

# Ethnomedicinal uses, phytochemistry and pharmacological properties of *Chironia baccifera*

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## Abstract

*Chironia baccifera* is a perennial shrub widely used as traditional medicine in South Africa. The present review aims to provide a comprehensive review of the ethnomedicinal uses, phytochemical and pharmacological properties of *C. baccifera*. Diverse electronic search engines and specialized reference tools such as Google, Google Scholar, Scopus, Web of Science, scientific literature, publishing sites and electronic databases (Pubmed, Springer, Wiley and Science Direct) were used for data retrieval. The fruits, leaves, stems and whole plant parts of *C. baccifera* are used as purgative, tonic, post-partum to expel retained placenta and blood purifier, and as traditional medicine to treat and manage arthritis, bladder infections, kidney problems, sexually transmitted diseases, diabetes, gastro-intestinal problems, sores and skin diseases. The roots of *C. baccifera* contain chironioside, eustomoside, gentiopicroside, sweroside, swertiamarine, phenolics, saponins and tannins. Pharmacological research showed that fruit and leaf extracts of *C. baccifera* exhibited antibacterial, antifungal, antidiabetic and antioxidant activities. *Chironia baccifera* is a popular medicinal plant, but there is need for more precise studies to evaluate the safety and clinical relevance of its main active crude and pure compounds and to clarify their mechanisms of action.

**Keywords:** *Chironia baccifera*, ethnopharmacology, Gentianaceae, herbal medicine, indigenous pharmacopeia

## INTRODUCTION

*Chironia baccifera* L. is a small multi-stemmed shrub belonging to the Gentianaceae or gentian family. Gentianaceae is a family of flowering plants such as trees, shrubs and herbs characterized by opposite leaves and regular flowers belonging to about 100 genera and 1800 species.<sup>1-3</sup> The largest genera within the family Gentianaceae include *Gentiana* L. with about 360 species distributed in Africa, Asia, Australia, Europe, central, north and south America, *Gentianella* Moench with about 275 species recorded in Africa, Asia, Australia, Europe, central, north and south America and *Swertia* L. with about 150 species distributed in Africa, Asia, Europe and north America.<sup>3</sup> Several *Gentiana* L. species are widely used as sources of traditional medicines for treatment and management of human disorders such as menstrual problems, conjunctivitis, vitiligo, snake venom poisoning, injuries, wounds, pain and swellings, stomach problems and sprains of muscles.<sup>4,5</sup> Ethnopharmacological research focusing on *Gentiana* species revealed that these species are characterized by secoiridoidal and iridoid glycosides such as gentiopicroside, xanthones, monoterpene alkaloids, polyphenol and flavones and associated pharmacological activities include anti-inflammatory, antimicrobial, antioxidant, antitumour, hepatoprotective and diuretic effects.<sup>4,5</sup> Many *Gentianella* species are bitter and therefore, employed as traditional medicines in Asia, central, north and south America to stimulate appetite, treat disorders of the gallbladder, as herbal medicines for fever, obesity, diabetes, jaundice and heart diseases.<sup>4,6-11</sup> Some of the *Gentianella* species possess antimicrobial, anti-inflammatory, antioxidant, hypoglycemic, anticholinergic, hepatoprotective, radioprotective and antitumor activities.<sup>4,11-14</sup> Similarly, *Swertia* species are popular traditional medicines in Asia, traditionally used to treat and manage ailments such as liver disorders, malaria, diabetes, anaemia, bronchial asthma, hepatitis, gastritis, constipation, dyspepsia, skin diseases, worms, epilepsy, ulcers, hypertension and mental disorders.<sup>4,15-19</sup> Some of

