

# An update review on ethnomedicinal, phytochemical and pharmacological profile of genus *Boerhavia*

## Abstract

The genus *Boerhavia* (Nyctaginaceae) consists of 40 species that are distributed in humid, subtropical and warm climate regions. Traditional healers have been patronizing various species of this genus in numerous disorders since time immemorial. Some of them are already validated scientifically such as antimicrobial, antioxidant, antidiabetic, antiasthmatic, anticonvulsant, cytotoxic, antiulcer, anti-inflammatory, analgesic and hepatoprotective. While much more is still needed to address. Phytochemically different groups of compounds have been isolated from various species of this genus like alkaloids, flavonoids, rotenoids and phytosterols. This review presents chemical and pharmacological data from recent phytochemical studies on various plants of the genus *Boerhavia*.

**Keywords:** *boerhavia*, traditional healers, phytochemical, pharmacology, rotenoids

Volume 6 Issue 3 - 2017

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**Received:** March 26, 2017 | **Published:** April 04, 2017

## Introduction

Plants have been a key source of medicine for many years. World Health Organization estimates that up to 80 percent of people still depend upon traditional medicines.<sup>1</sup> More than 35,000 plant species are being used around the world as medicinal plants in traditional and ethnomedicinal practices.<sup>2</sup> An impressive number of modern drugs have been isolated from natural sources.<sup>3</sup> It is very important to have sufficient knowledge regarding herbs not only because of their widespread uses but also because they have potential to cause toxic reactions or interact with other drugs.<sup>4</sup> Hence requirements of officinal plants cannot be neglected.<sup>5</sup> Genus *Boerhavia*, consists of 40 species which is distributed in humid and subtropical regions and warm climate.<sup>6</sup> *Boerhavia* genera have ancient medicinal use in different societies from the times of the B.C.<sup>7</sup> Databases used to search for the literature were: Google, Google scholar, PubMed and Research Gate.

## Ethnomedicinal importance of genus *boerhavia*

*Boerhavia diffusa* is used to treat different ailments like wound, inflammations and in hypertension<sup>8,9</sup> roots decoction to expel kidney stone.<sup>10</sup> roots have been widely used for the treatment of dyspepsia, jaundice, enlargement of the spleen and abdominal pain.<sup>11,12</sup> Roots of *Boerhavia diffusa* are used as diuretic, laxative, stomachic preparations and the leaves are used as an appetizer.<sup>13</sup> *Boerhavia diffusa* Linn. is a good liver stimulant and cures viral jaundice. It acts diuretic, anti-inflammatory, antiarthritic, spasmodic, and antibacterial. Roots are used as an anticonvulsant, analgesic, laxative, diuretic and abortifacient<sup>14</sup> in conjunctivitis.<sup>15</sup> It is believed to improve and protect eye sight. The plant has diuretic properties and is used by diabetics to lower blood sugar. The root is used as a diuretic to treat jaundice, enlarged spleen, gonorrhoea and other internal inflammations. It is also used as stomachic, cardio tonic, hepatic protective, laxative, anthelmintic (expels parasitic worms), febrifuge (reduces fever), and an expectorant. A paste of the roots is rubbed on the skin to ripen abscesses and ulcers.<sup>16</sup>

The leaves of *Boerhavia procumbens* are given in edema, dropsy and in dysmenorrhoea. The powder of the dried roots is snuffed in the flue. The powder of the roots of this plant along with honey is given

in a cough and asthma.<sup>17,18</sup> *Boerhavia procumbens* are used as blood purifiers.<sup>19,20</sup> For jaundice<sup>21,22</sup> Pastes of *Boerhavia procumbens* are used as antidotes, decoction as a refrigerant, to relieve irritation and bleeding from nose.<sup>23</sup>

*Boerhavia erecta* powder is smoked as a cigarette once a day for one month to get relief from asthma.<sup>24</sup> *Boerhavia repens* used as cardiotoxic.<sup>25,26</sup> *Boerhavia repens* was used by the Teli practitioner for treatment of edema, gonorrhoea, and chronic coughs.<sup>27</sup> Whole plant extract of *Boerhavia repens* L. is useful in women leucorrhoea.<sup>28</sup> The whole plant of *Boerhavia repens* is used as Stomachic, laxative, emetic and diuretic.<sup>29</sup> *Boerhavia repens* is an important medicinal plant having application in jaundice, fever, constipation and blood purifier.<sup>30</sup> For treatment of skin disorders, leaves of *Boerhavia repens* is used.<sup>31</sup>

