1-3]. TC belongs to Kingdom: Plantae, Division: Magnoliophyta, Class: Magnoliopsida, Order: Myrtales, Family: Combretaceae, Genus: *Terminalia*, Species: *Chebula* Retz [4,5].

It is known by different names in different languages such as Harad in Hindi, *Haritaki* in Sanskrit, *Chebula* in English, Karakkaya in Telugu, and in Tamil known as *Kadukkai*. Some other synonyms of TC are *Amrta*, *Abhya*, *Kayasha*, *Vayasha*, *Patthya*, *Vijaya*, *Siva Jaya*, and *Haimavti*.

**CATEGORIZATION OF TC AS PER AYURVEDA**

TC has different varieties and the information of these varieties differ in Ayurvedic and modern text [6,7].

**Categorization as per Bhavamisra**

Acharya Bhavamisra mentioned about different varieties of *Haritaki* in his text. He explained about number of different varieties along with their uses are given below:

1. **Vijya** – used for *sarvarog* (all diseases)
2. **Bhohini** – used as *varan* (bearing wound healing property)
3. **Putana** – used as prople (external applications)
4. **Amrta** – used for *shodhan* (purification procedures)
5. **Abhya** – used for *netrarog* (eye diseases)
6. **Jivani** – used for *sarvarog* (all diseases) [6].

**Categorization as per Indian Materia Medica**

Different varieties along their morphological characters and uses according to Indian Materia Medica are given below.

**Survariharade**

Large, dense and heavy size about 2" long, yellowish to brownish in color, when cut it contains pulp of yellowish to brownish tinge. This variety is valuable purgative.

**Rangariharade**

These are smaller in size, less wrinkled, and less furrowed than *Survariharade* and its length is about one inch; when cut it presents a yellow dried pulp and stone. The pulp is also less astringent than above variety. These are alterative, stomachic, laxative, and tonic. It is generally used in fevers, cough, asthma, urinary diseases, piles, worms and rheumatism and scorpion-sting.

**Balaharade**

This variety is smaller than above two mentioned categories, its color is homogenous, and the pulp is deep brown. There is no stone into it. This is mild and safe aperients and antibilious, though astringent. Ripe fruits are considered as purgative removing bile and phlegm and to adjust bile. It is used in is highly useful in chronic diarrhea and dysentery, flatulence, vomiting, hicups, colic and enlarged spleen and liver. Brayed with sugar and water it is used in ophthalmia.

**Java harade**

These are smallest than all of above varieties and rest characters are similar as that of *Balaharade*. The uses of this variety are similar as that of *Balaharade*. Along with that cold infusion of it is used as a gargle in sore mouth and stomatitis, spongy and ulcerated gums. Brayed in rose water it is a cooling application to swellings [8].

**Categorization as per Hooker’s flora of British India**

In Hooker’s flora of British India, apart from TC, six other varieties of TC are mentioned [9,10]:

**TC Retz. (variety chebula proper)**

Fruits, one-to one-and-a-half inches, ellipsoidal or obovoid, from a broad base, more or less glabrous, and five-ribbed are abundant in Northern India at 1000-3000 ft.

**TC (var. typica)**

They have a young ovary and are shaggy without calyx teeth. They are distributed in Deccan, Ceylon, and Burma.

**TC (var. citrina)**

They have a young ovary, are quite glabrous, with ovate fruit, and a round base. It is common in Northern India, from Kumaon to Bengal and in Chota Nagpur.

**TC (var.)**

The fruits of this variety are much smaller than the other varieties. Generally found in Bihar up to an altitude of 1000 ft.
**TC (var. tomentella, Kurz)**  
Young ovary, are glabrous, fruit is ovoid, and hardly one inch in diameter.

**TC (var. gangetica Roxb.)**  
They have fruits with brown silky hair, which covers the twigs. It may be a very good variety. The fruit is similar to that of chebula, distributed in Northwest India.