the *Swertia* species possess anti-viral, anthelmintic, antileishmanial, hypoglycemic, antidiabetic, antipyretic, analgesic, hepatoprotective, hypoglycemic, antimalarial, antifungal, antibacterial, cardiostimulant, antifatigue, anti-inflammatory, antiaging and antidiarrheal properties.<sup>19-33</sup> In South Africa, the family Gentianaceae consists of 9 genera and 84 species with *Chironia* L. and *Sebaea* Sol. ex R. Br. as the most well-known genera<sup>34</sup> with *C. baccifera* regarded as the most important medicinal species belonging to the family Gentianaceae in the country.<sup>35-39</sup> In South Africa, the fruits of *C. baccifera* are eaten as snacks.<sup>40-43</sup> The leaves and stems of *C. baccifera* are sold in informal herbal medicine markets as sources of traditional medicines in the Eastern Cape and Western Cape provinces of South Africa.<sup>44-47</sup> *Chironia baccifera* is one of the valuable medicinal plant species in South Africa, and the species is included in the book “medicinal plants of South Africa,” a photographic guide to the most commonly used herbal medicines in the country, including its botany, major medicinal applications and active phytochemical compounds.<sup>37</sup> Research by Van Wyk,<sup>36</sup> Van Wyk<sup>38</sup> and Van Wyk<sup>39</sup> showed that the leaves and stems of *C. baccifera* have commercial potential as sources of traditional medicines for acne, haemorrhoids and ulcers as well as production of bitter tonics and appetite stimulants in South Africa. It is therefore, within this context that this review was undertaken aimed at reviewing the ethnomedicinal uses, phytochemical and pharmacological properties of *C. baccifera* so as to provide baseline data required in evaluating the therapeutic potential of the species.

## Botanical profile of *Chironia baccifera*

The genus name “*Chironia*” is in honour of Chiron, the god Centaur of Greek mythology who studied medicine, astronomy, music and other arts and was a skilled herbalist. The species name “*baccifera*” is derived from the Latin word “*bacciferus*” which means “berry-bearing”<sup>48</sup> in reference to red berries produced by the

species.<sup>49</sup> The English common names of *C. baccifera* include “christmas berry”, “wild gentian”, “piles bush” and “toothache berry”. Synonyms associated with *C. baccifera* include *C. baccata* Hoffmanns., *C. parviflora* Salisb., *Roeslinia baccifera* G. Don and *R. tetragona* Moench.<sup>50</sup> *Chironia baccifera* is a rounded shrublet with woody and multi-branched stems which can grow up to 1 metre in height with angular twigs.<sup>48</sup> The leaves of *C. baccifera* are small, linear in shape, dark green in colour, opposite in arrangement and spreading with hooked leaf-tips. The flowers of *C. baccifera* are starry, glossy pink in colour with a short tube that is pinched above the ovary. The fruit of *C. baccifera* is a red and rounded fleshy berry. *Chironia baccifera* has been recorded in dry, sandy or rocky flats, slopes, sand dunes and growing in the shade of other plants in the Eastern Cape, Northern Cape, Western Cape and KwaZulu-Natal provinces in South Africa at an altitude ranging from 5 m to 1450 m above sea level.<sup>50-52</sup>

### Medicinal uses of *Chironia baccifera*

The fruits, leaves, stems and whole plant parts of *C. baccifera* are used as purgative, tonic, post-partum to expel retained placenta and blood purifier, and as traditional medicine to treat and manage arthritis, bladder infections, kidney problems, sexually transmitted diseases, diabetes, gastro-intestinal problems, sores and skin diseases (Table 1, Figure 1). The whole plant parts of *C. baccifera* are mixed with leaves of *Notobubon galbanum* (L.) Magee as traditional medicine for arthritis.<sup>35,49,53</sup> Other medicinal applications of *C. baccifera* supported by less than five literature records include arthritis, backache, cancer, epilepsy, fever, headache, high blood pressure, infertility, immune system booster, menstrual problems, muscle pain, pain, rheumatism, toothache and urinary problems (Table 1).