Traditionally the roots of *Boerhavia chinensis* are taken orally for its antihelmintic, leucorrhoea, and Galactoseamine and paracetamol intoxication effects.<sup>32</sup> The plant *Boerhavia chinensis* has been used in various ayurvedic and siddha preparations as Hepato-protective, Gastro-protective, Useful in Down's syndrome, analgesic, antipyretic and anti-inflammatory.<sup>33</sup> *Boerhavia elegans* has been used to treat dysmenorrhoea, urinary tract disorders, intestinal infections, inflammation, jaundice, and body weakness in traditional medicine.<sup>34</sup>

## Pharmacology of genus *boerhavia*

### Antimicrobial activity

The crude methanolic extract of *Boerhavia repens* was tested for antibacterial and antifungal activities. All of the gram positive bacteria, gram negative bacteria and Fungi showed moderate susceptibility to the high concentration of methanolic extract of *Boerhavia repens* and only gram negative bacteria exhibited mild susceptibility at low concentration. From the results, we can conclude that the whole plant extract of *Boerhavia repens* showed significant antimicrobial activity.<sup>35</sup>

The antimicrobial activity of the methanolic extract of *Boerhavia diffusa* L. roots against some human pathogens like *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella typhimurium*, *Staphylococcus aureus*, *Shigella flexneri*, *Streptococcus*

*pneumoniae*, *Klebsiella pneumoniae* and fungi *Aspergillus niger* by using agar well diffusion method. Inhibition zones ranged between  $4.26 \pm 0.12$  -  $16.61 \pm 0.24$  mm. Roots extract inhibited the growth of all tested microorganisms with large zones of inhibition. The standard antibiotics chloramphenicol and miconazole nitrate were found to have a zone of inhibitions  $10.40 \pm 0.26$  -  $24.80 \pm 0.37$  mm at the concentration of  $30 \mu\text{g/ml}$ .<sup>36</sup>

The antimicrobial study indicated that the crude extracts of *B. diffusa* showed better antibacterial activities at higher concentrations against the tested microorganism. *B. diffusa* extracts showed significant antifungal activity, which may be related to the presence of anthraquinones.<sup>37</sup> *B. diffusa* root extract has antimicrobial activity. The zone of inhibition was observed for both gram positive as well as gram negative bacterial strains that were *Bacillus subtilis*, *Escherichia coli*, *Klebsiella pneumonia*, *Staphylococcus aureus* and *Streptococcus*.<sup>38</sup> The ethanol extract of *B. diffusa* L. leaves showed more activity against Gram-positive (e.g. *S. aureus*, zone of diameter 11 mm) and Gram-negative bacteria (e.g. *E. coli*, zone of diameter 9mm) when compared to other solvent extracts except for *V. cholerae*. The results confirmed the presence of antibacterial activity of *B. diffusa* L. leaves extract against various human pathogenic bacteria.<sup>39</sup>

Antibacterial and antifungal activities of *Boerhavia erecta* extract were studied against four different strains of bacteria and fungus by agar diffusion by pour plate & cup diffusion methods. From the results, we can conclude that the whole plant extract of *Boerhavia erecta* showed significant antimicrobial activity.<sup>40</sup>

Antibacterial of *Boerhavia coccinea* was determined. The antibacterial properties were determined *in vitro* by the agar dilution method against multi-resistant enteric bacteria obtained from clinical isolates of *Escherichia coli*.<sup>41</sup>

### Diuretic activity

The diuretic activity of the aqueous extract of roots of the plant *Boerhavia diffusa* and comparison of its activity with that of the standard diuretic furosemide were carried out in albino rats. It was observed that "the diuretic dose-response relationship" with the extract of *Boerhavia diffusa* was maximum at  $300 \text{mg/kg}$  (oral). The test drug also showed an optimum increase in the urinary volume and excretion of urinary electrolytes.<sup>42</sup> *Boerhavia diffusa* Linn. caused diuresis and hasten the process of dissolving the preformed crystal deposits, improved the renal function by increasing the removal of nitrogenous waste product and decreased the oxalate excretion probably by interfering with metabolism. All these activities synergistically attribute to the antiurolithiatic activity to *Boerhavia diffusa* Linn.<sup>43</sup>