**TC (var. parviflora Thwaitos Enum.)**  
They have fruits that are more acutely ribbed [9,10].

Table 1 describes varieties of TC according to different ancient texts such as Raja Balabh Nighantu, Atreya Shamita, Haritaki Shmita, Saligrim Nighantu, Raj Nighantu, Bhav Prakash Nighantu [11-13].

### CHEMICAL CONSTITUENTS

TC mainly contains hydrolysable tannins as active constituent. Chebulinic acid (CA) is the main active constituent present in TC. Other constituents are chebulagic acid and D-galloyl glucose, free tannic acid, gallic acid, ellagic acid, and resin myrobalanin. Anthaquinone glycosides, senno sides are also found in TC [1,3]. These tannins contain phenolic carboxylic acid like gallic acid, ellagic acid, chebulic acid, and gallo tannins such as 1.6 di-O-galloyl-β-D-glucose, 3,4,6 tri-O-galloyl-β-D-glucose, 2,3,4,6 tetra-O-galloyl-β-D-glucose, and 1,2,3,4,6 penta-O-galloyl-β-D-glucose. Ellag tannin such as punacalagin, casurarinin, corilagin, and terchebulin and others such as chebulanin, neo chebulic acid, chebulagic acid, and CA are also present in TC [1,3].

### ISOLATION AND EXTRACTION OF ACTIVE CONSTITUENTS PRESENT IN TC

CA and chebulagic acid was extracted from TC by high-speed counter current chromatography method [3]. The solvent system used for this was n-hexane-ethyl acetate-methanol-water (1:20:1:20 v/v). The partition coefficient at this solvent system for chebulagic acid was 0.65 and CA was 1.20 respectively. Using this process, Quanbin et al., in 2006, extracted 33.2 mg chebulagic acid and 15.8 mg CA with a purity of 95.3 and 96.1% recovery from 300 mg of TC crude extract [3].

Mahajan et al., in 2010, isolated CA from TC by reverse phase high performance liquid chromatography (HPLC). They isolate 8 compounds gallic acid, methyl gallate, ethyl gallate, chebulic acid, tetra-O-galloyl-β-D-glucose, ellagic acid, CA, and penta-O-galloyl-β-D-glucose from TC. The purities were checked by spectroscopic methods. UV absorption maxima of the hydrolysable tannins obtained from TC is shown in Table 2 [4].

Pfundstein et al., in 2010, determined polyphenolic and other active constituents of TC and Terminalia harri dian. It was reported that TC contained 6.18 g/kg of chebulic ellagittannins. Out of this chebulagic acid was 24.2 g/kg. Methyl neochebulinate, chebulic acid, chebulanin and methyl neochebullagate were present in decreasing order, in the range 7.1-9.0 g/kg. The recovery of CA was 4.5 g/kg along with small amounts of the partial hydrolyzed product (0.11 g/kg). Methyl neochebulanan is 2.2 g/kg, 3.2 g/kg gallic acid and gallate ester were present. The non- chebulic ellagittannins (25.0 g/kg) were represented by about equal amounts of corilagin and punicalagin. Ellagic acid was present at 4.1 g/kg [5]. In TC and its related plants, tannins are the main biologically active substances. They are present in different molecular forms such as dimers, tetramers and polymers, depending on the mode of extraction. In aqueous or ethanol extracts the lower molecules are prevalent.

Kilka et al., in 2004 extracted and isolate 1,3,6-Tri-O-galloyl-2,4- chebuloyl-β-D-glucopyranoside (CA) and its novel thrice hydrolyzed derivative, 2,4-Chebuloyl-β-D-glucopyranoside (galloyl-free CA), together with ellagic and gallic acids, ethyl gallate, and lutestin, from the dried fruit of TC. They also identified and confirmed structure by UV, MS, and NMR data [14].

