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Southern African traditional herbal medicinal plants used to treat cardiovascular disease and related medical conditions: Traditional use and scientific evidence

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ABSTRACT

Multiple plant species are used in traditional southern African medicine to treat cardiovascular diseases. Traditional southern African therapies used to treat cardiovascular diseases were identified and recorded following an extensive review of ethnobotanical books, reviews, and other scientific literature. This was followed by a critical analysis of the validation studies, while highlighting gaps for further investigation. A total of 235 plant species were identified and are itemised herein. Notably, only 45 of these plant species (~19%) have been tested *in vivo* or screened *in vitro* for any bio-activities relevant to the treatment of cardiovascular diseases. The remaining 190 species are yet to be tested in any cardiovascular disease biomarker assay. Additionally, the plant species that have been evaluated for cardiovascular disease-relevant activities have generally only been tested in a single bio-assay model (most frequently ACE inhibition assays). This study highlights the need for further *in vitro* and *in vivo* assays in this neglected field of research.

1. Introduction

Cardiovascular diseases (CVDs) are defined by the World Heart Federation as any disease of the heart or vascular system that carries the blood throughout the body (WHO, 2017). The CVDs encompass several conditions that include (but are not limited to) coronary heart disease, cerebrovascular disease, peripheral arterial disease, rheumatic heart disease, congenital heart disease, deep vein thrombosis and pulmonary embolism. In 2017, the World Health Organization (WHO) ranked CVDs as the leading cause of death globally, with more people dying annually from CVDs than from any other single disease or condition (WHO, 2017). Indeed, the World Health Organization (WHO) estimated that 17.9 million people globally died from CVDs in 2016. This accounts for 31% of all recorded deaths that year. Whilst those statistics represent global trends, they are similar to the statistics from individual countries and regions. For example, CVDs are the second leading cause of death in South Africa after the Human immunodeficiency virus/ Acquired immunodeficiency (HIV/AIDS) syndrome (WHO, 2018). They were responsible for 17.3% of the nation's deaths in 2014. Similarly, in Eswatini (formerly named Swaziland), ischaemic heart disease and stroke are ranked as the country's third and fifth causes of death respectively, further highlighting the impact of CVDs across the region (Msemburi et al., 2014; Statistics South Africa, 2014; WHO, 2018).

The CVD-related deaths can be further divided into subcategories. The WHO lists the most common CVD-related conditions that cause death as ischaemic heart disease, cerebrovascular disease, hypertensive heart disease, inflammatory heart disease and rheumatic heart disease (WHO, 2011). Ischaemic heart disease is responsible for 46% and 38% of deaths due to CVDs in men and women respectively, whilst cerebrovascular diseases are responsible for 34% and 37% in men and women. Hypertensive heart disease is responsible for a further 6% and 7% in men and women respectively, whilst inflammatory heart disease is responsible for 2% in both sexes, and rheumatic heart disease is responsible for a further 1% in both men and women. A variety of other CVDs are responsible for the remaining 11% and 14% in men and women respectively.

1.1. Ischaemic heart disease

The heart muscle (myocardium) requires oxygen and nutrients to efficiently contract and relax, and thereby to pump blood throughout the body (Boyette and Manna, 2020). The coronary arteries are responsible for facilitating adequate blood flow to the myocardium to deliver the required oxygen and nutrients (Boyette and Manna,

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2020). Ischaemic heart disease occurs when blood flow through the coronary arteries is reduced, resulting in the inability of the coronary arteries to effectively supply adequate amounts of oxygen and nutrients, thereby affecting the myocardium's functionality (Pappano and Wier, 2019). The most common cause of ischaemic heart disease is coronary heart disease, followed by less common conditions including coronary artery spasm and microcirculatory dysfunction (Bogaert and Symons, 2020). Coronary artery disease occurs when plaques (also known as atherosclerotic plaques), which consist of fats, cholesterol, calcium, etc. form on the inside surfaces of arterial walls. As this disease progresses, the plaques harden and increase in size, reducing the diameter of the arterial lumen, as well as arterial flexibility, and therefore the supply of blood to the myocardium (Mohrman and Heller, 2018). Progression of ischaemic heart disease may result in congestive heart failure, electrical instability with cardiac dysrhythmias, or myocardial infarction (commonly known as a heart attack) (Akhtar, 2017). Ischaemic heart disease may initially present as angina pectoris (the chest pain, discomfort, pressure, or heaviness that is experienced when the myocardium is deprived of oxygen), acute myocardial infarction (AMI, commonly known as a heart attack), or even sudden death. The discomfort from angina pectoris may also radiate to the neck, jaw, left shoulder, left arm, the back, or down both arms, causing referred pain (Akhtar, 2017). Angina pectoris may often cause discomfort in the upper central region of the abdomen, which can resemble indigestion and chest constriction and may sometimes be mistaken for dyspnea, hampering timely treatment (Akhtar, 2017). The risk factors for the development of ischaemic heart disease include increasing age, hypercholesterolemia, hypertension, cigarette smoking, diabetes mellitus, obesity, sedentary lifestyle, as well as genetic factors/family history (Akhtar, 2017). Additionally, ischaemic heart disease has a gender correlation and is significantly more common in males than in females (Akhtar, 2017). Hypertension has the largest impact and is the number one risk factor for mortality due to cardiovascular diseases (WHO, 2011; Kjeldsen, 2018).

1.2. Stroke (cerebrovascular accident)

The brain is one of the most highly vascularised organs in the body, with an average blood supply of ~15 % of the cardiac output, as it requires a constant supply of oxygen to function correctly. Indeed, the brain consumes 20 % of the total body's resting oxygen consumption (Rink and Khanna, 2011). A stroke occurs when a part of the brain receives an inadequate supply of oxygen and nutrients due to diminished or interrupted blood flow (American Stroke Association, 2022). When blood flow to an area of the brain is completely blocked, brain tissue in that area will die within four to ten minutes, resulting in a myriad of functional inadequacies (Smith et al., 2018). Stroke is broadly classified as either ischaemic or haemorrhagic. Ischaemic stroke occurs due to a blockage in one of the cerebral blood vessels, whilst haemorrhagic stroke occurs due to a ruptured blood vessel, which causes bleeding within the brain (referred to as intracerebral haemorrhage) or in the area between the brain and tissue covering the brain (referred to as subarachnoid haemorrhage) (Ropper et al., 2019). Ischemic strokes are the major class, accounting for aproximately 85 % of strokes, whilst the remaining 15 % of strokes are haemorrhagic (Jameson et al., 2020). Both classes of stroke may be caused by numerous factors, including (but not limited to) atherosclerotic thrombosis, transient ischemic attack, embolism, hypertensive hemorrhage, and ruptured or unruptured saccular aneurysm or arteriovenous malformation, with the most common cause being atherosclerosis of the large and medium-sized blood vessels in the neck and the base of the brain (Henderson, 2017; Ropper et al., 2019). Nausea and vomiting may also follow, along with lost or impaired consciousness that may last for a short period, or may progress to coma and death, depending on the severity (Douglas and Aminoff, 2022). The risk factors for ischaemic stroke include hypertension, smoking, diabetes mellitus, obesity, physical inactivity, poor diet, alcohol consumption, psychosocial factors, depression and/or cardiac causes (*e.g.* atrial fibrillation, and the ratio of apolipoprotein B to apolipoprotein A1) (McGrath et al., 2017). Of these, hypertension is considered as the most important risk factor for stroke and is estimated to be responsible for approximately 500 % of all ischaemic strokes (World Heart Federation, 2017).

1.3. Cardiovascular risk factors

The development of cardiovascular disease can be attributed to several risk factors, which collectively account for ~75 % of all cardiovascular disease (WHO, 2002). These risk factors are divided into two groups: modifiable risk factors, and non-modifiable risk factors. The WHO (WHO, 2002) categorized high blood pressure (or hypertension), abnormal blood lipids, diabetes mellitus, tobacco use, physical inactivity, obesity, and unhealthy diets as the major modifiable risk factors. Advancing age, gender, ethnicity or race, and heredity or family history make up the main non-modifiable risk factors.

1.3.1. Hypertension

Hypertensive is characterised by chronic elevation of blood pressure (systolic blood pressure greater than/equal to 140 mm Hg and/or diastolic blood pressure greater than/equal to 90 mm Hg) (Alexander, 2019). Additionally, hypertension can be further categorized as: primary hypertension (also known as essential), whose cause(s) are not clearly defined; or identifiable, (secondary hypertension), which has clear and identifiable causes (Alexander, 2019). Primary hypertension is significantly more common than secondary hypertension. Indeed, the causes of hypertension generally can not be identified in 80–95 % of patients (Jameson et al., 2018). Despite the inability to identify the causes of primary hypertension, several notable factors may be associated with development. For example, lack of physical activity, a diet consisting of excessive salt, saturated fats, inadequate consumption of fruits and vegetables, excessive alcohol intake, and being overweight are common in people with primary hypertension (Benziger et al., 2017). Often patients with hypertension are unaware of their condition as they are asymptomatic during the early stages, and they usually remain that way until there is accumulation of substantial organ damage. For this reason, hypertension is often referred to as "the silent killer" (Vongpatanasin, 2017). However, despite the serious nature of hypertension, it can be effectively controlled in most patients through pharmacological intervention, generally with minimal adverse effects (Katzung et al., 2018). Several classes of drugs are useful for treating hypertension, including diuretics, sympathoplegics, vasodilators, angiotensin antagonists and renin inhibitors (Katzung et al., 2018). If left uncontolled, hypertension can lead to the development of myocardial infarction, stroke, peripheral artery disease, retinopathy and renal failure (Graham, 2020).

1.3.2. Blood lipids

Abnormal blood lipids (particularly high total cholesterol, LDL-cholesterol, and triglyceride levels) and low levels of HDL cholesterol increase the risk of coronary heart disease and ischaemic stroke (WHO, 2002). High levels of blood cholesterol can result in the development of atherosclerotic cardiovascular disease and lowering its level reduces the risk of cardiovascular disease (Blaha, 2020). The formation of plaques in response to high blood lipid levels is not fully understood. However, reducing blood lipid levels can reduce arterial plaque formation in artherosclerosis (Sharma and Shah, 2020). The cause of elevated lipid levels may be metabolic, renal, hepatic, hormonal, due to medication, or due to lifestyle factors, including physical inactivity, obesity and consumption of foods rich in saturated fats (Genest and Libby, 2018). Chemotherapeutic intervention with statins, bile acid absorption inhibitors, cholesterol absorption inhibitors,

and fibrates are commonly used to decrease blood lipid levels (Papadakis et al., 2022).

1.3.3. *Diabetes mellitus*

Individuals with diabetes mellitis are between two and four times more likely to develop CVD compared to non-diabetic patients. Cardiovascular disease is the leading cause of death in people with diabetes mellitus (World Heart Federation, 2017). Uncontrolled diabetes can induce heart, blood vessel, eye, kidney, and nerve damage (Powers et al., 2018). However, type 2 diabetes mellitus is generally readily controlled, most frequently through lifestyle changes, although chemotherapeutic options are also available (Cock et al., 2021).

2. Current treatments for cardiovascular disease

The three common risk factors each require pharmacological intervention to prevent the progression to cardiovascular disease resulting in coronary artery disease, heart failure, stroke, kidney damage, or dementia (Katzung et al., 2012). The medications used in hypertension are targeted toward reducing blood pressure either via volume loss by means of a diuretic, vasodilation, or by direct or indirect aldosterone inhibition (Katzung et al., 2012). Medications for dyslipidemia inhibit lipid synthesis or absorption, regulate gene expression, promote degradation of low-density lipoprotein receptors, or inhibit the catalytic enzyme that regulates the conversion of HMG CoA to mevalonate (Katzung et al., 2012; Lemus and Mendivil, 2015; Hajar, 2019). Diabetic medications may include insulin itself, or drugs aimed at increasing insulin secretion, or treatments aimed at sensitizing the cells to insulin, decreasing insulin absorption, increasing excretion of glucose, inhibiting glucagon release, increasing incretin levels, or increasing feelings of satiety (Katzung et al., 2012; Vella, 2012; Wilcox, 2020; Fisman and Tenenbaum, 2021). Overall, each risk factor has multiple targets, (Fig. 1.) that can be considered for treatment.

3. Medicinal plant use for cardiovascular diseases

While the treatment of cardiovascular disease is complex and often requires a holistic treatment plan, natural products have been considered as alternate options. A study on ten medicinal plants was undertaken whereby the therapeutic effects on isoproterenol-induced heart failure in rats was monitored (Keihanian et al., 2021). *Allium sativum* L., *Peganum harmala* Hadidi, and *Berberis vulgaris* Vell, significantly enhance cardiac function (Keihanian et al., 2021). In another study the antihypertensive and vasodilator effects of ethanolic extracts prepared from *Calea glomerata* Klatt, *Croton schiedeanus* Schlecht, *Curatella americana* L., *Lippia alba* (Mill) N.E.Br. and *Lupinus amandus* C.P.Sm were evaluated.