### Antioxidant activity

The methanol extract of the leaves, stem, and the root of *Boerhavia diffusa* was estimated for total antioxidant capacity using 1, 1-diphenyl picrylhydrazyl (DPPH) free radical scavenging assay, total phenolic, flavonoid and ascorbic acid contents using spectrophotometric methods. The plant extracts exhibits significant antioxidant activity.<sup>44</sup> *B. diffusa* displayed DPPH, ABTS, and NO radical scavenging activity. The scavenging ability of the extracts against these three radicals increases with increase in concentration.<sup>45</sup> *In vitro* antioxidant activity of ethanolic extract *Boerhavia diffusa* were assessed for 1, 1-diphenyl-2-picrylhydrazyl (DPPH) scavenging activity, reduction potential, and nitric oxide scavenging activity. The percentage (I %) DPPH, NO and thiocyanate inhibition activity of *B. diffusa* root was  $91.25\% \pm 2.26\%$ ,  $90.39\% \pm 1.23\%$ ,  $88.59\% \pm 1.72\%$  respectively. The

activity was compared with that of standard ascorbic acid and gallic acid. The results of this research showed that the antioxidant played an important role in protecting the human body against free radicals.<sup>46</sup> The seeds extract of *Boerhavia elegans* Choisy exhibited potent the most promising free radical scavenging effects evaluated by DPPH and ABTS tests and a good antioxidant activity through different mechanisms of action (FRAP assay, carotene bleaching test,  $\text{Fe}^{2+}$  chelating assay).<sup>47</sup> Aqueous extract of *Boerhavia chinensis* leaves exhibits high antioxidant and free radical scavenging activities. It also scavenges NO and DPPH free radicals and has reducing power. The whole plant of *Boerhavia procumbens* possesses anti-oxidant activity.<sup>48</sup>

### Cytotoxic activity

The ethanolic extract of *Boerhavia diffusa* inhibited T cell mitogen phytohemagglutinin and concanavalin A-stimulated proliferation of human peripheral blood mononuclear cells (PBMC). It also inhibited purified protein derivative antigen-stimulated PBMC proliferation and human mixed lymphocyte culture. In addition, *B. diffusa* extract inhibited the growth of several cell lines of mouse and human origin, such as mouse macrophage cells (RAW 264.7), human macrophage cells (U937), human monocytic cells (THP-1), mouse fibroblast cells (L929), human embryonic kidney cells (HEK293), mouse liver cells (BNLCL.2), African green monkey kidney cells (COS-1), mouse lymphoma cells (EL-4), human erythroleukemic cells (K562), and human T cells. Thus the plant has the antiproliferative potential of ethanolic extract *in vitro*.<sup>49</sup> Pharmacological evaluation of the crude ethanolic extract of *B. diffusa* roots has been shown to possess anti proliferative and immunomodulatory properties. The fraction *Boerhavia diffusa* caused cell death via apoptosis as evident from DNA fragmentation and caspase-9 activation. Thus *B. diffusa* fraction could inhibit the proliferation of human cervical cancer cell line.<sup>50</sup>

### Antimalarial activity

*Boerhavia elegans* (Choisy) showed promising anti-plasmodial activity *in vitro* ( $\text{IC}_{50} < 50$  microgram/ml) and *in vivo* with no toxicity.<sup>51</sup>

The plant extract of *Boerhavia erecta* showed significant antimalarial activities in the 4-day suppressive antimalarial assay in mice inoculated with red blood cells parasitized with *Plasmodium berghei berghei*.<sup>52</sup>

The crude methanolic root extract of the plant was tested for its *in vivo* anti-plasmodial activity against *Plasmodium berghei* NK 65 (chloroquine resistant strain) using the three malaria models, suppressive, curative and prophylactic tests. The methanolic root extract of *B. diffusa* possessed antimalarial potential.<sup>53</sup>

### Antiulcer activity

The aqueous leaf extract of *Boerhavia chinensis* showed significant antiulcer activity in comparison with standard drug rabeprazole. The aqueous extract significantly reduced the ulcer index and enhanced the percentage protection in a dose-dependent manner. The plant extract of *B. diffusa* possessed antacid activity.<sup>54</sup>