**Table 1: Medicinal uses of *Chironia baccifera***

Medicinal use	Parts used	Reference
Arthritis	Whole plant	Nzue <sup>54</sup> ; Nortje and Van Wyk <sup>55</sup>
Arthritis	Whole plant mixed with leaves of <i>Notobubon galbanum</i> (L.) Magee	Van Wyk and Gericke <sup>35</sup> ; Carolus <sup>49</sup> ; Van Wyk and Gericke <sup>53</sup>
Backache	Whole plant	Nortje and Van Wyk <sup>55</sup> ; Hulley and Van Wyk <sup>56</sup>
Bladder infections	Whole plant	Van Wyk and Gericke <sup>35</sup> ; Carolus <sup>49</sup> ; Van Wyk and Gericke <sup>53</sup> ; Chinyama <sup>57</sup> ; Ndhala et al. <sup>58</sup>
Blood purification	Roots	Koekemoer et al. <sup>34</sup> ; Van Wyk and Gericke <sup>35</sup> ; Van Wyk et al. <sup>37</sup> ; Manning <sup>48</sup> ; Carolus <sup>49</sup> ; Van Wyk and Gericke <sup>53</sup> ; Hulley and Van Wyk <sup>56</sup> ; Chinyama <sup>57</sup> ; Thring and Weitz <sup>59</sup> ; Deutschländer et al. <sup>60</sup> ; Semenya et al. <sup>61</sup>
Cancer	Whole plant	Nzue <sup>54</sup> ; Hulley and Van Wyk <sup>56</sup>
Diabetes	Whole plant	Van Wyk and Gericke <sup>35</sup> ; Carolus <sup>49</sup> ; Van Wyk and Gericke <sup>53</sup> ; Nzue <sup>54</sup> ; Nortje and Van Wyk <sup>55</sup> ; Hulley and Van Wyk <sup>56</sup> ; Chinyama <sup>57</sup> ; Ndhala et al. <sup>58</sup> ; Deutschländer et al. <sup>60</sup> ; Van de Venter et al. <sup>62</sup> ; Philander <sup>63</sup> ; Odeyemi and Bradley <sup>64</sup>
Epilepsy	Whole plant	Nzue <sup>54</sup>
Fever	Whole plant	Hulley and Van Wyk <sup>56</sup>
Gastro-intestinal problems (constipation, diarrhoea and stomach complaints)	Whole plant	Koekemoer et al. <sup>34</sup> ; Van Wyk and Gericke <sup>35</sup> ; Van Wyk et al. <sup>37</sup> ; Van Wyk and Gericke <sup>53</sup> ; Nzue <sup>54</sup> ; Nortje and Van Wyk <sup>55</sup> ; Hulley and Van Wyk <sup>56</sup> ; Chinyama <sup>57</sup> ; Thring and Weitz <sup>59</sup> ; Deutschländer et al. <sup>60</sup> ; Philander <sup>63</sup> ; Thring et al. <sup>65</sup>
Haemorrhoids	Whole plant	Koekemoer et al. <sup>34</sup> ; Van Wyk and Gericke <sup>35</sup> ; Van Wyk et al. <sup>37</sup> ; Carolus <sup>49</sup> ; Van Wyk and Gericke <sup>53</sup> ; Nzue <sup>54</sup> ; Nortje and Van Wyk <sup>55</sup> ; Hulley and Van Wyk <sup>56</sup> ; Chinyama <sup>57</sup> ; Ndhala et al. <sup>58</sup> ; Thring and Weitz <sup>59</sup> ; Deutschländer et al. <sup>60</sup> ; Philander <sup>63</sup> ; Watt and Breyer-Brandwijk <sup>66</sup> ; Springfield et al. <sup>67</sup>
Headache	Whole plant	Hulley and Van Wyk <sup>56</sup>
High blood pressure	Whole plant	Nzue <sup>54</sup> ; Hulley and Van Wyk <sup>56</sup> ; Philander <sup>63</sup>
Infertility	Whole plant	Nzue <sup>54</sup>
Immune system booster	Whole plant	Nzue <sup>54</sup>
Kidney infections	Whole plant	Van Wyk and Gericke <sup>35</sup> ; Carolus <sup>49</sup> ; Van Wyk and Gericke <sup>53</sup> ; Hulley and Van Wyk <sup>56</sup> ; Chinyama <sup>57</sup> ; Ndhala et al. <sup>58</sup>
Menstrual problems	Leaves	Nortje and Van Wyk <sup>55</sup>
Muscle pain	Leaves and stems	Thring and Weitz <sup>59</sup> ; Thring et al. <sup>65</sup>
Pain	Whole plant	Hulley and Van Wyk <sup>56</sup>