<table>
<thead>
<tr>
<th>Serial number</th>
<th>Varieties of Haritaki, Saligram Nighantu, Raj Nighantu, Bhav Prakash Nighantu</th>
<th>Raja Balabh Nighantu</th>
<th>Atreya Shamita</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Abhaya</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>Anrita</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>Chetaki</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>Haimvati</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>Jaya</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>Jivanti</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>Kalika</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>Pathyta</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>9</td>
<td>Putana</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>10</td>
<td>Rohani</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>1</td>
<td>Vijaya</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Mahajan et al., in 2011 found significant variation in active constituent concentrations of three market samples of TC churna. They used HPLC method for quantification and qualification of the sample. Due to this variation, it is better to use active constituent [1].

Hydrolysable tannins on treatment with hydrochloric acid and sulfuric acid yield gallic or ellagic acid [16].

### RASA PANCHAK: PROPERTIES OF TC AS PER AYURVEDA

Rasa (Taste) – Madhura, Amla, Tikta, Katu, Kahasaya  
Guna (Property) – Laghu, Ruksha  
Vipaka (Digestive stage) – Madhur  
Prabhav (Distinctive action) – Tridosha shamanak

The above mentioned different Rasas (Taste) present in different parts of TC fruit.

**Fruits of TC contain five Rasas (Taste),**

1. Madhur – (sweet) - the fruit pulp
2. Amla – (sour) - the bulky portion of the fruit
3. Tikta – (bitter) - seeds
4. Katu – (Pungent) - the covering of the fruit
5. Kahasaya – (astringent) - the hard portion of the seed [7].

### PHARMACOLOGICAL AND THERAPEUTIC ACTIVITIES

In ancient time, Charaka mentioned the use of TC in Javaraghna, Arroghan, Kaaghahn, Kusthagha, Prajastahapan, while Susrutaused TC in Amalakjadi, Parusadaki, Triphala, and Vaghbhatt used in Parusakadi. Gogotey has mentioned both internal and external uses. In external uses, it is mentioned that TC is used for inflammation, conjunctivitis and...
it can be used on the eyelids. Decoction of Haritaki is used for the washing of wounds. In combination with Phyllanthus emblica and Terminalia bellirica under the name Triphala, fruits of TC are extensively used as adjunct to other medicines in almost in almost all diseases [17]. Triphala had also been found to be anti-inflammatory activity in gouty arthritis [18].

Anti-inflammatory activity

Sabina et al., in 2008, in showed anti-inflammatory activity in monosodium urate crystal-induced inflammation in mice of Triphala. They showed its significance in gouty arthritis [18].

Reddy et al., in 2009, showed that chebulagic acid is the compound in TC responsible for anti-inflammatory activity. They showed that chebulagic acid inhibit COX and 5-LOX responsible for anti-inflammatory and anticancer activity. Chebulagic acid showed potent COX-LOX dual inhibition activity with IC50 values of 15±0.288, 0.92±0.011 and 2.1±0.057 μM for COX1, COX2, and 5-LOX, respectively. They also showed apoptosis by chebulagic acid in COLO 205 cells. While ethanol extract of TC showed IC 50 for COX1 and COX2 and LOX is 90 μg/ml, 3.75 μ, 20 μg/m [19].

Anti-viral activity

Extract of TC has antiviral properties [20]. Ma et al., in 2010, demonstrated the antiviral activity of acetone extract of TC. They used mixture of Tannic acid and TC, instead of a single compound in order to get synergistic action of mixture. They showed the activity of acetone extract against swine influenza A virus [21].