A rat model was used and *C. schiedeanus* demonstrated antihypertensive and bradycardic effects (Guerrero et al., 2002). Some reviews have focused on specific areas of natural product research with cardiac therapy as the emphasis. The dysregulation of mitochondrial homeostasis and mitophagy and the protective role of medicinal plants on heart failure also received attention (Wang et al., 2022). Medicinal plants and their effects on cardiac ischemia-reperfusion injury has also been reported (Sedighi et al., 2019). However, little attention has been given to traditional use

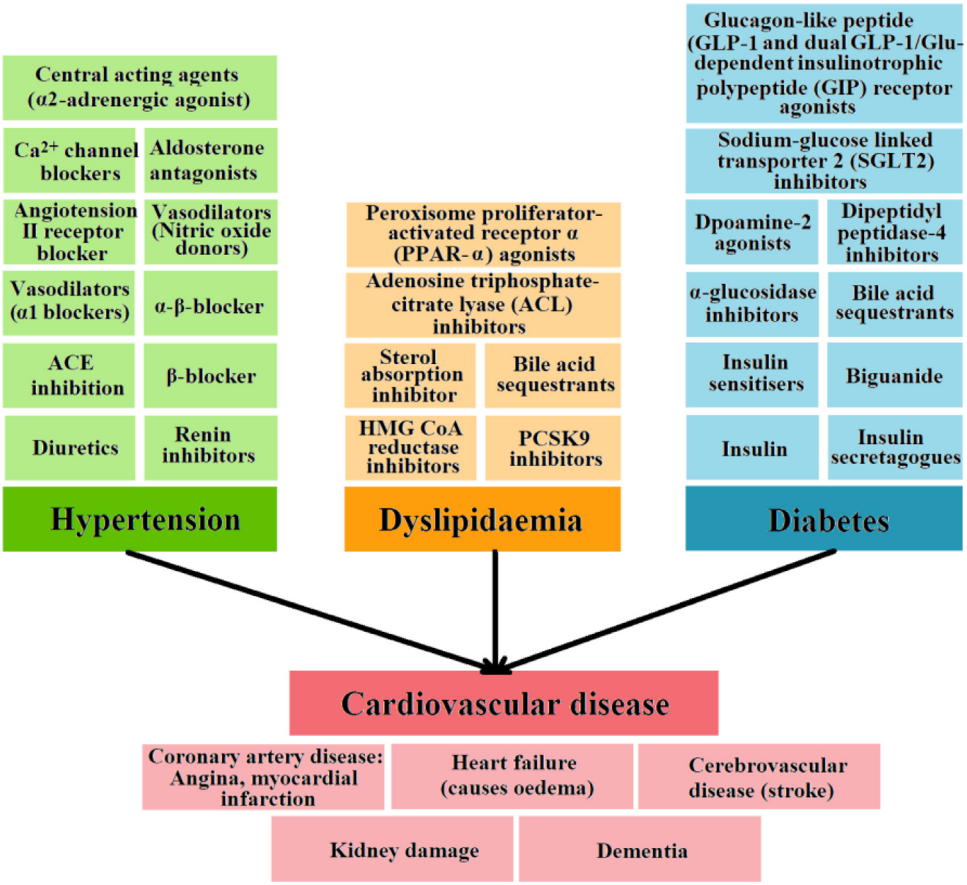

Fig. 1. Summary of cardiovascular disease risk factor treatment target sites and progression (Katzung et al., 2012; Vella, 2012; Lemus and Mendivil, 2015; Hajar, 2019; Wilcox, 2020; Fisman and Tenenbaum, 2021).

of medical plants for the treatment of heart disease. This review examines the traditional use of medicinal plants to treat cardiac diseases in southern Africa to provide insights into this relatively neglected area of research.

4. Materials and methods

4.1. Search strategy

This study aimed to identify plant species used in southern African traditional medicine to treat cardiovascular diseases in humans. The information obtained was subsequently used to determine if the traditional uses of these plants is supported by scientific evidence. A thorough literature survey was undertaken using ethnobotanical books (Watt and Breyer-Brandwijk, 1962; Hutchings, 1996; Felhaber and Mayeng, 1997; Adeniji et al., 2000; Van Wyk, 2008; Moffett, 2010), reviews and surveys. The ethnobotanical reviews and surveys were identified by searching the following electronic databases: ScienceDirect, Google Scholar, PubMed, and Scopus. The filters that were used (either alone or in combination) to identify the relevant literature were: “South African”, “southern African”, “medicinal plant”, “traditional medicine”, “high blood pressure” heart condition”, “heart ailment”, “weak heart”, “stroke”, and “myocardial infarction” “ethnobotany”, “cardiovascular”, “cardiac disease”, “hypertension”, “heart disease”, “cardioprotective”, and “angiotensin-converting enzyme inhibitors”. Following identification of plant species, keywords were used to identify studies which included, “ACE”, “ARB”, “diuretic”, “calcium channel blocker", "beta-blocker", "vasodilator”, “anti-coagulant”, and “anti-thrombotic”.

4.2. Eligibility criteria

Publications retrieved from the various electronic database searches were evaluated for eligibility based on their titles. The abstracts of all retrieved publications were read to confirm their suitability to this study. For studies that met the initial study criteria, full-text manuscripts were then obtained, and read to verify suitability. To be deemed eligible for this study, the following inclusion criteria was evaluated;

- Only English language publications were used to avoid misinterpretation.
- Plants used in traditional medicine practices of any ethnic group in the southern African region were recorded.
- Introduced plant species were included if they conformed to all other inclusion criteria.
- The study was non-biased, without taxonomic preference, nor bias towards the traditional medicine practices of any single ethnic group.
- To be included herein, plant species must be recorded to be specifically used in the treatment of a cardiovascular ailment, rather than symptoms that are shared between multiple conditions (*e.g.*, chest pain). Additionally, if a plant is used to treat other ailments (*e.g.*, diabetes, inflammation) that are not cardiovascular diseases (despite being able to induce cardiovascular diseases) it was not included in this study.

Publications were deemed ineligible and were not included herein if they met the following exclusion criteria;

- Incomplete publications, where only the abstract and references were available.
- Traditional medicines that did not indicate specific plant species, or studies where the species identity was in doubt.

4.3. Data collection

Following a thorough review of ethnobotanical literature, the plant species, family, common name (and ethnic-specific names), the plant part used, and the method of traditional use (where available) were documented and recorded using Microsoft Excel software Version 365.

5. Results

A thorough literature review identified 235 medicinal plants used traditionally in southern Africa to treat cardiovascular diseases (Table 1). The plants used in the treatment of cardiovascular diseases were from 69 families (Fig. 2). The greatest number of plant species were from the family Asteraceae (36 species), which is consistent with their usage to treat other medicinal conditions reported in other studies (Cock et al., 2019; Cock and Van Vuuren, 2020a, b; Van Wyk, 2020). Fabaceae was also well represented (30 species). Multiple species of Lamiaceae (16 species); Asphodelaceae, (eight species); Anacardiaceae, Apocynaceae, Aizoaceae (seven species each), Amaryllidaceae, Cucurbitaceae, Rutaceae (six species each); Celastraceae, Euphorbiaceae, Malvaceae (five species each); Apiaceae, (four species each) were also used to treat cardiovascular disease. All other families were represented by three or less species.

While some plant species have been cited once or twice, others such as *Cannabis sativa* L., *Commelina africana* L., *Elephantorrhiza elephantina* (Burch.) Skeels, *Eriocephalus punctulatus* DC., *Leonotis leonurus* (L.) R.Br., *Lessertia frutescens* subsp. *microphylla* (Burch. ex DC.), *Nidorella ivifolia* (L.) J.C.Manning & Goldblatt, *Olea europaea* subsp. *cuspidata* (Wall. & G.Don) Cif., *Pseudodictamnus africanus* (L.) Salmaki & Siadati, and *Ruta graveolens* L., have been cited four or more times, denoting their importance in treating cardiovascular disease.

For several cardiovascular conditions, the specific uses were ambiguous, whilst the uses of others were clearly listed. For example, the specific uses of plants listed for the treatment of hypertension, heart palpitations, angina, and stroke are indisputable. One hundred and sixty-three of the plant species used traditionally for the treatment of cardiovascular diseases were listed as treatments for hypertension or high blood pressure. Sixteen were used to treat oedema, twelve were used to treat or prevent stroke, seven were used to treat heart palpitations, four were used to promote diuresis, and four were used to treat low blood pressure (Fig.3). In contrast, “heart problems”, “heart complaints”and “heart conditions” were listed for some plant species. These descriptions could refer to multiple cardiovascular conditions. Sixty-one species were listed as being used to treat unspecified CVD. In this study, plants used traditionally to treat symptoms that could be attributed to conditions other than CVDs were excluded. For this reason, it is likely that the number of plant species identified herein may substantially underestimate the total number of southern African medicinal plants used for the treatment of cardiovascular diseases. Further ethnobotanical surveys of some ethnic groups may clarify this point and subsequently add to this inventory. Notably, in our study, we have only included plant species that are directly involved in treating CVDs (including hypertension and stroke), whilst plants used to treat conditions such as diabetes and inflammation are not recorded herein. The reader is referred to other detailed reviews by Cock et al. (2021) and Khumalo et al. (2022) for information of plants used to treat diabetes and inflammation respectively.

Roots/bulbs and rhizomes (29.4 %), and leaves (27.8 %) were the most frequently used southern African plant part to treat cardiovascular conditions (Fig. 4). Bark was also commonly used, accounting for 10.2 % of the total usage to treat CVDs. In contrast, whole plants (6.9 %) and fruit (2.3 %) were used substantially less frequently. For

Table 1
Southern African plants used traditionally to treat cardiovascular and related diseases.