### Analgesic activity and anti-inflammatory activity:

The analgesic activity of the whole plant of *B. repens* was studied for central (narcotic) and peripheral (non-narcotic) activities. Diclofenac was used as a standard drug. The whole plant possesses analgesic activity.<sup>55</sup> The analgesic and anti-inflammatory activity exhibited by *B. diffusa* state that only the ethanol extract exhibited

good analgesic potential as well as an anti-inflammatory activity when compared with standard drug analgin at a dose of 200mg/kg.<sup>56</sup> Anti-inflammatory and analgesic activities of *B. diffusa* were studied in carrageenan-induced paw edema, cotton pellet granuloma, and analgesic activities were studied in carrageenan-induced inflammatory pain, and tail immersion methods. *B. diffusa* aqueous root extract (1000mg/kg) showed a highly significant anti-inflammatory effect when compared to control and standard drug. In analgesic models, the test compound showed a significant analgesic effect in both the models.<sup>57</sup> The aqueous extract of the root of *B. diffusa* possesses anti-inflammatory properties which can be attributed to its cell membrane stabilizing effect which therefore inhibit the lysis and release of the proinflammatory mediators.<sup>58</sup>

### Hepatoprotective activity

An alcoholic extract of the whole plant *Boerhavia diffusa* given orally exhibited hepatoprotective activity against experimentally induced carbon tetrachloride hepatotoxicity in rats and mice.<sup>60</sup> The aerial parts of hydro alcoholic extract of *Boerhavia diffusa* L. has a preventive and curative effect in Ibuprofen-induced hepatotoxicity in albino rats.<sup>61</sup> The plant extract of *Boerhavia diffusa* obtained showed hepatoprotective activity in albino rats where the hepatotoxicity was induced by administering CCl<sub>4</sub>.<sup>62</sup> An alcoholic extract of stem and leaves of *Boerhavia diffusa* was studied for hepatoprotective activity against Carbon Tetrachloride (CCl<sub>4</sub>) induced hepatotoxicity in rats. Hepatotoxicity was introduced in Albino rats of either sex by intraperitoneal injection of CCl<sub>4</sub> (in olive oil). The hepatoprotective effects of the extracts were evaluated by the assay of liver function biochemical parameters like Serum Glutamate Oxaloacetate Transaminase (SGOT), Serum Glutamate Pyruvate Tranaminase (SGPT), Serum Alkaline Phosphatase (SALP), and Total and direct Serum Bilirubin. It was concluded that the alcoholic extract of *B. diffusa* has hepatoprotective activity against CCl<sub>4</sub> induced hepatotoxicity in rats.<sup>63</sup>

### Antidiabetic and antihyperlipidemic activity

The leaf extract of *B. diffusa* produced a dose-dependent reduction in blood glucose in streptozotocin-induced NIDDM rats comparable to that of glibenclamide. The results indicate that the reduction in blood glucose produced by the extract is probably through rejuvenation of pancreatic  $\beta$ -cells or through extra pancreatic action. Thus the chloroform extract of *B. diffusa* has significant antidiabetic activity.<sup>64</sup> Ethanolic extract of roots of *Boerhavia Diffusa* has antidiabetic potential and significantly reduced Total Cholesterol, Triglycerides, VLDL, and LDL with an increase in HDL which is having a protective function for the heart compared with diabetic control group. Thus ethanol extract of roots *B. diffusa* was found to reduce blood sugar in streptozotocin induced diabetic rats.<sup>65</sup> A significant decrease in blood glucose and a significant increase in plasma insulin levels were observed in normal and diabetic rats treated with aqueous solution of *Boerhavia diffusa* L. leaf extract (200 mg/kg) for 4 weeks on blood glucose concentration and hepatic enzymes in normal and alloxan induced diabetic rats.<sup>66</sup> Ethanolic extract of *Boerhavia diffusa* root exhibited significant antihyperglycemic activities in streptozotocin-induced rats.<sup>67</sup>

### Anti-histaminic activity

Ethanol extract of *Boerhavia diffusa* Linn. roots in experimental animals. *B. diffusa* was evaluated for anti-histaminic activity using isolated goat tracheal chain preparation and histamine-induced Bronchoconstriction in Guinea pig. *B. diffusa* significantly inhibited dose-dependent contraction of goat tracheal chain produced by

histamine and also showed significant protection by prolonging Preconvulsion dyspnoea time (PCD) in guinea pigs. Thus, plant showed anti-histaminic and broncho-dilating activity against histamine and hence possesses a potential role in the treatment of asthma.<sup>68</sup>