Anti-cancer activity

It is used traditionally as anticancer drug in Africa and Asia. Saleem et al., in 2002, showed in vitro anticancer activity of methanolic extract of TC Cytotoxicity of Terminalia phonolics in HOS-1 cells was determined by the level of adenosine triphosphate (ATP). IC50 of CA was reported to be 53.2 μM [22]. Anticancer activity of 70% methanolic extract of TC was shown on cell lines of human (MCF-7), mouse (S115) breast cancer cell line, human osteosarcoma cell line, human prostate cancer cell line (PC-3), non-tumorogenic, and immortalized human prostate cell line (PNT1A). The parameters used to prove anticancer activity were proliferation thymidine incorporation and cohort counting. Cell viability was determined by ATP determination. The results revealed that concentration of 100 μg/ml, inhibit cell growth. It took some time to start its effect due to initiation of cellular processes causing decrease in proliferation and cell death. But at concentration of 400 μg/ml, it showed direct cytotoxic effect. The main components responsible for this action are CA, tannic acid, and ellagic acid [22].

CA is reported to inhibit HeLa cancer cell of cervical carcinoma. Although action of CA was restoration of gap junctional intracellular communication, exact mechanism is unknown [23].

Tannin extract of TC possess antimutagenic properties. Kaur et al., in 1998, showed that gallic acid derivative and other tannins have antimutagenic activity against S9-dependent mutagen and 2AF in Salmonella typhi [24].

Prasad et al., in 2006, showed the chemomodulatory effect of TC in Wister rat against nickel induced oxidative stress. Nickel chloride treatment caused an increase in tumor promoters. The treatment of rat with TC with 25 mg/kg body weight dose reduces effect of nickel chloride. Thus, its extract can also be used in the prevention of cancer [25].

Chebulagic acid also has anticancer properties. TC is used to cure and stomach cancers [26]. It has 5-LOX inhibitory action 2.1±0.057 μM. It had demonstrated anticancer properties against HCT-15 (colon), COLO-205 (colon), MDA-MB-231 (breast), DU- 145 (prostate), and K562 (chronic myeloid leukemia) cancer cell lines. It also showed anti-proliferative activity against HCT-15, COLO-205, MDA-MB-231, DU-145, and K562 cell lines [19].

Cardiac effect

CA has anti-hypertensive properties. This effect may be due to decrease in cardiac output which causes reduced left ventricular contraction. Hydrolyzable tannins potentiate activity of beta-adrenergic blocker by depressing muscle contraction [27,28]. Mitochondria play an important role at molecular level in ischemia. Pretreatment of alcoholic extract of TC at dose of 50 mg/100 g body weight had protective action in isoproterenol (ISO) (at dose 20 mg/100 g body weight) induced toxicity in rats. It was reported that TC retains normal function of mitochondria in ISO induced toxicity [29].

Antihyperlipidemic activity

TC has hypcholesterolemic effect. Thakur et al., in 1988 showed hypcholesterolemic effect in rabbits. Authors reported that TC has more lipid lowering activity than Amla and Baheera and it could be used as antihyperlipidemic agent for the treatment of atherosclerosis [30].

Antidiabetic activity

Aqueous extract of TC has been reported to have antidiabetic activity. Chebulic acid has protective action in case of glycation induced end product that causes endothelial cell dysfunction. According to Lee et al., in 2011, chebulic acid had IC50 values of 1.71 mM for protein cross-linking and 1.32 mM for advanced glycation end products (AGE) formation. As a positive control, aminoguanidine had IC50 values of 21.3 mM and 2.37 mM, respectively. They treat human umbilical vein endothelial cell with chebulic acid in the presence of AGEs. Due to chebulic acid dose-dependent reduction glycer-AGE induced formation 108.2±1.9% for 25 μM versus 137.8±1.1% for glycer-AGEs treated alone. They showed chebulic acid may be an agent can be used in diabetic vascular complication [31].

Aqueous methanolic extract of TC has been reported to have alpha-glucosidase inhibitory action. This extract has been reported to inhibit the inhibitory action of maltase that is present in rat’s intestine. Chebulalin, chebulagic acid, and CA have malatase inhibitory action with IC50 of 690, 97 and 36 μM, respectively. CA also has potent alpha-glucosidase inhibitory action. Thus, chebulin and CA can be used in treatment and control of diabetes specially in type 2 diabetes [32].