Plant species	Family	Common name	Plant part(s) used	Traditional use	Reference
Acmella caulirhiza Delile	Asteraceae	Isishoshokazane, Isisinini (Zulu)	Not specified	High blood pressure	(Mhlongo and Van Wyk, 2019)
Acokanthera oblongifolia Benth. & Hook.f.	Apocynaceae	Inhlungunyemba, Inhlungunyembe (Zulu)	Not specified	High blood pressure	(Mhlongo and Van Wyk, 2019)
Acokanthera oppositifolia (Lam.) Codd	Apocynaceae	Inhlungunyembe (Zulu)	Not specified	High blood pressure	(Mhlongo and Van Wyk, 2019)
***Adenanthos linearis* Meisn.**	Proteaceae	Unspecified	Not specified	High blood pressure	(Nortje and Van Wyk, 2015)
Adenia digitata (Harv.) Engl.	Passifloraceae	umphindamshaya; imfule; imfulwa; impinda (Zulu)	Not specified	High blood pressure	(Mhlongo and Van Wyk, 2019)
Agapanthus africanus (L.) Hoffmanns.	Amaryllidaceae	African lily (English), bloelelie (Afrikaans), ubani-oluncane), uhlakahla (Zulu)	Root	Unspecified heart disease	(Watt and Breyer-Brandwijk, 1962; Hutchings, 1996)
Agapanthus campanulatus F.M. Leight.	Amaryllidaceae	Bell agapanthus (English), bloulelie (Afrikaans), ugebeleweni (Xhosa), ubani (Zulu)	Tubular roots	Unspecified heart disease	(Mugomeri et al., 2016)
Agathosma betulina (P.J. Bergium) Pillans	Rutaceae	Buchu (Xhosa)	Leaves, stems	High blood pressure	(Olorunnisola et al., 2011)
Agathosma capensis (L.) Dümmer	Rutaceae	Steenbokboegoe, boegoe, breëblaarboegoe, semelboegoe, lemoenboegoe (Afrikaans)	Not specified	High blood pressure	(Hulley and Van Wyk, 2019)
***Agave americana* L.**	Asparagaceae	Ikhamanga (Zulu)	Leaf sap, whole plant	High blood pressure	(Maroyi, 2017)
Ajuga ophrydis Burch. ex Benth.	Lamiaceae	Senyarrla (Southern Sotho)	Not specified	High blood pressure, oedema	(Moffett, 2010)
Albizia versicolor Welw ex. Oliv	Fabaceae	Muvhambangoma (Venda)	Leaves, roots	High blood pressure	(Mudau et al., 2020)
Albuca flaccida Jacq.	Asparagaceae	White onion (English), inqwebeba (Xhosa, Zulu)	Bulbs	High cholesterol and hypertension	(Philander, 2011)
Aloe arborescens Mill.	Asphodelaceae	Krantz aloe (English), kransaalwyn (Afrikaans), ikalene (Xhosa), inkalane, umhlabana (Zulu)	Not specified	High blood pressure	(Mhlongo and Van Wyk, 2019)
Aloe castanea Schönland	Xanthorrhoeaceae	Sekgopha sa setswiki, segafane (Sepedi)	Leaves	High blood pressure	(Mogale et al., 2019)
Aloe ferox Mill.	Asphodelaceae	Cape aloe (English), bitteraalwyn, winkelaalwyn, (Afrikaans), ikhala (Xhosa), *inhlaba* (Zulu)	Leaves, roots	Hypertension	(Moffett, 2010; De Beer and Van Wyk, 2011; Davids et al., 2016)
Aloe maculata All.	Asphodelaceae	Soap aloe, zebra aloe (English)	Not specified	High blood pressure	(Mhlongo and Van Wyk, 2019)
Aloe striatula (Haw.) Klopper & Gideon F.Sm.	Asphodelaceae	Hardy aloe, striped stem aloe (English)	Leaves	High blood pressure	(Moffett, 2010; Kose et al., 2015)
Aloe vossii Reynolds	Asphodelaceae	Tshikhopha, tshikopa (Venda)	Leaves	High blood pressure	(Mudau et al., 2020)
Aloidendron barberae (Dyer) Klopper & Gideon F.Sm.	Asphodelaceae	Eastern tree aloe (English), boomaalwyn (Afrikaans), ikhala, umgxwala (Xhosa), inkalane enkulu, inhlaba yesilungu (Zulu)	Not specified	High blood pressure	(Mhlongo and Van Wyk, 2019)
Athanasia cuneifolia Lam.	Asteraceae	Ghwarrieson, kwarison (Afrikaans)	Not specified	heart conditions	(Van Wyk and Gericke, 2000)
***Artemisia absinthium* L.**	Asteraceae	Wormwood (English), groenamara (Afrikaans)	Not specified	High blood pressure	(Nortje and Van Wyk, 2015)
Artemisia afra Jacq. Ex Willd.	Asteraceae	African wormwood (English), als, alsem, wildeals (Afrikaans), umhlonyane (Xhosa, Zulu), lengana (Sotho, Tswana)	Leaves	High blood pressure, heart problems	(Thring and Weitz, 2006; Nortje and Van Wyk, 2015; Davids et al., 2016)
Aspalathus linearis (Burm.f.) R. Dahlgren	Fabaceeae	Rooibos (Afrikaans)	Not specified	High blood pressure	(Nortje and Van Wyk, 2015)
Asparagus capensis L.	Asperagaceae	Wild asparagus (English), katdoring (Afrikaans)	Root	High blood pressure	(Philander, 2011)
Athanasia cuneifolia Lam.	Asteraceae	Not specified	Whole plant	Weak heart	(Philander, 2011)
Berkheya montana J.M. Wood & M. S. Evans	Asteraceae	Mohatollo, ntsoa-ntsane-ea-loti (Sotho)	Roots	High blood pressure, oedema	(Moffett, 2010)
Berkheya setifera DC.	Asteraceae	Buffalo-tongue thistle (English), rasperdissel, rasperdisseldoring (Afrikaans), indlebe-lenkomo (Xhosa), ikhakhasi, ulimi-lwenkomo, ulimi-lwenyathi (Zulu), lelelemla-khomo, ntsoantsane (Sotho)	Root	Circulatory problems	(Moffett, 2010)
***Bidens pilosa* L.**	Asteraceae	Blackjack (English); gewone knapsekerel (Afrikaans); ucadolo, uqadolo (Zulu)	Leaves	High blood pressure, oedema	(Mhlongo and Van Wyk, 2019; Mudau et al., 2020)
Brachystegia boehmii Taub	Fabaceae	Mupfuti (Shona)	Leaves	Handful of chopped leaves added to 1 L of boiling water for 30 min, 1/2 cup taken 3 times/day for heart problems	(Shopo et al., 2022)
Bridelia micrantha (Hochst.) Baill.	Phyllanthaceae	Munzere (Venda)	Bark	High blood pressure	(Mudau et al., 2020)
Bulbine latifolia (L.f.) Spreng.	Asphodelaceae	Red carrot (English), rooiwortel (Afrikaans)	Root	Hypertension	(Philander, 2011)
Bulbine narcissifolia Salm-Dyck	Asphodelaceae	Strap-leafed bulbine, snake flower (English), lintblaar bulbine, geelslangkop, wildekopieva (Afrikaans), khomo-ea-balisa, serelelile (Sotho)	Roots	Dilates blood vessels, promotes diuresis, improves blood circulation	(Moffett, 2010; Mugomeri et al., 2016)
Burkea africana Hook.	Fabaceae	Mufhulu (Venda)	Leaves	High blood pressure	(Mudau et al., 2020)
Cadaba aphylla (Thunb.) Wild	Capparaceae	Leafless worm bush (English), swartstormbos (Afrikaans), mfitshwana (Tswana), mudiatsiwana (Venda)	Leaves, stem	High blood pressure	(Davids et al., 2016; Hulley and Van Wyk, 2019)
***Cannabis sativa* L.**	Cannabaceae	Marijuana (English), dagga (Afrikaans), umya (Xhosa), insangu (Zulu), matekwane (Sotho), mbanzhe (Venda)	Leaves, stem	Hypertension, unspecified heart ailments, Stroke, high blood pressure	(Hutchings, 1996; Olorunnisola et al., 2011; Van Wyk and Gorelik, 2017; Hulley and Van Wyk, 2019; Mudau et al., 2020)
Capparis tomentosa Lam.	Brassicaceae	Muobadali (Venda)	Roots	High blood pressure	(Mudau et al., 2020)
Carpobrotus acinaciformis (L.) L. Bolus	Aizoaceae	Sour fig (English), ikhambilamabulawo, umgongozi (Zulu)	Leaves, fruit	Unspecified heart ailments	(Watt and Breyer-Brandwijk, 1962)

(*continued*)

Table 1 (*Continued*)

Plant species	Family	Common name	Plant part(s) used	Traditional use	Reference
Carpobrotus edulis (L.) N.E.Br.	Aizoaceae	Sour fig (English), hotnotsvye, vyerank (Afrikaans)	Not specified	High blood pressure, oedema	(Moffett, 2010)
Catha edulis (Vahl) Endl.	Celastraceae	Abyssinian tea, bushman's tea (English), boesmanstee (Afrikaans), umhlawazizi, umhlwazi (Zulu)	Bark	Heart stimulant	(Hutchings, 1996)
***Catharanthus roseus* (L.) G.Don**	Apocynaceae	Madagasscan perriwinkle, Cape perriwinkle, graveyard plant (English), imbali yamathuna, imbali yesibaya, isona, ubanibezwe, umangashi (Zulu)	Not specified	High blood pressure	(Mhlongo and Van Wyk, 2019)
***Centaurea benedicta* (L.) L.**	Asteraceae	Holy thistle (English), karmedik (Afrikaans)	Not specified	High blood pressure	(Hulley and Van Wyk, 2019)
Centella asiatica (L.) Urb	Apiaceae	Marsh pepperwort (English), waternael (Afrikaans), icudwane, umangobozane (Zulu), bolila-balinku (Sotho)	Not specified	Circulatory problems	(Moffett, 2010)
Chrysanthemoides monilifera L.	Asteraceae	Tick berry, bitou bush, boneseed (English), bietou, bosluisbessie (Afrikaans), igwababa, ikhambi lenyongo, imbozisa, yasolwandle, isifulwane, ithenanja, ugudlulwandle, ugudlumfula, ulimi lwenkomo, unkuphunyane (Zulu)	Not specified	High blood pressure	(Mhlongo and Van Wyk, 2019)
Chrysocoma ciliata L.	Asteraceae	Beesbos, swaelbossie (Afrikaans)	Not specified	Hypertension	(Davids et al., 2016; Hulley and Van Wyk, 2019)
***Cinnamomum camphora* (L.) J. Presl**	Lauraceae	Camphor (English), urosalina (Zulu)	Bark	Unspecified heart problems	(Philander, 2011)
Cissampelos capensis L.f.	Menispermaceae	Dawidjie (Afrikaans), umayisake (Xhosa)	Root	High blood pressure, unspecified heart problems	(Van Wyk, 2008; Olorunnisola et al., 2011)
Clausena anisata (Willd.) Hook.f. ex Benth.	Rutaceae	Horsewood (English), basternieshout, perdeboom, perdepis (boom/bos) (Afrikaans); isifudu, isifuthu, umnukambhiba, umnukelambiba, umsanka (Zulu)	Root, leaves, wood	Unspecified heart ailments, strengthens the heart, heart tonic	(Watt and Breyer-Brandwijk, 1962; Hutchings, 1996)
Cliffortia strobilifera L.	Rosaceae	Bog rice bush, cone rice-bush (English), kammiebos, kammie-rysbos, vleibos (Afrikaans), umnwele, unwele (Xhosa)	Not specified	High blood pressure	(Hulley and Van Wyk, 2019)
Combretum molle R.Br. ex G. Don	Combretaceae	Velvet bushwillow (English), basterrooibos, hardekool, rooibos, (Afrikaans), umdubu wehlathi, umbondwe; umbondwe-omhlope; umbondo (Zulu)	Not specified	High blood pressure	(Mhlongo and Van Wyk, 2019)
Combretum zeyheri Sond.	Combretaceae	Mufhatelathundu (Venda)	Roots	High blood pressure	(Mudau et al., 2020)
Commelina africana L.	Commelinaceae	Common yellow commelina (English), geeleendagsblom (Afrikaans), idangabane (Zulu), khotsoana (Sotho),	Roots	Strengthens heart	(Watt and Breyer-Brandwijk, 1962; Hutchings, 1996; Moffett, 2010; Moteetee and Van Wyk, 2011)
Commelina benghalensis L.	Commelinaceae	Tropical spiderwort (English), blouselblommetjie (Afrikaans), uhlotshane (Xhosa), idangabane (Zulu), khotsoana (Sotho), damba (Venda)	Whole plant	High blood pressure	(Hutchings, 1996)
Convolvulus capensis Burm. f.	Convolvulaceae	Bitterpatat (Afrikaans)	Bulb	High blood pressure	(Davids et al., 2016)
Crassula muscosa L.	Crassulaceae	Lizard's tail, watch chain, zipper plant (English), Akkedisbos (Afrikaans)	Leaves, stems, flowers, roots	High blood pressure	(Davids et al., 2016)
Crotalaria natalitia Meisn.	Fabaceae	Not specified	Root	Unspecified heart conditions	(Watt and Breyer-Brandwijk, 1962)
Croton gratissimus Burch.	Euphorbiaceae	Masunungule (Venda)	Leaves	High blood pressure	(Mudau et al., 2020)
Croton sylvaticus Hochst.	Euphorbiaceae	Amahlabakufeni, indumbahlozi, ugibeleweni, umgeleweni, umhlalajuba, umhloshazane, uminya, ummbila, umzilanyoni (Zulu)	Not specified	High blood pressure, stroke	(Mhlongo and Van Wyk, 2019)
Cussonia paniculata Eckl. & Zeyh.	Araliaceae	Mountain cabbage tree (English), bergkiepersol (Afrikaans)	Bark	Unspecified heart conditions	(Mugomeri et al., 2016)
Cynanchum insipidum E. Mey	Apocynaceae	Morogo wa lebje, leshwe, lefotosane (Pedi)	Roots	High blood pressure, heart attack	(Mogale et al., 2019)
***Datura stramonium* L.**	Solanaceae	Jimsonweed, devil's trumpet, thornapple (English), malpitte (Afrikaans), ijoqi, iloyi (Zulu)	Not specified	Stroke	(Mogale et al., 2019)
Dianthus micropetalus Ser.	Caryophyllaceae	Grashoutjie, grashout (Afrikaans)	Root	Angina	(Van Wyk, 2008)
Dicerothamnus rhinocerotis (L.f.) Koek	Asteraceae	Renosterbos (Afrikaans)	Leaves, stem	High blood pressure	(Davids et al., 2016)
Dicoma anomala Sond.	Asteraceae	Fever bush (English), maagbitterwortel, kalwerbossie, koorbossie, gryshout (Afrikaans), isihlabamakhondlwane, umuna (Zulu)	Roots, leaves	High blood pressure	(Moffett, 2010; Kose et al., 2015; Mugomeri et al., 2016)
Dicoma capensis Less.	Asteraceae	Wilde karmedik, koorsbossie (Afrikaans)	Leaves, twigs, roots	High blood pressure	(Van Wyk, 2008; De Beer and Van Wyk, 2011)
Dietes iridioides (L.) Sweet ex Klatt	Iridaceae	Painted lady, wild Iris (English), wilde-iris, klein wittulp (Afrikaans), ndaw'ihlathi, indawo yehlathi, isigqiki-sikatokoloshe, isishupe somfula (Zulu)	Rhizomes	Hypertension	(Hutchings, 1996)
Dioscorea hemicrypta Burkill	Dioscoreaceae	Olifantsvoet, skilpadtoon (Afrikaans)	Not specified	Unspecified heart conditions	(Hulley and Van Wyk, 2019)
Diosma oppositifolia L.	Rutaceae	Skaapbos (Afrikaans)	Leaves, stems, flowers	High blood pressure	(Davids et al., 2016)
Dipcadi brevifolium (Thunb.) Fourc.	Asparagaceae	Brownbells, curly-curly, wild hyacinth (English), slangui (Afrikaans), ikhakhakha elimpofu (Zulu)	Bulb	Heart pains	(Hutchings, 1996)
***Dittrichia graveolens* (L.) Greuter**	Asteraceae	Kakiebos (Afrikaans)	Not specified	High blood pressure	(Nortje and Van Wyk, 2015)

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Table 1 (*Continued*)