Medicinal use	Parts used	Reference
Post-partum to expel placenta	Fruits, leaves and stems	Van Wyk and Gericke <sup>35</sup> ; Carolus <sup>49</sup> ; Van Wyk and Gericke <sup>53</sup> ; Hulley and Van Wyk <sup>56</sup> ; Chinyama <sup>57</sup> ; Van Wyk et al. <sup>68</sup> ; Van Wyk and Gorelik <sup>69</sup>
Purgative	Whole plant	Van Wyk et al. <sup>37</sup> ; Manning <sup>48</sup> ; Carolus <sup>49</sup> ; Hulley and Van Wyk <sup>56</sup> ; Philander <sup>63</sup>
Rheumatism	Leaves	Nortje and Van Wyk <sup>55</sup>
Respiratory problems (bronchitis, chest pains, pneumonia, rash and tuberculosis)	Whole plant	Hulley and Van Wyk <sup>56</sup> ; Semanya and Maroyi <sup>70</sup>
Sexually transmitted diseases (syphilis and venereal sores)	Whole plant	Van Wyk and Gericke <sup>35</sup> ; Carolus <sup>49</sup> ; Van Wyk and Gericke <sup>53</sup> ; Hulley and Van Wyk <sup>56</sup> ; Chinyama <sup>57</sup> ; Ndhala et al. <sup>58</sup>
Skin diseases (abscesses, acne, inflammation and leprosy)	Whole plant	Koekemoer et al. <sup>34</sup> ; Van Wyk and Gericke <sup>35</sup> ; Van Wyk et al. <sup>37</sup> ; Carolus <sup>49</sup> ; Van Wyk and Gericke <sup>53</sup> ; Hulley and Van Wyk <sup>56</sup> ; Chinyama <sup>57</sup> ; Ndhala et al. <sup>58</sup> ; Thring and Weitz <sup>59</sup> ; Deutschländer et al. <sup>60</sup> ; Philander <sup>63</sup> ; Thring et al. <sup>65</sup> ; Watt and Breyer-Brandwijk <sup>66</sup> ; Springfield et al. <sup>67</sup> ; Hutchings <sup>71</sup> ; Mabona <sup>72</sup> ; Mabona and Van Vuuren <sup>73</sup> ; Pattanayak <sup>74</sup>
Sores	Whole plant	Van Wyk and Gericke <sup>35</sup> ; Van Wyk et al. <sup>37</sup> ; Carolus <sup>49</sup> ; Van Wyk and Gericke <sup>53</sup> ; Hulley and Van Wyk <sup>56</sup> ; Chinyama <sup>57</sup> ; Thring and Weitz <sup>59</sup> ; Deutschländer et al. <sup>60</sup> ; Philander <sup>63</sup> ; Thring et al. <sup>65</sup> ; Watt and Breyer-Brandwijk <sup>66</sup> ; Springfield et al. <sup>67</sup> ; Hutchings <sup>71</sup> ; Mabona <sup>72</sup> ; Mabona and Van Vuuren <sup>73</sup> ; Pattanayak <sup>74</sup>
Tonic	Whole plant	Van Wyk and Gericke <sup>35</sup> ; Carolus <sup>49</sup> ; Van Wyk and Gericke <sup>53</sup> ; Hulley and Van Wyk <sup>56</sup> ; Deutschländer et al. <sup>60</sup>
Toothache	Whole plant	Hulley and Van Wyk <sup>56</sup>
Ulcers	Whole plant	Van Wyk and Gericke <sup>35</sup> ; Carolus <sup>49</sup> ; Van Wyk and Gericke <sup>53</sup> ; Hulley and Van Wyk <sup>56</sup> ; Chinyama <sup>57</sup> ; Ndhala et al. <sup>58</sup>
Urinary problems	Whole plant	Hulley and Van Wyk <sup>56</sup>