### Nephroprotective activity

*Boerhavia diffusa* was evaluated in the animal model of nephrotoxicity induced by lead acetate. The treatment with *Boerhavia diffusa* extract enhances the recovery from lead acetate induced nephritic damage due to its nephrotoxicity.<sup>69</sup>

### Anti-convulsant activity

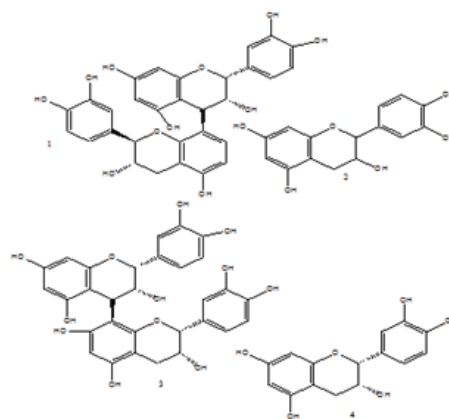
The methanolic extract of *B. diffusa* roots had anti-convulsant activity against PTZ-induced convulsions. As this activity retained only in lirioidendrin-rich fraction, this confirms that the anti-convulsant activity of the crude methanolic extract is due to the presence of lirioidendrin. Furthermore, protection of BAY k-8644-induced seizures by lirioidendrin-rich fraction substantiates that the activity of lirioidendron is due to its calcium channel antagonistic properties.<sup>70</sup>