Plant species	Family	Common name	Plant part(s) used	Traditional use	Reference
Dombeya rotundifolia (Hochst.) Planch.	Malvaceae	Wild pear (English), dikbas (Afrikaans), unhliziyonkulu (Zulu), mohlabaphala (Sotho), mulanga (Venda)	Inner bark, leaves	Weakness of the heart, palpitations, heart problems	(Hutchings, 1996; Reid et al., 2001)
Dodonaea viscosa subsp. *angustifolia* (L.f.) J.G.West	Sapindaceae	Ysterhouttoppe (Afrikaans)	Leaves	Heart conditions	(Olorunnisola et al., 2011)
Drimia elata Jacq. ex Willd.	Asparagaceae	Red onion (English), jeukoi, roijukei (Afrikaans), intelezi, mascaban, brandui, indongana-zibomvana, isiklenama (Zulu)	Bulb	Brings back sensation after a stroke, high blood pressure	(Hutchings, 1996; Philander, 2011)
Drimia sanguinea (Schinz) Jessop	Asparagaceae	Tshiganama (Venda)	Bulb	High blood pressure	(Mudau et al., 2020)
***Durio graveolens* Becc.**	Malvaceae	Durian (English)	Not specified	High blood pressure	(Nortje and Van Wyk, 2015)
Ekebergia capensis Sparrm.	Meliaceae	Cape ash (English), essenhout (Afrikaans), isimanaye (Xhosa), umnyanmathi (Zulu), nyamaru, mmidibidi (Sotho), nyamaru (Tswana), mutovuma (Venda)	Bark, root	Unspecified heart conditions	(Hutchings, 1996; Oyedeji-Amusa et al., 2021)
Elachyptera parvifolia (Oliv.) N. Hallé	Celastraceae	Malambamapikwa (Venda)	Roots	High blood pressure	(Mudau et al., 2020)
Elaeodendron transvaalense (Burtt Davy) R.H. Archer	Celastraceae	Transvaal saffron wood (English), Transvaal saffraan (Afrikaans), ingwavuma (Zulu), monamane (Sotho), mukuvhazwivhi (Venda)	Bark	High blood pressure	(Hutchings, 1996; Mudau et al., 2020)
Elephantorrhiza elephantina (Burch.) Skeels	Fabaceae	Eland's bean, elephant's foot (English), baswortel, elandsboontjie (Afrikaans), intolwane, igwejobmvu (Xhosa), intolwana enkulu, intolwane, ugweje, umdabu (Zulu)	Rhizome or root	Hypertension and rheumatic heart conditions, chest complaints	(Watt and Breyer-Brandwijk, 1962; Hutchings, 1996; Moteetee and Van Wyk, 2011; Olorunnisola et al., 2011; Kose et al., 2015; Mudau et al., 2020)
***Eriobotrya japonica* (Thunb.) Lindl.**	Rosaceae	Ulokhwathi (Zulu)	Not specified	High blood pressure, heart "sickness"	(Watt and Breyer-Brandwijk, 1962; Mhlongo and Van Wyk, 2019)
Eriocephalus africanus L.	Asteraceae	Infection bush (English), kapokbos (Afrikaans)	Leaves	High blood pressure and oedema	(Philander, 2011)
Eriocephalus punctulatus DC.	Asteraceae	Cape chamomile (English), kapokbos (Afrikaans)	Whole plant, leaves	High blood pressure; Heart problems	(Thring and Weitz, 2006; Moffett, 2010; Moteetee and Van Wyk, 2011; Philander, 2011)
Erythrina caffra Thunb.	Fabaceae	Umsinsi (Zulu)	Not specified	High blood pressure	(Mhlongo and Van Wyk, 2019)
Erythrina lysistemon Hutch.	Fabaceae	Common coral tree (English), gewone koraalboom (Afrikaans), umnsinsi, umsinsi (Zulu), muvale (Sotho)	Not specified	High blood pressure	(Mhlongo and Van Wyk, 2019)
***Eucalyptus camaldulensis* Dehnh.**	Myrtaceae	Murray red gum (English), ugamthrini omhlophe (Zulu)	Not specified	High blood pressure	(Mhlongo and Van Wyk, 2019)
Euclea crispa subsp. *linearis* Zeyh. Ex Hiern	Ebenaceae	Mukwatikwati (Venda)	Roots	High blood pressure	(Mudau et al., 2020)
Euclea undulata Thunb.	Ebenaceae	Ghwarrie (Afrikaans)	Leaves, bark	Unspecified heart problems	(Watt and Breyer-Brandwijk, 1962; Philander, 2011)
Euphorbia clavarioides Boiss.	Euphorbiaceae	Lion's spoor (English), grootvingerpol, melkpol, slangpol, vingerpol (Afrikaans), isantilele, isihlekehleke (Zulu), sehlehle, sehloko, thethebale (Sotho)	Whole plant	High blood pressure and oedema	(Moffett, 2010; Kose et al., 2015)
Euphorbia inaequilatera Sond.	Euphorbiaceae	Not specified	Leaf	Unspecified heart problems	(Watt and Breyer-Brandwijk, 1962)
Euphorbia milii Des Moul.	Euphorbiaceae	Le blommo, malese (Pedi)	Whole plant	Angina	(Mogale et al., 2019)
Euryops abrotanifolius (L.) DC.	Asteraceae	Harpuisbos (Afrikaans)	Stem, leaves	High blood pressure	(Davids et al., 2016)
Garuleum woodii Schinz	Asteraceae	Mahloko-a-baroa (Sotho)	Leaves, roots, stems	Hypertension	(Mugomeri et al., 2016)
Geranium incanum (Burm. F)	Geranaiceae	Tlako (Xhosa)	Leaves, stem	Heart conditions	(Olorunnisola et al., 2011)
Gladiolus dalenii Van Geel	Iridaceae	African gladiolus, Natal lily (English), papegaai gladiolus, wildeswaardlelie (Afrikaans), isidwi esibomvu, udwendweni, uhlakahle (Zulu), khahla-e-kholo (Sotho)	Corms	High blood pressure and oedema	(Moffett, 2010)
Gunnera perpensa L.	Gunneraceae	River pumpkin (English), ubhoqo, ughobo (Xhosa, Zulu), iPhuzi, lomlambo (Xhosa)	Root bulb, leaves	Hypertension and high cholesterol	(Olorunnisola et al., 2011; Mugomeri et al., 2016)
Gymnosporia buxifolia (L.) Szyszył.	Celastraceae	Not specified	Thorns	Unspecified heart problems	(Watt and Breyer-Brandwijk, 1962)
Harpagophytum procumbens DC. ex Meisn.	Pedaliaceae	Devil's claw (English), duiwelsklou (Afrikaans), lekgagamare (Tswana), x'aata-taba, tloutaxaba (San)	Tuber	High blood pressure, stroke and heart disease	(Felhaber and Mayeng, 1997; Mncwangi et al., 2012)
Helichrysum crispum (L.) D.Don	Asteraceae	Kooigoed (Afrikaans)	Dried leaf infusions drunk as tea	Unspecified heart conditions	(Thring and Weitz, 2006)
Helichrysum cymosum (L.) D. Don	Asteraceae	Umathithibala (Xhosa), timie (Afrikaans)	Leaves	Unspecified heart problems	(Philander, 2011)
Helichrysum odoratissimum (L.) Sweet	Asteraceae	Everlanstings (English), kooigoed (Afrikaans), imphepho (IsiXhosa), imphepho (Zulu)	Leaves, whole plant, root	Unspecified heart problems, high blood pressure, stroke, chest pain complaints. and hypertension	(Van Wyk, 2008; Olorunnisola et al., 2011; Philander, 2011)
Helichrysum pandurifolium Schrank	Asteraceae	Not specified	Not specified	Unspecified heart problems	(Watt and Breyer-Brandwijk, 1962)
Helichrysum patulum D.Don	Asteraceae	Honey everlasting (English), kooigoed (Afrikaans), impepho (Xhosa), phefo (Sesotho)	Not specified	Heart problems	(Watt and Breyer-Brandwijk, 1962)
Hypoxis colchicifolia Baker	Hypoxidaceae	Broad-leaved Hypoxis, yellow star (English), gudu, ilabatheka, ilabetheka, ingcobo, inkomfe (Zulu)	Corms	Strengthens heart, diuretic	(Hutchings, 1996)
Hypoxis filifolia Eckl	Hypoxidaceae	Ikhubalo (Xhosa)	Bulb	High blood pressure	(Olorunnisola et al., 2011)
Hypoxis hemerocallidea Fisch., C.A. Mey. & Avé-Lall.	Hypoxidaceae	Inonqwe (Xhosa), inkomfe (Zulu),	Corm, root	High blood pressure, stroke, and heart weakness	(Olorunnisola et al., 2011; Mhlongo and Van Wyk, 2019)

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Table 1 (*Continued*)

Plant species	Family	Common name	Plant part(s) used	Traditional use	Reference
Hypoxis obtusa Burch. ex Ker Gawl	Hypoxidaceae	Mmona wa maledu, titikwane, sesogadi (Sepedi)	Roots	High blood pressure	(Mogale et al., 2019)
Kedrostis capensis (Sond.) A. Meeuse	Cucurbitaceae	Not specified	Tubular roots, leaves	Hypertension	(Mugomeri et al., 2016)
Kedrostis nana (Lam.) Cogn.	Cucurbitaceae	Bitter patat (Afrikaans)	Tuber	Hypertension	(Philander, 2011)
Kirkia wilmsii Engl.	Kirkiaceae	Mogaba, legaba, modumela (Pedi)	Roots	High blood pressure	(Mogale et al., 2019)
Lagenaria sphaerica (Sond.) E. Naudin	Cucurbitaceae	Inthsungu, iselwa lentaba (Zulu)	Not specified	High blood pressure	(Mhlongo and Van Wyk, 2019)
***Lannea schweinfurthii* (Engl.) Engl.**	Anacardiaceae	Muadaba, mulivhadza (Venda)	Roots	High blood pressure	(Mudau et al., 2020)
***Lavandula angustifolia* Mill.**	Lamiaceae	Lavander (English)	Leaves	Hypertension	(Philander, 2011)
Ledebouria apertiflora (Baker) Jessop	Asparagaceae	Sekanama, sefulanyana, sekunkuru (Sepedi)	Leaves	Angina	(Mogale et al., 2019)
Leonotis leonurus (L.) R.Br.	Lamiaceae	Wild dagga (English), wildedagga, duiwelstabak (Afrikaans), mvovo, umfincafincane (Xhosa), uyshwala-bezinyoni (Zulu)	Leaves, bulbs	Hypertension; heart problems; high blood pressure and chest complaints	(Thring and Weitz, 2006; Olorunnisola et al., 2011; Philander, 2011; Davids et al., 2016)
Leonotis ocymifolia (Burm.f.) Iwarsson	Lamiaceae	Minaret flower (English), rooidagga (Afrikaans), umcwili (Zulu), mununzu (Venda)	Not specified	High blood pressure	(Van Wyk, 2008)
Lessertia depressa Harv.	Fabaceae	Musa-pelo (Sotho)	Not specified	Heart palpitations	(Moffett, 2010; Moteetee and Van Wyk, 2011)
Lessertia frutescens subsp. *microphylla* (Burch. ex DC.) J.C. Manning & Boatwr.	Fabaceae	Cancer bush (English), wildekeur, kalkoenbel, kankerbos (Afrikaans), umnwele (Xhosa), insiswa, unwele (Xhosa, Zulu), musa-pelo, motlepelo (Sotho)	Whole plant, leaves	High blood pressure, oedema, heart failure	(Watt and Breyer-Brandwijk, 1962; Van Wyk and Gericke, 2000; Van Wyk, 2008; Moffett, 2010; Olorunnisola et al., 2011; Philander, 2011; Davids et al., 2016)
Lessertia montana (E.Phillips & R. A. Dyer) Goldblatt & J.C. Manning	Fabaceae	Mountain cancer bush, balloon pea (English), kankerbos, blaasbossie, blaasertjie, eendjies, gansiekeurtjie, klappers, hoenderbelletjie (Afrikaans), umnwele (Xhosa, Zulu)	Leaves	High blood pressure, oedema	(Moffett, 2010)
Lessertia perennans (Jacq.) DC.	Fabaceae	Blaasertjie (Afrikaans), musa-pelo-o-moholo-oa-lilliba (Sotho)	Not specified	High blood pressure, oedema	(Moffett, 2010; Moteetee and Van Wyk, 2011)
Leucosidea sericea Eckl. & Zeyh.	Rosaceae	Oldwood (English), ouhout (Afrikaans), isidwadwa, umyityi (Xhosa), umtshitshi (Zulu)	Leaves, stem (bark)	High blood pressure	(Moffett, 2010; Kose et al., 2015)
Lichtensteina lacera Cham. & Schltdl.	Apiaceae	Iqwili (Xhosa)	Leaves, bulbs	Heart conditions	(Olorunnisola et al., 2011; Davids et al., 2016)
Lotononis decumbens (B.-E. van Wyk) B.-E. van Wyk & Boatwr.	Fabaceae	Nomele (Sotho)	Not specified	High blood pressure, oedema	(Moteetee and Van Wyk, 2011)
***Mangifera indica* L.**	Anacardiaceae	Mango (English)	Stem bark	Heart conditions	(Mongalo and Makhafola, 2018)
***Medicago sativa* L**	Fabaceae	Luserene (Pedi), Lesere (Sotho)	Whole plant	Heart conditions	(Mogale et al., 2019)
***Melia azedarach* L.**	Meliaceae	Museranga (Venda)	Leaves	High blood pressure	(Mudau et al., 2020)
Melolobium alpinum Eckl. & Zeyh.	Fabaceae	Motsoehla, 'musa-pelo-o-moholo-oa-thaba (Sotho)	Leaves	High blood pressure, oedema	(Moffett, 2010; Moteetee and Van Wyk, 2011)
Mentha aquatica L.	Lamiaceae	Aromatic thyme, wild mint, water mint (English), kruisememt, kruistement, waterment (Afrikaans), ityaleba (Xhosa), umaliwane, umayime, umnukani, amabunu, imbozisa (Zulu), koena-e-nye-nyane, koena-ya-libida (Sotho)	Leaves	Hypertension	(Moffett, 2010; Moteetee and Van Wyk, 2011)
Mentha longifolia (L.) L.	Lamiaceae	Ballerja (Afrikaans)	Stem, leaves	High blood Pressure	(Davids et al., 2016)
Mesembryanthemum tortuosum (L.) N.E. Br.	Aizoaceae	Kougoed (Afrikaans)	Leaves and roots	High blood pressure	(Davids et al., 2016)
Millettia stuhlmannii Taub	Asteraceae	Muangaila (Venda)	Roots	High blood pressure	(Mudau et al., 2020)
Momordica balsamina L.	Cucurbitaceae	Balsam pear (English), laloentjie (Afrikaans), intshungu (Zulu), mohodu (Sotho)	Not specified	High blood pressure	(Mhlongo and Van Wyk, 2019)
Momordica boivinii Baill.	Cucurbitaceae	Nyapiringuhule (Venda)	Roots	High blood pressure	(Mudau et al., 2020)
Momordica foetida Schumach.	Cucurbitaceae	Gifappel, gifappeltjie (Afrikaans), intshungu (Zulu)	Leaves, stems	High blood pressure	(Hutchings, 1996)
Moraea spathulata (L.f.) Klatt	Iridaceae	Umaphipha (Xhosa, Zulu)	Bark	Strengthens the heart	(Philander, 2011)
***Moringa oleifera* Lam.**	Moringaceae	Muringa (Venda)	Leaves	High blood pressure	(Mudau et al., 2020)
Myrovernix glandulosus (Less.) Koek.	Asteraceae	Not specified	Not specified	Unspecified heart problems	(Watt and Breyer-Brandwijk, 1962)
Myrsine melanophloeus (L.) R.Br. ex Sweet	Primulaceae	Cape beech (English), boekenhout, beukehout (Afrikaans), isiqwane sehlati (Xhosa), isicalabi, umaphipha, ikhubalwane, isiqalaba sehlati (Zulu)	Bark	Strengthens the heart	(Hutchings, 1996)
Mystroxylon aethiopicum (Thunb.) Loes.	Celastraceae	Mukwatikwati (Venda)	Bark, root	High blood pressure	(Mudau et al., 2020)
Nidorella ivifolia (L.) J.C.Manning & Goldblatt DC.	Asteraceae	Oven bush, albany gall-sick bush (English), bakbesembossie, galsiektebossie, kouebos, bakbos (Afrikaans), uhlabo, umanzimnyama (Zulu)	Leaf infusion	Strengthens heart, low blood pressure	(Thring and Weitz, 2006; Van Wyk, 2008; Van Wyk et al., 2008; Van Wyk and Gorelik, 2017; Hulley and Van Wyk, 2019)
Notobubon galbanum (L.) Magee	Apiaceae	Berg celery, blister bush (English), bergseldery (Afrkaans)	Leaves	Hypertension	(Philander, 2011)