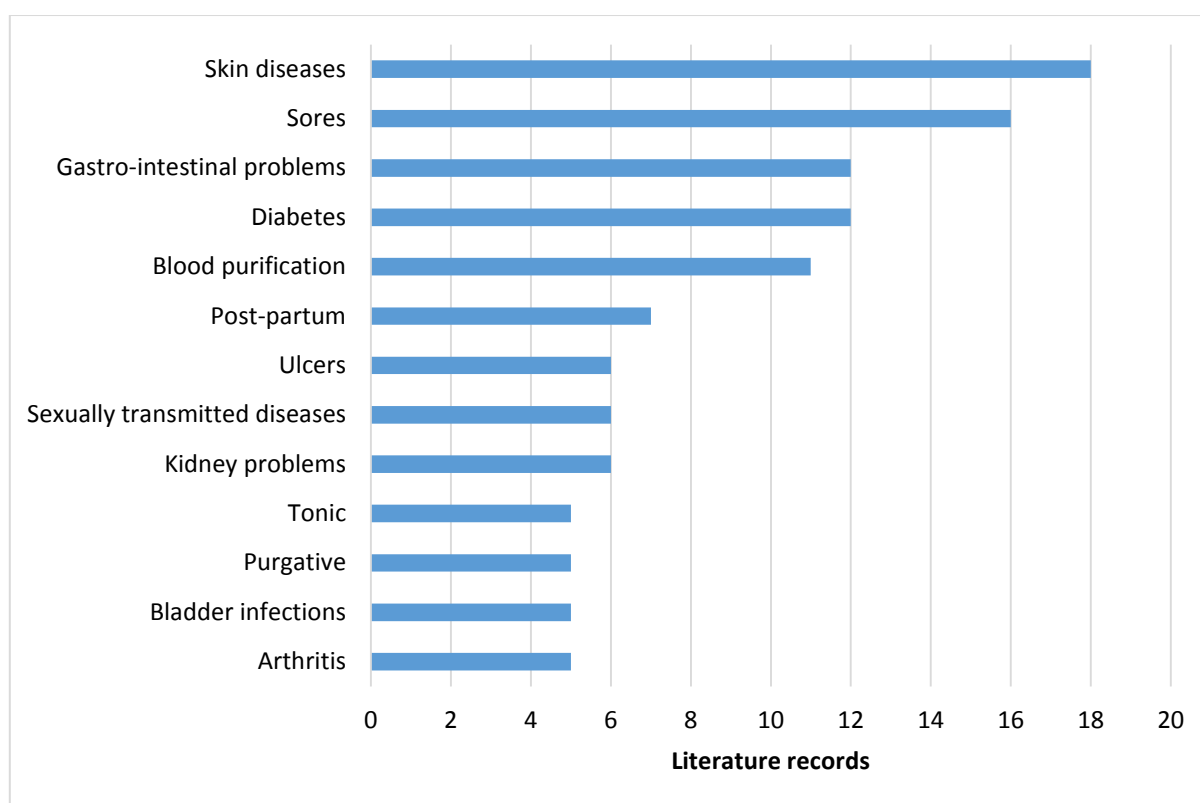


Figure 1. Medicinal applications of *Chironia baccifera* derived from literature records

### Phytochemistry and biological activities of *Chironia baccifera*

The roots of *C. baccifera* contain chironioside, eustomoside, gentiopicoside, sweroside and swertiamarine.<sup>75</sup> Other phytochemical compounds that have been identified from *C. baccifera* include phenolics, saponins and tannins.<sup>42,67</sup> The following biological activities have been reported from the fruit, leaf and whole plant part extracts of *C. baccifera*: antibacterial,<sup>57,65</sup> antifungal,<sup>57,65</sup> antidiabetic<sup>62</sup> and antioxidant<sup>42</sup> activities.