It is also reported that TC possesses dose-dependent anti-diabetic activity in lowering blood glucose of streptozotocin induced diabetic rats [33].

Radioprotective action

TC extract has been found to possess radioprotective action in mice. Damage to DNA due to radiation was reduced [33,34]. TC along with other herbs (Triphala) is shown to be radioprotective properties at a dose of 10 mg/Kg when administered intraperitoneally in mice. It acts by scavenging free radicals that are produced by radiation [35].

Anti-ulcer activity

TC has antulcer properties. Sharma et al., in 2011, showed antulcer activity [26]. It acts by inhibiting action of Helicobacter pylori by inhibiting urease activity which is responsible for ulcers in stomach. It

<p>| Table 3: Vehicles used for TC according to season [6] |</p>
<table>
<thead>
<tr>
<th>Serial number</th>
<th>Seasons (Ritu)</th>
<th>Vehicle used for administration of TC (Anupaan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ilaveni (midly sunny)</td>
<td>Honey</td>
</tr>
<tr>
<td>2</td>
<td>Muthuveni (intense sunny)</td>
<td>Jaggery</td>
</tr>
<tr>
<td>3</td>
<td>Kar (cloudy rainy)</td>
<td>Rock salt</td>
</tr>
<tr>
<td>4</td>
<td>Kuthir (Cold)</td>
<td>Sugar</td>
</tr>
<tr>
<td>5</td>
<td>Munpani (Early misty)</td>
<td>Dried ginger</td>
</tr>
<tr>
<td>6</td>
<td>Pinapani (Late misty)</td>
<td>Long pepper</td>
</tr>
</tbody>
</table>