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Table 1 (*Continued*)

Plant species	Family	Common name	Plant part(s) used	Traditional use	Reference
***Ocimum basilicum* L.**	Lamiaceae	Basil (English), timie (Afrikaans)	Leaves, stem	Heart conditions	(Olorunnisola et al., 2011)
Oldenlandia affinis (Roem. & Schult.) DC.	Rubiaceae	Umampeshane (Zulu)	Root	Unspecified heart problems	(Watt and Breyer-Brandwijk, 1962; Hutchings, 1996)
Olea europea subsp. *africana.* Mill. P.S. Green	Oleaceae	Umquma (Xhosa)	Roots, leaves	Heart conditions	(Olorunnisola et al., 2011)
Olea europaea subsp. *cuspidata* (Wall. & G. Don) Cif.	Oleaceae	Wild olive (English), olienhout (Afrikaans), umnquma (Zulu, Xhosa), mohlware (Sotho), mutlhwari (Venda)	Leaves, roots, stem bark	High blood pressure, stroke, and palpitations	(Van Wyk, 2008; Moffett, 2010; Philander, 2011; Kose et al., 2015; Nortje and Van Wyk, 2015)
Opuntia ficus-indica (L.) Mill.	Cactaceae	Mudoro (Venda)	Bark	High blood pressure	(Mudau et al., 2020)
Osteospermum imbricatum Subsp. *nervatum* (DC) T. Nor	Asteraceae	Inkhupuhlana (Xhosa)	Bulb and leaves	Heart conditions	(Olorunnisola et al., 2011)
Osteospermum monilifera L.	Asteraceae	Igwababa, ikhambi lenyongo, imbozisa, yasolwandle, isifulwane, ithenanja, ugudlumfula, ulimi iwenkomo, unkuphunyane (Zulu)	Not specified	High blood pressure	(Mhlongo and Van Wyk, 2019)
Osyris lanceolata Hochst. & Steud.	Santalaceae	Mupeta (Venda)	Roots	High blood pressure	(Mudau et al., 2020)
Ozoroa reticulata (Baker f.) R.Fern. & A.	Anacardiaceae	Mununguma swi (Venda)	Roots	High blood pressure	(Mudau et al., 2020)
Paederia bojeriana (A.Rich. Ex DC.) Drake	Rubiaceae	Sulesule (Venda)	Leaves	High blood pressure	(Mudau et al., 2020)
Parinari curatellifolia Planch. ex Benth.	Chrysobalanaceae	Muchakata, muhute (Shona), muvhula (Venda)	Bark or fruits	Unspecified heart problems, high blood pressure	(Mudau et al., 2020; Shopo et al., 2022)
Pelargonium odoratissimum (L.) L'Her.	Geraniaceae	Not specified	Leaves	Cardiac stimulant	(Van Wyk, 2008)
Pentanisia prunelloides (Klotzsch) Walp.	Rubiaceae	Wild verbena (English), sooibrandbossie (Afrikaans), icimamlilo (Zulu), setima-mollo (Sotho)	Root	Palpitations, high blood pressure	(Hutchings, 1996; Felhaber and Mayeng, 1997; Kose et al., 2015)
***Persea americana* Mill.**	Lauraceae	Avocado, alligator pear (English)	Not specified	Hypertension	(Adeniji et al., 2000)
***Petroselinum crispum* (Mill.) Fuss**	Apiaceae	Parsley (English)	Leaves, seeds	Can raise blood pressure	(Asowata-Ayodele et al., 2016)
Phyllogeiton discolor (Klotzsch) Herzog	Rhamnaceae	Munie (Venda)	Leaves	High blood pressure	(Mudau et al., 2020)
***Phylsalis peruviana* L.**	Scophulariaeae	Gquzu (Xhosa)	Leaves, bulb	Chest complaints	(Olorunnisola et al., 2011)
Piper capense L.f.	Piperaceae	Wild pepper (English), wildepeper (Afri-kaans), ihlolane, uluphokwane (Zulu)	Fruit	Unspecified heart problems	(Watt and Breyer-Brandwijk, 1962)
Pittosporum viridiflorum Sims	Pittosporaceae	Umkhwenkhwe (Zulu)	Bark	Hypertension	(Philander, 2011)
***Polygonum aviculare* L.**	Polygonaceae	Litjiesgras (Afrikaans)	Roots	Angina	(Van Wyk, 2008)
Protorhus longifolia (Bernh.) Engl.	Anacardiaceae	Red beech, purple currant, (English), harpuis-boom, rooibeukeblaar, rooibeukehout, rooi-boekenhout, rooimelkhout (Afrikaans), ikhubalo, isifuce, umhluthi (Xhosa), isifice, isifico-sehlathi, isifuze, umhlangothi, umh-luthi (Zulu), mutu-musolde (Venda)	Not specified	Strengthens the heart	(Hutchings, 1996)
Pseudodictamnus africanus (L.) Sal-maki & Siadati	Lamiaceae	Cat mint (English), kattekruie (Afrikaans)	Leaves	Improves blood circulation, low-ers blood pressure,	(Watt and Breyer-Brandwijk, 1962; De Beer and Van Wyk, 2011; Philander, 2011; Davids et al., 2016; Hulley and Van Wyk, 2019)
Ptaeroxylon obliquum (Thub.) Radlk.	Rutaceae	Sneeze wood (English), umthathe (Zulu)	Bark, leaves	Unspecified heart problems	(Watt and Breyer-Brandwijk, 1962; Philander, 2011)
Pterocarpus angolensis DC	Fabaceae	Mutondo (Venda)	Leaves	High blood pressure	(Mudau et al., 2020)
Pterocarpus rotundifolius (Sond.) Druce	Fabaceae	Muhataha (Venda)	Roots	High blood pressure	(Mudau et al., 2020)
Pyrenacantha kaurabassana Baill.	Icacinaceae	Galange (Venda)	Roots	High blood pressure	(Mudau et al., 2020)
Rauvolfia caffra Sond	Apocynaceace	Munadzi (Venda)	Leaves	High blood pressure	(Mudau et al., 2020)
Rhoicissus digitata (L.f.) Gilg. & M. Brandt	Vitaceae	Uchithibhunga (Xhosa), mutumbulambud-zana (Venda)	Bulb, roots	High blood pressure	(Olorunnisola et al., 2011; Mudau et al., 2020)
Rhynchosia africanum Ser. var. *africanum* . Phillips & R.A. Dyer	Fabaceae	Moqopolla-thula, 'musa-pelo (Sesotho)	Whole plant	Heart trouble	(Moteetee and Van Wyk, 2011)
Rhynchosia burchellianum Ser. subsp. *Burchellianum* . Phillips & R.A. Dyer	Fabaceae	Moqopolla-thula, moroko, 'musa-pelo (Sesotho)	Roots	Heart problems	(Moteetee and Van Wyk, 2011)
Rhynchosia sutherlandia montana E. Phillips & R.A. Dyer	Fabaceae	'Musa-pelo-o-moholo-oa-noka (Sesotho)	Leaves	Dropsy of heart	(Moteetee and Van Wyk, 2011)
Rhynchosia tephrosia capensis (Jacq.) Pers.	Fabaceae	'Musa-pelo-oa-noka (Sesotho)	Root	Heart palpitations	(Moteetee and Van Wyk, 2011)
Roepera morgsana (L.) Beier & Thulin	Zygophyllaceae	Not specified	Seed	Stroke	(Watt and Breyer-Brandwijk, 1962)
Rumex lanceolatus Thunb.	Polygonaceae	Common dock (English), gladdetongblaar (Afrikaans), idolonyana (Xhosa), idolo lenkonyane (Zulu), khamane (Sotho)	Whole plant	Unspecified heart problems	(Moffett, 2010)
Ruschia putterillii (L. Bolus) L.Bolus	Aizoaceae	Leqhwaba, sebabetsane, sebabetsi, seba-betswane (Sotho)	Not specified	High blood pressure, oedema	(Moffett, 2010)
Ruschia spinosa (L.) Dehn	Aizoaceae	Steekkaroo (Afrikaans)	Leaves	Angina	(Van Wyk, 2008)
***Ruta graveolens* L.**	Rutaceae	Rue (English), wynruit (Afrikaans), gwabeni, ivendrit (Xhosa)	Leaves	High blood pressure, heart disease and cardiac asthma.	(Watt and Breyer-Brandwijk, 1962; Van Wyk, 2008; Olorunnisola et al., 2011; Philander, 2011; Van Wyk and Gorelik, 2017)

(*continued*)

Table 1 (*Continued*)