#### Antibacterial activities

Thring et al.<sup>65</sup> evaluated antibacterial activities of aqueous, methanol, ethanol and ethyl acetate whole plant extracts of *C. baccifera* against *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Mycobacterium smegmatis* using the disc diffusion assay and two-fold serial dilution with ciprofloxacin as a positive control. The ethanol and ethyl acetate extracts exhibited activities against *Mycobacterium smegmatis* with zone of inhibition ranging from 0.5 mm to 1.0 mm which was lower than 2.0 mm to 4.0 mm exhibited by the positive control. The methanol, ethanol and ethyl acetate extracts exhibited activities against the tested pathogens with the minimum inhibitory concentrations (MIC) values ranging from 1.3 mg/ml to 5.0 mg/ml.<sup>65</sup> Chinyama<sup>57</sup> evaluated the antibacterial activities of aqueous, methanol and acetone whole plant extracts of *C. baccifera* against *Escherichia coli*, *Bacillus cereus*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Enterococcus faecalis*, *Streptococcus bovis*, *Staphylococcus epidermidis*, *Staphylococcus hominis*, *Providentia stuartii*; *Leuconostoc pseudomesenteroides*, *Enterobacter agglomerans*, *Acinetobacter baumannii*, *Acinetobacter haemolyticus*, *Acinetobacter lwoffii*, *Staphylococcus haemolyticus* and *Aeromonas hydrophila*, *Klebsiella pneumoniae*, *Klebsiella oxytoca* and *Enterobacter cloacae* using agar diffusion method and microtitre plate method. The extracts exhibited best activities against *Staphylococcus aureus*, *Acinetobacter haemolyticus* and *Staphylococcus haemolyticus* with MIC values ranging from 0.4 mg/ml to 6.3 mg/ml.<sup>57</sup>

#### Antifungal activities

Thring et al.<sup>65</sup> evaluated antifungal activities of aqueous, methanol, ethanol and ethyl acetate whole plant extracts of *C. baccifera* against *Candida albicans* using the disc diffusion assay and two-fold serial dilution with amphotericin B as a positive control. The extracts exhibited activities with MIC values ranging from 1.3 mg/ml to 5.0 mg/ml.<sup>65</sup> Chinyama<sup>57</sup> evaluated the antifungal activities of aqueous, methanol and acetone whole plant extracts of *C. baccifera* against *Candida albicans*, *Candida krusei* and *Candida lusitanae* using agar diffusion method. The extracts exhibited activities against the tested pathogens.<sup>57</sup>

#### Antidiabetic activities

Van de Venter et al.<sup>62</sup> evaluated the antidiabetic activities of aqueous and organic extracts of *C. baccifera* whole plant extracts against Chang liver, C2C12 muscle and

3T3-L1 adipose cells using a glucose utilisation assay with 1  $\mu$ M insulin for C2C12 and 3T3-L1 cells and 1  $\mu$ M metformin for Chang liver cells as positive controls. The extracts exhibited activities with negligible toxicity.<sup>62</sup>

#### Antioxidant activities

Kucich and Wicht<sup>42</sup> evaluated the antioxidant activities of aqueous fruit extracts of *C. baccifera* using 2,2'-azino-bis-3-ethylbenzothiazoline-6-sulphonate (ABTS), hydrophilic and lipophilic oxygen radical antioxidant capacity (H-ORAC and L-ORAC) assays with *Vaccinium corymbosum* L. (blueberry) and *Vaccinium macrocarpon* Aiton (cranberry) as positive controls. The extract exhibited activities with ABTS (8.7  $\mu$ mol Trolox equiv/g of fresh weight), H-ORAC (261.4  $\mu$ mol Trolox equiv/g of fresh weight) and L-ORAC (81.0  $\mu$ mol Trolox equiv/g of fresh weight) and antioxidant potency composite index value of 106.6.<sup>42</sup>

#### CONCLUSION

*Chironia baccifera* has been used in South Africa as medicinal plant for many centuries. Future research should focus on more comprehensive phytochemical characterization of both crude and pure extracts of the species. Detailed phytochemical studies of *C. baccifera* and its pharmacological properties, especially the mechanisms of action of its bioactive constituents will establish the existence of correlation between ethnomedicinal uses and pharmacological activities. There is also need for *in vivo* experiments to validate the existing pharmacological activities. However, because *C. baccifera* contains potentially toxic compounds, its toxicological properties need to be properly established via proper quality control of product development to ensure that potentially toxic components are kept below tolerance levels.

#### Conflict of interest

The author declares that he has no conflict of interest.

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