TC: Terminalia chebula
<table>
<thead>
<tr>
<th>Serial number</th>
<th>Year</th>
<th>Publication number</th>
<th>Single/Combination</th>
<th>Activity</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Use of TC extract for treatment of osteoarthritis</td>
<td>US 20150174184</td>
<td>Single</td>
<td>Osteoarthritis</td>
<td>[43]</td>
</tr>
<tr>
<td>2</td>
<td>Plants parts and extracts having anticoccidial activity</td>
<td>EP 2866794</td>
<td>Combination</td>
<td>Control coccidiosis in poultry</td>
<td>[44]</td>
</tr>
<tr>
<td>3</td>
<td>TC and Terminalia bellerica extracts for inhibition of xanthine oxidase</td>
<td>US 20150050369</td>
<td>Combination</td>
<td>Uricemia, hyperuricemia, and gout in a human</td>
<td>Weight-reducing</td>
</tr>
<tr>
<td>4</td>
<td>Weight-reducing tea and preparation method thereof</td>
<td>CN 103976056</td>
<td>Single</td>
<td>Weight-reducing</td>
<td>[46]</td>
</tr>
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<td>5</td>
<td>Traditional Chinese medicine preparation for effectively treating dry cough</td>
<td>CN 10393435</td>
<td>Combination</td>
<td>Dry cough</td>
<td>[47]</td>
</tr>
<tr>
<td>6</td>
<td>Tea with function of smoking cessation</td>
<td>CN 103892005</td>
<td>Combination</td>
<td>Clearing throat and smoking cessation</td>
<td>Dry cough</td>
</tr>
<tr>
<td>7</td>
<td>Traditional Chinese medicine preparation for effectively treating dry cough</td>
<td>CN 103933435</td>
<td>Combination</td>
<td>Broad anti-virus range, strong bacteriostatic</td>
<td>[49]</td>
</tr>
<tr>
<td>8</td>
<td>Broad-spectrum anti-toxic and bacteriostatic traditional Chinese medicine preparation and preparation method thereof</td>
<td>CN 103877320</td>
<td>Combination</td>
<td>Treating sore tongue and mouth, and swelling and pains in throat caused by internal heat</td>
<td>Coccidiosis in poultry and, more specifically, coccidiosis</td>
</tr>
<tr>
<td>9</td>
<td>Concentrated solution capable of clearing heat and removing toxicity</td>
<td>CN 103860859</td>
<td>Combination</td>
<td>Hot cough, sound dumbness and other main syndromes</td>
<td>[51]</td>
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<td>Plant parts and extracts having anticoccidial activity</td>
<td>CN 20140161919</td>
<td>Combination</td>
<td>Treatment of porcine virus diarrhea</td>
<td>[52]</td>
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<td>11</td>
<td>Blood purifying mixture for treating skin diseases</td>
<td>CN 103830379</td>
<td>Combination</td>
<td>Vomiting, nausea, abdominal pain and diarrhea</td>
<td>[53]</td>
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<tr>
<td>12</td>
<td>Physalisalkekengi heat-clearing throat-wetting wine and production method thereof</td>
<td>CN 103815400</td>
<td>Combination</td>
<td>Chronic pharyngitis</td>
<td>[54]</td>
</tr>
<tr>
<td>13</td>
<td>Compound tincture for treatment of porcine virus diarrhea, preparation method and application thereof</td>
<td>CN 103800804</td>
<td>Combination</td>
<td>Bronchial asthma</td>
<td>[55]</td>
</tr>
<tr>
<td>14</td>
<td>Blueberry wine with functions of invigorating stomach and relieving diarrhea and production method thereof</td>
<td>CN 103805422</td>
<td>Combination</td>
<td>Rheumatoid arthritis</td>
<td>[56]</td>
</tr>
<tr>
<td>15</td>
<td>Traditional Chinese medicine effective part composition for treating chronic pharyngitis</td>
<td>CN 103768138</td>
<td>Combination</td>
<td>Chronic pharyngitis</td>
<td>[57]</td>
</tr>
<tr>
<td>16</td>
<td>Traditional Chinese medicinal decoction for treating bronchial asthma</td>
<td>CN 103751674</td>
<td>Combination</td>
<td>Chronic pharyngitis and acute and chronic tonsillitis</td>
<td>[58]</td>
</tr>
<tr>
<td>17</td>
<td>Drug for treatment of rheumatoid arthritis and preparation method thereof</td>
<td>CN 103751305</td>
<td>Combination</td>
<td>To reduce diseases of the wide geese, the wide ducks, the African geese and the wide chickens and eliminate sanguinary smell and smell of meton and improve the immunity</td>
<td>[59]</td>
</tr>
<tr>
<td>18</td>
<td>Traditional Chinese medicine preparation for treating tonsillitis and pharyngolaryngitis and preparation method thereof</td>
<td>CN 103690695</td>
<td>Combination</td>
<td>From relieving Vibrio vulniificus septicemia</td>
<td>[60]</td>
</tr>
<tr>
<td>19</td>
<td>Chinese herbal medicine feed for wide geese, wide ducks, African geese and wide chickens</td>
<td>CN 103621837</td>
<td>Combination</td>
<td>Allergic rhinitis</td>
<td>[61]</td>
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<td>20</td>
<td>Chinese medicine (TCM) for treating allergic rhinitis</td>
<td>CN 103610788</td>
<td>Combination</td>
<td>Allergic rhinitis</td>
<td>[62]</td>
</tr>
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<td>21</td>
<td>Throat clearing and moistening healthcare tea</td>
<td>CN 103493921</td>
<td>Combination</td>
<td>Anticoccidial activity</td>
<td>[63]</td>
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<td>22</td>
<td>Plant parts and extracts having anticoccidial activity</td>
<td>WO/2014/004761</td>
<td>Combination</td>
<td>Dental ulcer</td>
<td>[64]</td>
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<td>23</td>
<td>External powder for treating dental ulcer and preparation method thereof</td>
<td>CN 103405578</td>
<td>Combination</td>
<td>TC</td>
<td>Antioxidant</td>
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</tbody>
</table>

(Contd..)
is reported that aqueous extract has strong anti- \textit{H. pylori} activity. It also improves the activity of Brunner’s gland, thus helpful in the treatment of duodenal ulcers [33].