Plant species	Family	Common name	Plant part(s) used	Traditional use	Reference
Salvia africana L.	Lamiaceae	Blousali, bloublomsalie (Afrikaans)	Leaves	High blood pressure	(Davids et al., 2016)
Salvia disermas L.	Lamiaceae	Teesalie, grootblousalie, terpentynbos, muishondbos (Afrikaans)	Not specified	Unspecified heart problems and high blood pressure	(Van Wyk and Gorelik, 2017)
Salvia repens Burch. ex Benth.	Lamiaceae	Creeping sage (English), kruipsalie (Afrikaans), usikiki (Xhosa)	Not specified	High blood pressure	(Moffett, 2010)
***Salvia rosmarius* Spenn.**	Lamiaceae	Rosemary (English)	Leaves	Low blood pressure and unspecified heart problems	(Philander, 2011)
***Scabiosa columbaria* L.**	Caprifoliaceae	Small scabious, dwarf pincushion flower (English)	Roots, leaves	High blood pressure	(Kose et al., 2015)
***Schkuhria pinnata* (Lam.) Kuntze ex Thell.**	Asteraceae	Yellow tumbleweed (English), rolkakiebossie (Afrikaans), tetapiso(Sotho)	Whole plant	High blood pressure and oedema	(Mahwasane et al., 2013)
Sclerocarya birrea (A.Rich.) Hochst.	Anacardiaceae	Marula (English), maroela (Afrikaans), umganu (Zulu), morula (Sotho), mufula (Venda)	Bark	Strengthen the heart	(Hutchings, 1996; Corrigan et al., 2011)
Scolopia mundii (Nees) Warb.	Salicaceae	Red pear (English), bergsaffraan, bergsaffraanhout, klipdoring, rooipeer (Afrikaans), udwendwelwegcuba (Zulu)	Not specified	Unspecified heart problems	(Hutchings, 1996)
Searsia burchellii (Sond. Ex Engl.) Moffett	Anacardiaceae	Taaibos (Afrikaans)	Leaves, stem and roots	High Blood Pressure	(Davids et al., 2016)
Searsia lancea (L.f.) F.A.Barkley	Anacardiaceae	Makkaree, kareeboom (Afrikaans), tšilabele (Sesotho)	Leaves, fruit	High blood pressure	(Moteetee and Van Wyk, 2011; Kose et al., 2015)
***Selaginella cinerascens* A.A. Eaton**	Selaginellaceae	Resurrection plant (English) matlapa, mafika (Sotho)	Not specified	High blood pressure	(Nortje and Van Wyk, 2015)
Senecio asperulus DC.	Asteraceae	Makhona-tsohle, moferefere (Sotho)	Whole plant	Improves blood circulation	(Moffett, 2010; Kose et al., 2015)
Senecio bupleuroides DC.	Asteraceae	Idwarane (Xhosa), indabula-luvalo, insangansanga yentaba, isiqandamatshana, unsonkonsoko (Zulu), lehlongoana, lereko (Sotho)	Not specified	Unspecified heart problems	(Hutchings, 1996)
Senecio cinerascens Aiton	Asteraceae	Handjiebos, vieroulap (Afrikaans)	Not specified	High blood pressure	(Nortje and Van Wyk, 2015)
Senecio inornatus DC.	Asteraceae	Tall marsh senecio (English), groot vleisenecio (Afrikaans), inkanga, uhlabo (Zulu), lehlongoana-le-leholo (Sotho)	Root	Palpitations	(Watt and Breyer-Brandwijk, 1962; Hutchings, 1996)
Senna didymobotrya (Fresen). H.S Irwin & Barneby	Fabaceae	Mutsheketsheke (Venda)	Aerial parts	High blood pressure	(Mudau et al., 2020)
Senna italica Mill.	Fabaceae	Muḓuwaḓuwane (Venda)	Leaf, root	High blood pressure	(Mudau et al., 2020)
***Senna obtusifolia* (L.) H.S. Irwin & Barneby**	Fabaceae	Muyekeyeke (Venda)	Root	High blood pressure	(Mudau et al., 2020)
***Senna occidentalis* (L.) Link**	Fabaceae	Mutsheketsheke (Venda)	Root	High blood pressure	(Mudau et al., 2020)
Seriphium cinereum L.	Asteraceae	Not specified	Not specified	Unspecified heart problems	(Watt and Breyer-Brandwijk, 1962)
Sida cordifolia L.	Malvaceae	Flannel weed (English), hartblaartaaiman, koekbossie (Afrikaans)	Whole plant	High blood pressure	(Mongalo and Makhafola, 2018)
Solanum aculeastrum Dunal	Solanaceae	Bitter apple (English), bitterappel (Afrikaans), umthuma, itunga (Xhosa), intuma (Zulu), thola (Tswana), murulwa (Venda)	Not specified	High blood pressure and stroke	(Mhlongo and Van Wyk, 2019)
***Solanum americanum* Mill.**	Solanaceae	Seshoa-bohloko (Sotho)	Roots, leaves, berries	Unspecified heart problems, angina	(Watt and Breyer-Brandwijk, 1962; Moteetee and Van Wyk, 2011)
Solanum incanum L.	Solanaceae	Intuma, intuma encane, umagangeni (Zulu)	Not specified	Cardiovascular (stroke)	(Mhlongo and Van Wyk, 2019)
***Solanum schefferi* F.Muell.**	Solanaceae	Intuma, intuma encane, umagangeni (Zulu)	Not specified	High blood pressure and stroke	(Mhlongo and Van Wyk, 2019)
Solanum tomentosum L.	Solanaceae	Slangappel, slangappelbos (Afrikaans)	Roots and stem	Angina	(Mugomeri et al., 2016)
Spermacoce natalensis Hochst.	Rubiaceae	Insulansula, isindiyandiya, umabophe (Zulu)	Bark	Unspecified heart problems	(Hutchings, 1996)
Stangeria eriopus (Kunze) Baill.	Zamiaceae	Natal grass cycad (English), (Afrikaans), umncuma (Xhosa), imfingo (Zulu)	Tuber	High blood pressure	(Hutchings, 1996)
Strelitzia nicolai Regel & K. Körn	Strelitziaceae	Isigude, inkalvasi, inkamanga (Zulu)	Not specified	High blood pressure, heart problems	(Mhlongo and Van Wyk, 2019)
Strychnos madagascariensis Poir.	Loganiaceae	Black monkey range, spineless monkey orange, wild orange (English), botterklapper, swartklapper (Afrikaans), mukwakwa (Venda)	Not specified	High blood pressure	(Mhlongo and Van Wyk, 2019)
Strychnos potatorum L.f.	Loganiaceae	Mukongovhoti (Venda)	Leaves, roots	High blood pressure	(Mudau et al., 2020)
Strychnos spinosa Lam.	Loganiaceae	Amahlala, igulukungqa, igulukuza, ingola (Zulu)	Not specified	High blood pressure	(Mhlongo and Van Wyk, 2019)
Tabernaemontana elegans Stapf	Apocynaceae	Muhatu (Venda)	Roots	High blood pressure	(Mudau et al., 2020)
Teedia lucida (Aiton) Rudolphi	Scrophulariaceae	Klipkersie, predikant-op-die-preekstoel, stinkbos (Afrikaans), hlwenya (Zulu)	Not specified	High blood pressure	(Moffett, 2010)
Tephrosia capensis (Jacq.) Pers.	Fabaceae	Not specified	Roots	Strengthens heart, heart palpitations	(Watt and Breyer-Brandwijk, 1962; Moffett, 2010; Kose et al., 2015)
Tephrosia semiglabra Sond.	Fabaceae	Not specified	Roots, leaves	Unspecified heart problems and tachycardia	(Mugomeri et al., 2016)
Thespesia garckeana F. Hoffm.	Malvaceae	Tree hibiscus, slime apple, snot apple (English), slymappel, snotappel (Afrikaans), mutogwe (Venda)	Roots	High blood pressure	(Mongalo and Makhafola, 2018)
***Thymus serpyllum* L.**	Lamiaceae	German thyme, common thyme (English)	Not specified	Unspecified heart problems	(Watt and Breyer-Brandwijk, 1962)
Trifolium africanum Ser.	Fabaceae	Erasmus clover, wild clover (English), wildeklawer (Afrikaans), mmusapelo,	Roots	High blood pressure, heart related ailments, diuretic	(Watt and Breyer-Brandwijk, 1962; Moffett, 2010)

(*continued*)

Table 1 (*Continued*)

Plant species	Family	Common name	Plant part(s) used	Traditional use	Reference
		moroko, musapelo, mokopshwe, mootsa-pelo, moqoiqoi, moqophi (Sotho)			
Trifolium burchellianum Ser.	Fabaceae	Erasmus clover, wild clover (English), wild-eklawer (Afrikaans), mmusapelo, moroko, musapelo, mokopshwe, mootsa-pelo, moqoiqoi, moqophi (Sotho)	Roots	High blood pressure, heart related ailments, diuretic	(Moffett, 2010)
***Tropaeolum majus* L.**	Tropaeolaceae	Bopa (Venda)	Leaves	High blood pressure	(Mudau et al., 2020)
Tulbaghia acutiloba Harv.	Amaryllidaceae	Sefotha-fotha (Sesotho)	Not specified	High blood pressure	(Moffett, 2010; Moteetee and Van Wyk, 2011)
Tulbaghia alliacea L.f.	Amaryllidaceae	Wild garlic, woodland garlic (English), wild-eknoflok (Afrikaans), ishaladilezinyoka, umwelela (Zulu), molela (Southern Sotho)	Bulb	Infusion (milk) used to treat high blood pressure	(Van Wyk, 2008)
Tulbaghia capensis L.	Amaryllidaceae	Wild garlic (English), wilde knoffel (Afri-kaans)	Bulb	Hypertension	(Philander, 2011)
Tulbaghia violacea Harv.	Amaryllidaceae	Wild garlic (English), wilde knoffel (Afri-kaans), isihaqa (Zulu)	Bulb, leaves, roots	High blood pressure	(Davids et al., 2016; Mhlongo and Van Wyk, 2019)
Turraea floribunda Hochst.	Meliaceae	Honeysuckle (English), kanferfoelieboom (Afrikaans), umadlozane (Zulu), umdlo-zana (Swazi)	Root	Weak heart, high blood pressure, oedema	(Watt and Breyer-Brandwijk, 1962; Hutchings, 1996)
***Urtica urens* L.**	Urticaceae	Annual nettle, burning nettle, sting nettle bush, dwarf stinging nettle (English), brandnekel (Afrikaans)	Leaves	Unspecified heart problems	(Moffett, 2010; Moteetee and Van Wyk, 2011)
***Vachellia eburnea* (L. f.) P.J.H. Hurter & Mabb.**	Fabaceae	Isinqawe esimphlope, umkhamba, uselephe (Zulu)	Not specified	High blood pressure	(Mhlongo and Van Wyk, 2019)
Vachellia sieberiana (DC.) Kyal. & Boatwr.	Fabaceae	Paperbark thorn (English), papierbasdoring (Afrikaans), umkhamba (Zulu), mphoka (Sotho), umnganduzi (Swazi), mokha (Tswana)	Not specified	High blood pressure	(Mhlongo and Van Wyk, 2019)
Vigna vexillata (L.) A.Rich.	Asteraceae	Mukundulela (Venda)	Leaves	High blood pressure	(Mudau et al., 2020)
Viscum capense L.f.	Santalaceae	Cape mistletoe (English), lidjiestee, voelent (Afrikaans)	Not specified	Strengthens the heart	(Van Wyk, 2008)
***Vitis vinifera* L.**	Vitaceae	Grape vine (English)	Roots	High blood pressure, used for weak heart	(Van Wyk et al., 2008; Mongalo and Makhafola, 2018)
Volkameria glabra (E. Mey.) Mabb. & Y.W. Yuan	Lamiaceae	Mukwatikwati (Venda)	Leaf, root	High blood pressure	(Mudau et al., 2020)
Warburgia salutaris (G. Bertol.) Chiov.	Canellaceae	Pepper-bark tree (English), peperbasboom (Afrikaans), isibhaha (Zulu), mulanga, manaka (Venda)	Bark, leaves	Angina, high blood pressure	(Felhaber and Mayeng, 1997; Mudau et al., 2020)
***Withania somnifera* (L.) Dunal.**	Solanaceae	Indian ginseng, poison gooseberry, winter cherry (English), bitterappelliefie, koorshout (Afrikaans), ubuvuma (Xhosa), ubuvimbha (Zulu)	Tubular roots, leaves	Strengthens blood circulation	(Mugomeri et al., 2016)
Ximenia americana L.	Olacaeae	Tshitanzwatanzwa (Venda)	Roots	High blood pressure	(Mudau et al., 2020)
Xylopia odoratissima Welw. Ex Oliv	Annonaceae	Muvhulavhusiku (Venda)	Roots	High blood pressure	(Mudau et al., 2020)
Xysmalobium undulatum (L.) W.T. Aiton	Apocynaceae	Milk bush (English), ishongwe, ishinga (Zulu)	Root	Unspecified heart problems	(Watt and Breyer-Brandwijk, 1962; Hutchings, 1996)

Introduced and/or widely used alien species are indicated in **bold text**.

approximately 29.6 % of species, the plant part used was not definitively documented. Notably, most of the ethnobotanical studies identified in the literature review documented Zulu traditional plant usage as a substantially greater number of Zulu ethnobotanical studies have been published. Future studies into the traditional medicine systems (when they are ultimately available) may provide additional detail about the plant part used, as well as the method of preparation of the medicines and their methods of use.

Of the 235 species documented in Table 1, only 43 species have been screened for bio-activies related to CVDs (Table 2). Notably, the screening of foreign/introduced species has generally been substantially more extensively reported than for native southern African species. Indeed, of the 40 introduced species listed in Table 1, 13 (33 %) have been screened for one or more CVD-related effects. In contrast, of the 194 native southern African plant species listed herein, only 31 species (16 %) had been tested for CVD-related bio-activities. This greater exploration of the introduced species may be related to these species being used in multiple medicinal systems globally. They may therefore have been tested due to their usage in the other traditional systems. Thus, many of the plants listed herein are yet to be tested for any CVD-related bio-activities and substantially more research is required.