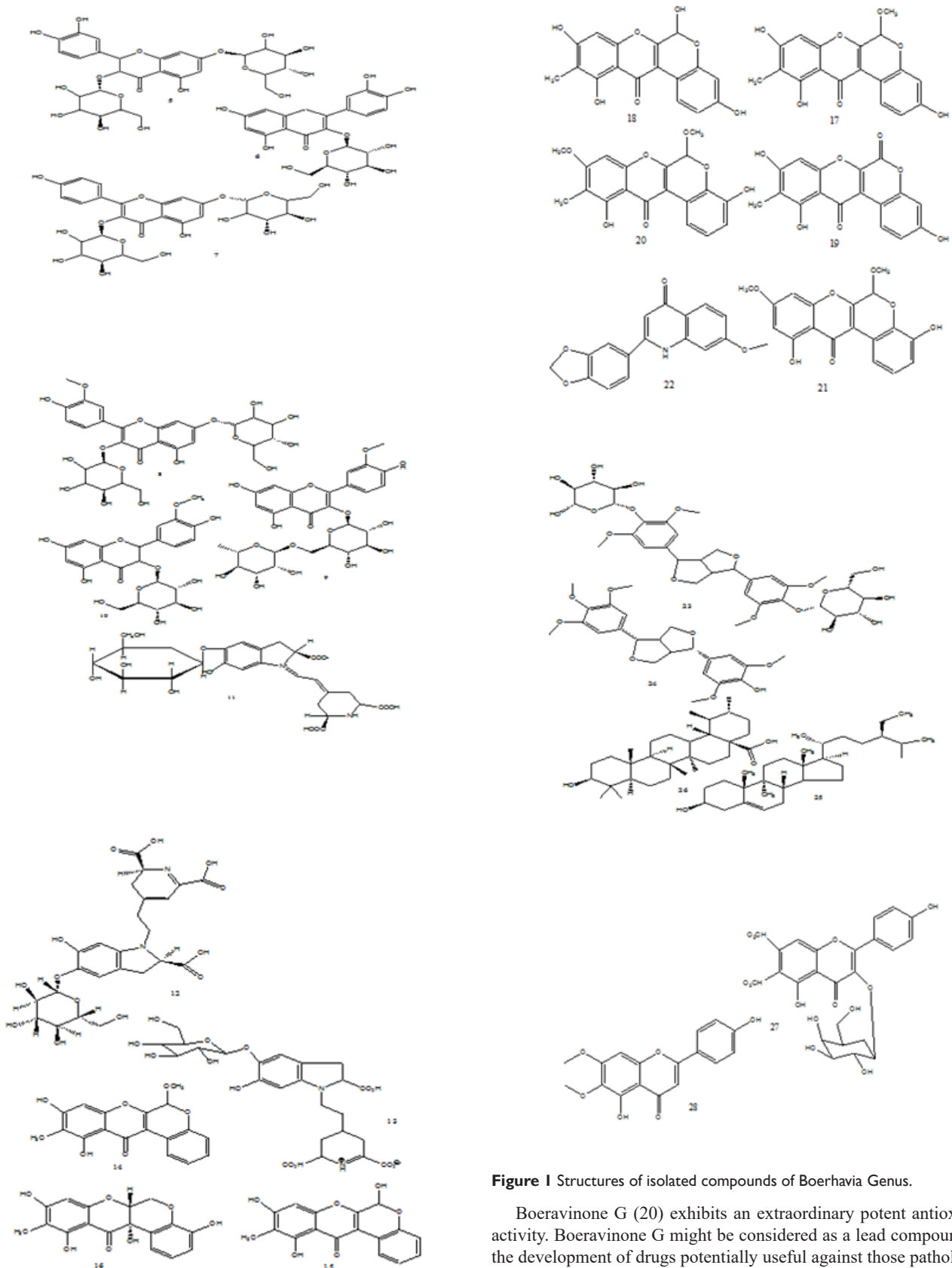
### Phytochemistry of boerhavia genera

***Boerhavia erect*:** Procyanidin B1 (1), Catechin (2), Procyanidin B2, Epicatechin (3), Dimeric Procyanidin, Quercitin diglycoside (4), Quercitin 3-O-rutinoside (5), Quercitin 3-O-glucoside (6), Kaempferol diglycoside (7), Isorhamnetin diglycoside (8), Isorhamnetin 3-O-rutinoside (9), Isorhamnetin 3-O-glucoside (10), Betanin (11), Isobetanin (12), Neobetanin (13).<sup>71</sup> 2,3-dihydroxypropylbenzoate-3-O- $\beta$ -4'-methoxy glucuronide.<sup>72</sup>

***Boerhavia diffusa*:** Boeravinone A(14), Boeravinone B (15), Boeravinone C (16), Boeravinone D (17), Boeravinone E (18) Boeravinone F(19), Boeravinone G (20) Boeravinone H (21). Punarnavine (22), lirioidendrin (23), syringaresinol (24), Phytosterols (25), ursolic acid (26), hypoxanthine 9-L-arabinose, Dihydroisofuroxanthone-borhavine, Boerhavin and Boerhaavic acid <sup>7</sup>. 3,3',5-trihydroxy-7-methoxyflavone, 4',7-dihydroxy-3'-methylflavone, 3,4-dimethoxyphenyl-1-O-beta-D-apiofuranosyl-(1'' --> 3')-O-beta-D-glucopyranoside.<sup>73</sup>

**Isolated compounds having Pharmacological potential:** The ethanolic extract of *Boerhavia diffusa* root has significant immunomodulatory potential. Two pure compounds Bd-I (27) (eupalitin-3-O-beta-D-galactopyranoside) and Bd-II (28) (eupalitin) were evaluated in vitro. These isolated compounds have immunomodulatory potential.<sup>74</sup>





**Figure 1** Structures of isolated compounds of Boerhavia Genus.

Boeravinone G (20) exhibits an extraordinary potent antioxidant activity. Boeravinone G might be considered as a lead compound for the development of drugs potentially useful against those pathologies whose etiology is related to ROS-mediated injuries.<sup>75</sup> Punarnavine (22), a quinolizidine alkaloid isolated from *Boerhavia diffusa* possess

potent anti-angiogenic effects due to the Punarnavine and can be extended further to develop therapeutic protocols for treatment of cancer.<sup>76</sup> *B. diffusa* (Punarnava) possesses very good anti-arthritis potential as a single drug and the activity is directly related to the concentration of eupalitin- 3- $\beta$ -D galactopyranoside.<sup>77</sup>

## Conclusion

The present review describes the phytochemical screening of genus *Boerhavia* for the different medicinal purpose. The different compounds isolated from different species with the structures have been studied along with their traditional uses and pharmacological activity. The evaluation needs to be carried out on *Boerhavia* in order to use the plant in the formulation for their practical and clinical applications, which can be used for the welfare of the mankind.

## Acknowledgments

None.

## Conflicts of interest

Author declares there are no conflicts of interest.

## Funding

None.

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