**Anti HIV activity**

CA present in TC has anti-HIV properties. CA act by inhibiting binding of HIV gp120 to CD4. CA was found to non-toxic at dose up to 10 times [36]. Several hydrolysable tannins inhibit the expression of HIV antigen present in human lymphotropic virus type 1-positive MT-4 cells. These tannins inhibit HIV adsorption on cells [37].

**Antioxidant activity**

Aqueous extract of TC has antioxidant properties. Extract of TC is found to have more antioxidant properties than \textit{Momordica charantia}, \textit{Glycyrrhiza glabra}, and \textit{Acacia catechu}. Aqueous extract of TC had antioxidant activity by IC50 by thiobarbituric acid reactive substances is 14.5 µg/ml, IC50 by DPPH is 11.5 µg/ml, and ascorbate equivalent is 60% [38].

Chebulagic acid has antioxidant properties. It has DPPH radical scavenging activity with IC50 of 1.4 µM and strong inhibition of ABTS radical with an IC50 value of 1.7±0.023 µM [19].
TC had antioxidant properties due to the presence of hydrolysable tannins [39]. Tannins were found to have more potent antioxidant activity than flavonoids [40]. Chebulinic and chebulagic acid, both were found to have antioxidant properties [1,4,19,41]. CA has been reported for better antioxidant activity than other tannins due to higher DPPH activity [5].

Hepatoprotective action

TC extract has hepatoprotective action against rifampicin, isoniazid, and pyrazinamide toxicity [33]. Hydrolysable tannins generally exhibit an intense enzyme inhibitory action on glutathione-pyruvic transaminase [42].

Miscellaneous

Adrenocorticotrophic hormone-induced lipolysis could be enhanced by CA and tellimagrandin I at 5-100 g/ml [41]. TC and its extract are used in wound healing and as anti-spasmodic. It has antibacterial properties also. It is used as antacaries agent/mouth washes. It has been used to treat respiratory disorders in Ayurveda. It is also reported to be used in urticaria and skin allergies. It has also been found to have purgative and anti-amoebic action [26,33].

FORMULATIONS AND PREPARATIONS

TC is a rejuvenating medicinal fruit and it is used with different vehicles for the rejuvenation of body. Different formulations and ayurvedic preparations of TC available are Abhayamodaka, Abhayavrisha, Pathyadhvati, Pathyaidakwath, Vyaghrithartaki, Haritkleha, Chitrakharitaki, Agasthartaki, Dantharthaki, Haritakakanda, Pathyadhurna, Abhayadigulgul, Abhayadikalaka, Amritartharaki, Abhyoamalakyarasayan, and Kayakalpa. To act as Kayakalpa, it should be consumed with different vehicles according to the season as shown (Table 3) [6]. Various patents related to TC are depicted in Table 4.

From the medicinal point of view, most of tannins of TC bring good results. They are effective against bacteria, viruses, parasites, and cancer cells. They protect animals and organs with their antioxidant property. They are reported to be nearly toxic. But because there are no dosages known for the use in humans, they cannot be recommended for the internal use in humans [26]. YL et al., in 2004, showed that IC50 of CA for erythroid differentiation was 40 µmol/L for hemin-induced cell and 4 µmol/L for BA induced cells, respectively. CA has an inhibitory effect on erythroid differentiation of K 56 cells [80].

CONCLUSION

TC is a unique herb having various therapeutic potential as anti-inflammatory, antioxidant, anti-cancer, and digestant. Classification, chemical constituents, therapeutic uses, and patents that have been reported for TC. Various pharmacological activities of TC that make it as potential medicine and its Ayurvedic formulations are highlighted.

REFERENCES