With regard to the screening of the southern African plants used traditionally to treat CVDs, the predominant bio-activity screened was angiotensin-converting enzyme (ACE) inhibitory activity. The ACE is involved in increased blood pressure in hypertension. Inhibition of ACE reduces blood pressure, and it is a target for the development of drugs targeting hypertension (Benowitz, 2017). In general, plant preparations are regarded as drug targets for the development of anti-hypertensive therapies if they inhibit ACE activity by greater than 50 % (Duncan et al., 1999; Ramesar et al., 2008).

Of the 21 plant species that were screened specifically for ACE-inhibitory activity, only ten species/plant extracts had an ACE-inhibitory effects greater than 50 % and were therefore considered to be targets for anti-hypertensive drug development. Leaf extracts produced noteworthy ACE-inhibitory activity more frequently than other plant parts. No clear correlation was observed regarding the best solvent, with similar numbers of aqueous and ethanolic extracts inhibiting ACE activity by >50 %. The effects of the extracts in rat hyperlipedemia models were also relatively well studied. Ten of the

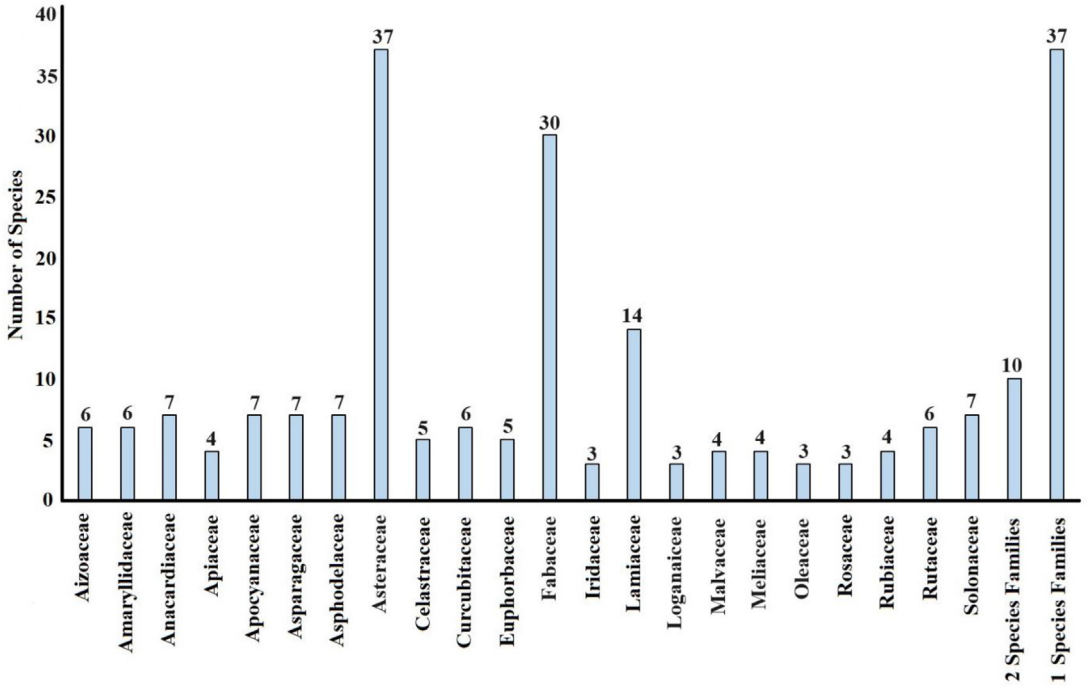

Fig. 2. The frequency that plant families were cited as being used in southern African traditional medicine to treat cardiovascular disease. Numbers above individual bars indicate the number of species in that family listed to treat CVDs. Bars labelled as either 2 or 1 species families refers to the number of families represented by the indicated number of species.

plant preparations were reported to significantly decrease hyperlipidemia.

Surprisingly, relatively few studies have examined the direct effects of the plant extracts on hypertension *in vivo*. Indeed, only ten studies (Table 2) examined the effects of the extracts on hypertension, and nearly all those studies used rats as the test model. *In vitro* studies that screen the effects of the extracts against specific *in vitro* targets are important to understand the therapeutic mechanisms in treating CVDs. However, these models do not account for the bioavailability of the therapeutic components (including gastrointestinal absorption rates, metabolism and inactivation, cell entry etc.). *In vivo* studies are required to verify that the extracts/isolated components also work in complex multicellular systems. Substantially more research is required to verify that these plant preparations have therapeutic effects against CVDs *in vivo*, and thereby to validate their use for those purposes. Furthermore, only a single clinical trial in humans was found, with *A. ferox* treatment inducing substantial decreases in hyperlipidemia and hypertension in obese human patients.

6. Discussion

Notably, of the 235 documented plant species recorded herein as being used traditionally to treat CVDs, only 43 species have been screened for any CVD-related properties (Table 2). Perhaps more surprisingly, only 10 studies (one clinical trial and nine studies using rat models) directly verified the anti-hypertensive activity of the extracts *in vivo*. A further 10 studies reported the ability of some extracts to reduce blood lipid levels in both normal and induced-hyperlipidemia

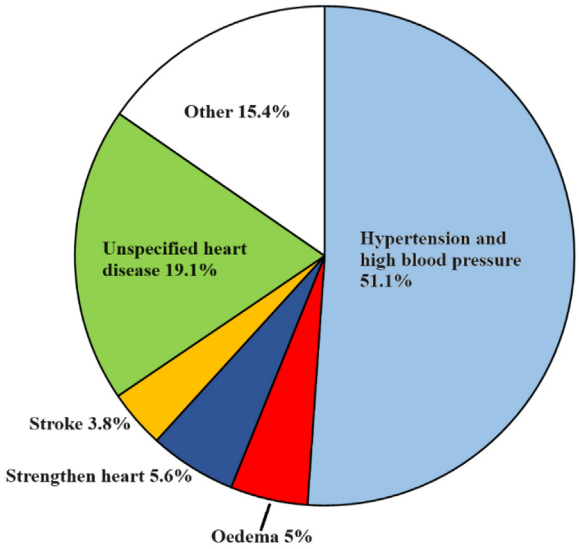

Fig. 3. The cardiovascular disease types treated with the southern African plants expressed as a percentage of the total uses. Several plant species were used to treat more than one type of CVD. Those species are included in all the administration categories in which they are listed.

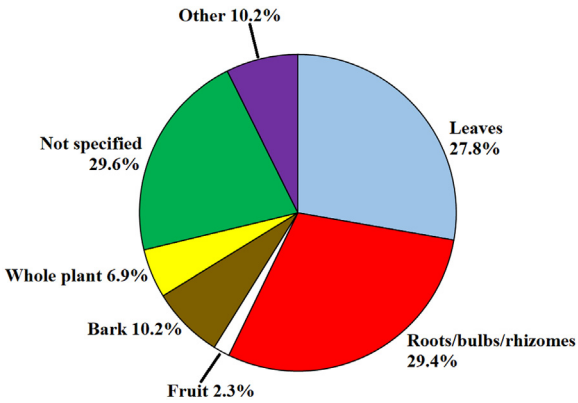

Fig. 4. The relative proportion that individual plant parts were used to treat cardiovascular disease, expressed as a percentage of the overall usage. For several plant species, more than one part was used therapeutically to treat CVDs. Those species are included in all of the plant part categories in which they are listed.

Table 2
Scientific evaluations of southern African medicinal plants for cardio-preventative and/or therapeutic properties.

Plant species	Plant part tested	Type of extract	Outcome of study	References
Agapanthus africanus (L.) Hoffmanns.	Leaves	Aqueous extract	Inhibited ACE activity by 63 %	(Duncan et al., 1999)
		Ethanol extract	Inhibited ACE activity by 44 %	
	Roots	Aqueous extract	Inhibited ACE activity by 37 %	
		Ethanol extract	Inhibited ACE activity by 19 %	
***Agave americana* L.**	Leaves	Aqueous extract	Inhibited ACE activity by 72 %	(Duncan et al., 1999)
		Ethanol extract	Inhibited ACE activity by 82 %	
Aloe ferox Mill.	Multiple dietary supplements containing powdered *A. ferox* leaf	Powdered leaf	All supplements reduced hyperlipidemia and reduced blood pressure in a clinical study of obese patients.	(Gherbon et al., 2021)
Artemisia afra Jacq.	Leaves	Methanol extracts	Highest% ACE inhibition activity noted at approximately 60 % at a concentration of 250 μg/ml.	(Reddy et al., 2023)
Aspalathus linearis (Burm.f.) R.Dahlgren	Leaves	Aqueous extract	Protects against nicotine-induced vascular injury in Wistar rats.	(Smit-van Schalkwyk et al., 2020)
	Leaves	Aqueous extract	Reported to have a significant reduction after 30 min ($P < 0.01$) and after 60 min ($P < 0.05$) of ACE in 17 healthy volunteers, however, no nitric oxide (NO) donation was observed.	(Persson, 2012)
	Leaves	Fermented tea	The lipid profiles showed that tea consumption decreased serum LDL-cholesterol (4.6 ± 1.3 mmol/L *vs.* 3.9 ± 0.7 mmol/L) and triacylglycerols (1.7 ± 0.8 mmol/L *vs.* 1.2 ± 0.7 mmol/L), Consumption of fermented, traditional rooibos significantly improved the lipid profile as well as redox status which are both relevant to heart disease	(Marnewick et al., 2011)
***Bidens pilosa* L.**	Leaves	Methanol extract	Reduces hypertension and systolic blood pressure in hypertensive rats. Also reduces hyperlipidemia.	(Dimo et al., 2003)
	Leaves	Aqueous extract	Decreased systolic blood pressure by 34 % at 20 mg/kg in induced hypertensive rats.	(Dimo et al., 2003)
[a] *Boophone disticha* (L.f.)	Bulbs	Aqueous ethanolic extract	Significantly reduced blood pressure response in mice as compared to diazepam treatments	(Pote et al., 2013)
***Cannabis sativa* L.**	Seeds	Aqueous extract	Whole seeds incorporated into rat feed exhibited significantly post- ischemic recovery and enhanced rates of cardiac tension development and relaxation in Sprague-Dawley rat hearts.	(Al-Khalifa et al., 2007)
	Leaves	Not specified	Decreased levels of LDH in experimental mice compared to untreated mice.	(Ahmed et al., 2016)
	Leaves	Aqueous extract	Inhibited ACE activity by 3 %	(Duncan et al., 1999)
		Ethanol extract	Inhibited ACE activity by 18 %	
Catha edulis (Vahl) Forssk. Endl.	Leaves	Aqueous extract	Inhibited ACE activity by 48 %	(Duncan et al., 1999)
		Ethanol extract	Inhibited ACE activity by 82 %	
***Catharanthus roseus* (L.) G. Don**	Leaves	Leaf juice	Reduces hyperlipidemia in rats.	(Azam et al., 2022)
Centella asiatica (L.) Urb	Not specified	Aqueous extract	Inhibited ACE activity by 38 %	(Ramesar et al., 2008)
		Ethanol extract	Inhibited ACE activity by 11 %	
Clausena anisata (Willd.) Hook.f.	Leaves	Aqueous extract	Inhibited ACE activity by 54 %	(Duncan et al., 1999)
		Ethanol extract	Inhibited ACE activity by 1 %	
		Methanol	Highest% ACE inhibition activity noted at approximately 60 % at a concentration of 250 μg/ml.	(Reddy et al., 2023)
Combretum molle R.Br. ex G. Don	Leaf	Aqueous extract and an isolated compound (1α-hydroxycycloartenoid saponin)	Both the extract and the isolated saponin reduced contractions of the portal veins in guinea pig and Wistar rats. They also relaxed pre-contracted aortic rings and produced significant reductions in arterial blood pressure and heart ratess in hypertensive rats.	(Ojewole et al., 2006)
Dicoma anomala Sond.	Roots	Aqueous extract	Treatment with extract (500 mg/kg) ameliorated oedema and myocardial necrosis in myocardial damage induced Wistar rats.	(Balogun and Ashafa, 2016)
Dietes iridioides (L.) Sweet ex Klatt	Leaves	Aqueous extract	Inhibited ACE activity by 80 %	(Duncan et al., 1999)
		Ethanol extract	Inhibited ACE activity by 7 %	
	Roots	Aqueous extract	Inhibited ACE activity by 13 %	
		Ethanol extract	Inhibited ACE activity by 13 %	
	Leaves	Aqueous extract	Inhibited ACE activity by 10 %	

(*continued*)

Table 2 (*Continued*)

Plant species	Plant part tested	Type of extract	Outcome of study	References
Dombeya rotundifolia (Hochst.) Planch.		Ethanol extract Methanol	Inhibited ACE activity by 83 % Highest% ACE inhibition activity noted at approximately 90 % at a concentration of 250 μg/ml.	(Duncan et al., 1999; Reddy et al., 2023)
	Bark	Aqueous extract Ethanol extract	Inhibited ACE activity by 5 % Inhibited ACE activity by 24 %	
Drimia elata Jacq. ex Willd.	Leaves	Aqueous extract Ethanol extract	Inhibited ACE activity by 16 % Inhibited ACE activity by 16 %	(Duncan et al., 1999)
	Bulbs	Aqueous extract Ethanol extract	Inhibited ACE activity by 2 % Did not inhibit ACE activity.	
Ekebergia capensis Sparrm.	Leaves	Aqueous extract Ethanol extract	Inhibited ACE activity by 26 % Inhibited ACE activity by 37 %	(Duncan et al., 1999)
***Eriobotrya japonica* (Thunb.) Lindl.**	Leaves	Isolated polysaccharide	Improves myocardial ischemic injury via antioxidant and anti-inflammatory activities.	(Huang et al., 2022)
	Leaves	Aqueous infusion	Decreased cardiac heterotrophy in H9c2 cardioblasts, and in induced-hypertensive rats.	(Chiang et al., 2018)
[a] *Galenia africana* L. var. *africana*	Stems and leaves	Dichloromethane extrct	Reduced the peak tail human ether-a-go-go-related gene current by 50.4 ± 5.5 % (n = 3) at a concentration of 100 μg/mL, and therefore would mitigate cardiac arrhythmia.	(Du et al., 2015)
Harpagophytum procumbens DC. ex Meisn.	Roots	Aqueous extract	Inhibited blood coagulation and haemolysis by 11.5 % *in vitro*. May therefore prevent stroke.	(Cordier et al., 2012)
Hypoxis colchicifolia Baker	Leaves	Aqueous extract Ethanol extract	Inhibited ACE activity by 30 % Inhibited ACE activity by 37 %	(Duncan et al., 1999)
	Roots	Aqueous extract Ethanol extract	Inhibited ACE activity by 4 % Inhibited ACE activity by 15 %	
Hypoxis hemerocallidea Fisch., C.A. Mey. & Avé-Lall.	Corms	Aqueous extract	The extract (25–400 mg/kg) reduced inotropic and chronotropic effects in induced-hypertensive guinea pig isolated hearts. The extract also significantly reduced myogenic contractions of portal veins isolated from induced hypertensive rats.	(Ojewole et al., 2006)
***Lavandula angustifolia* Mill.**	Leaves	Essential oil	Lavendar oil (200 mg/kg) reduced myocardial injury via reductions in troponin I and TNF-α in experimental rats.	(Sadeghzadeh et al., 2017)
	Leaves	Essential oil	Injected essential oil had significant cardio-protective effects in Wistar rats.	(Ziaee et al., 2015; Souri et al., 2019)
Leonotis leonurus (L.) R.Br.	Leaves	Aqueous extract	Relieved hypertension in induced-hypertensive rats.	(Nkadimeng et al., 2018)
Momordica balsamina L.	Not specified	Aqueous extract Ethanol extract	Inhibited ACE activity by 49 % Inhibited ACE activity by 9 %	(Ramesar et al., 2008)
Olea europaea L	Leaf	Ethanol extract	Showed a possible ability to antogonise calcium in the aorta of rabbits.	(Rauwald et al., 1994)
***Persea americana* Mill.**	Fruit pulp	Fruit pulp	Improves cardiac recovery (heart rate, and rate variability) after running.	(Sousa et al., 2020)
	Leaves	Aqueous extract	Reduces hyperlipidemia in rats.	(Brai et al., 2007)
	Leaves	Aqueous extract	Significantly reduced blood pressure in hypertensive Sprague-Dawley rats.	(Sokpe et al., 2020)
***Petroselinum crispum* (Mill.) Fuss**	Aerial parts	Aqueous extract	Decreased systolic, diastolic and mean arterial pressure in hypertensive rats. Functions via vasodilation.	(Ajebli and Eddouks, 2019)
	Leaves	Aqueous extract	Significantly reduces hyperlipidemia in streptozotocin treated rats.	(Soliman et al., 2015)
Protorhus longifolia Engl.	Leaves	Aqueous extract Ethanol extract	Inhibited ACE activity by 64 % Inhibited ACE activity by 77 %	(Duncan et al., 1999)
***Ruta graveolens* L.**	Leaves	Methanolic extract	Increased atrioventricular conduction and functional refractory times in isolated rat hearts, indicating potential to treat tachyarrhythmia.	(Khori et al., 2008)
	Root	Dichloromethane	Showed a possible ability to antagonise calcium in the aorta of rabbits.	(Rauwald et al., 1994)
***Salvia Rosmarinus* Spenn.**	Leaves	Methanol extracts	Reduced vasoconstrictor peptide (angiotensin II and endothelin-1) levels, increased vasodilators angiotension 1–7 and bradikinin in ischemic Wistar rat hearts. Also restored intraventricular pressure and cardiac mechanical work.	(Cuevas-Durán et al., 2017)
	Leaves	Ground leaves were mixed with rat chow	Attenuates cardiac remodelling after induced myocardial infarction in rats.	(Murino Rafacho et al., 2017)

(*continued*)

Table 2 (*Continued*)

Plant species	Plant part tested	Type of extract	Outcome of study	References
	Leaves	Aqueous infusion	Reduces hyperlipidemia in streptozotocin-induced rats.	(Alnahdi, 2012)
***Schkuhria pinnata* (Lam.) Kuntze**	Whole plant	Aqueous extract	Reduces hyperlipidemia via inhibition of lipase activity in Wistar rats.	(Kiage-Mokua et al., 2020)
Sclerocarya birrea Hochst.	Leaves	Aqueous extract Ethanol extract Methanol	Did not inhibit ACE activity Inhibited ACE activity by 68 % Highest% ACE inhibition activity noted at approximately 80 % at a concentration of 250 μg/ml.	(Duncan et al., 1999) (Reddy et al., 2023)
Solanum aculeastrum Dunal	Bark	Aqueous and methanol extracts	Inhibited blood coagulation and haemolysis by up to 100 % *in vitro*. May therefore prevent stroke.	(Cordier et al., 2012)
Stangeria eriopus (Kunze) Baill.	Leaves	Aqueous extract Ethanol extract	Inhibited ACE activity by 55 % Inhibited ACE activity by 7 %	(Duncan et al., 1999)
***Thymus serpyllum* L.**	Aerial parts	Aqueous extract	Protects against induced myocardial ischemia at 15 mg/kg in Sprague-Dawley rats. Decreased the levels of the cardiac enzymes CK-MB, LDH, AST.	(Alotaibi et al., 2022)
	Leaves	Aqueous infusion	Injection of extract into Wistar rats induced substantial reductions in systolic and diastolic blood pressure.	(Mihailovic-Stanojevic et al., 2013)
Tulbaghia acutiloba Harv.	Roots, leaves and flowers	Hydro-methanol extracts	Inhibits ACE enzyme activity.	(Isaiah et al., 2019)
Tulbaghia violacea Harv.	Leaves	Aqueous extract Ethanol extract	Inhibited ACE activity by 72 % Inhibited ACE activity by 61 %	(Duncan et al., 1999; Ojewole et al., 2006; Balogun and Ashafa, 2016)
	Roots	Aqueous extract Ethanol extract	Inhibited ACE activity by 49 % Inhibited ACE activity by 27 %	
	Not specified	Aqueous extract Ethanol extract	Inhibited ACE activity by 68 % Inhibited ACE activity by 71 %	(Ramesar et al., 2008)
	Not specified	Not specified	Showed a reduction in systolic blood pressure of 10.8 % in the rat model.	(Mackraj et al., 2008)
Turraea floribunda Hochst.	Leaves	Aqueous extract Ethanol extract	Inhibited ACE activity by 45 % Did not inhibit ACE activity.	(Duncan et al., 1999)
***Urtica urens* L.**	Aerial parts	Hydro-alcohol extract	Blocked lipase activity and therefore decreases hyperlipidemia. Has a cardio-protective effect as hyperlipidemia can induce cardiac disease.	(Jaradat et al., 2017)
***Warburgia salutaris* (G. Bertol.) Chiov.**	Leaves	Methanol	Highest% ACE inhibition activity noted at approximately 35 % at a concentration of 250 μg/ml.	(Reddy et al., 2023)
***Withania somnifera* (L.) Dunal.**	An Ayugverdic medicine	Aqueous suspension	Protects against doxirubicin-induced cardiac toxicity.	(Hamza et al., 2008)
	Roots	Aqueous extract	Prevents hyperlipidemia and therefore cardic disease in rats.	(Anwer et al., 2017)
	Roots	Aqueous extract	Inhibited cardiac injury after ischemia and reperfusion in Wistar rats.	(Mohanty et al., 2004)

Introduced and/or widely used alien species are indicated in **bold text**. [a] indicates tested species for which no record of traditional use to treat cardiovascular diseases was found. ACE = angiotensin converting enzyme; DCM = dichloromethane.

rat models. Additionally, a single study also reported anti-hyperlipidemic effects of *A. ferox* leaves in obese human patients. Substantially more studies are required to test all the traditionally used plant species against these effects *in vivo*.

Most of the studies into the effects of southern African plants used *in vitro* assays to screen the extracts for specific effects relevant to CVDs. Many of these studies examined the extracts for ACE inhibitory activity. Notably, 10 species/plant extracts inhibited ACE activity by >50 % and were therefore deemed to be good drug targets. Specifically, methanolic and aqueous *A. americana* leaf, aqueous *A. africanus* leaf, ethanolic *C. edulis* leaf, aqueous *C. anisata* leaf, aqueous *D. iridoides* leaf, aqueous *D. rotundifolia* leaf, aqueous and ethanolic *P. longifolia* leaf, ethanolic *S. birrea* leaf, aqueous *S. eriopus* leaf, as well as aqueous and ethanolic *T. violaceae* leaf extracts each inhibited >50 % ACE activity and warrant further investigation as anti-hypertensive therapies. However, potent *in vitro* ACE inhibitory activity does not guarantee that the plant preparation would have good anti-hypertensive activity *in vivo* and substantially more work is required before these plants are used clinically. Similarly, poor ACE inhibitory activity does not necessarily mean that the plant species is ineffective at lowering blood pressure, as the extract compounds may function via different mechanisms. These plant species should also be tested against other anti-hypertensive targets, such angiotensin receptor blockers (ARBs), β-blockers, calcium channel blockers (CCBs) and vasodilators. Additionally, further studies are required to test the other species for ACE inhibitory activity (Wagner et al., 1991).

Except for the effect of the extracts on hyperlipidemia, other CVD biomarker assays, including oedema and hypertension have been relatively neglected. Eleven studies have confirmed the ability of southern African plant extracts to significantly reduce blood lipid levels. Hyperlipidemia can result in fatty deposits in the arteries and subsequent blockages. Therefore, the ability of the plant extracts to decrease blood lipid levels is interesting and indicates that those extracts may be useful in decreasing the incidence of some CVDs (*e.g.* strokes). Further studies are required to evaluate the specific blood lipids affected by these extracts. For example, decreases in low density lipoprotein (LDLs) levels would be beneficial. However, if high density lipoproteins (HDLs) also decrease, this may result in increased risks of artherosclerosis as HDLs (which contain low levels of cholesterol) essentially absorb free cholesterol, thereby decreasing its levels in the bloodstream. Notably, the studies documented in Table 2 that screen the southern African plants for anti-

hyperlipidemia effects generally did not discriminate between classes of lipid. Further studies are required to determine the types of lipids and lipoproteins affected by these extracts.

It is widely (although often erroneously) believed that plant-based medicines are safe for therapeutic use. However, many plants have substantial toxicity and caution may be required with the preparation and dosage of traditional medicines (Khumalo et al., 2023). This is especially true for long term therapeutic usage, as is required for anti-hypertensive and anti-hyperlipidemia medicines. Notably, few of the screening studies listed in Table 2 examined the toxicology profiles of the extracts in parallel with the bio-activity studies. For many of these plant species, the toxicity of the extracts has been evaluated in other studies examining different bio-activities. Toxicity should be evaluated in the same study that the therapeutic effects are examined to allow for determination of safety/therapeutic indices.

7. Conclusion

This study documented plant species that are used in southern African traditional medicine to treat CVDs, and highlighted previous studies that have verified their effects, or screened them for bio-activities relevant to treating CVDs. A review of the ethnobotanical records and surveys identified 235 plant species that are traditionally used in southern Africa to manage CVDs. Despite this, validation studies to confirm the therapeutic properties of preparations of these plants against CVDs have been largely neglected. Indeed, approximately 19 % of the plant species used in southern African traditional medicine to treat CVD have been screened for any properties relevant to CVD therapy. Furthermore, for those plants that have been examined scientifically, few have been tested against more than one target (most commonly ACE inhibitory activity). Additionally, relatively few *in vivo* studies were reported and only a single clinical study in humans was undertaken. Much more research is needed to verify the effectiveness of the southern African plant-based traditional medicines, as well, and to determine the therapeutic mechanisms. Additionally, the toxicity and therapeutic index of the listed plant species needs to be reported before these plants can be considered clinically.

Declaration of competing interest

The authors declare that they have no conflicts of interest.

CRediT authorship contribution statement

I.E. Cock: Writing – review & editing, Writing – original draft, Supervision, Formal analysis, Data curation, Conceptualization. **A. Orchard:** Writing – review & editing, Supervision. **L. Booi:** Writing – original draft, Investigation, Formal analysis, Data curation. **S.F. van Vuuren:** Writing – review & editing, Supervision, Software, Resources, Project administration, Methodology, Funding acquisition, Data curation, Conceptualization.

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