MEDICINAL PLANTS AND BIOACTIVE COMPOUNDS FOR TREATMENT OF CARDIOVASCULAR DISEASES IN AFRICA

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Contents

Summary

In this chapter, the medicinal and aromatic plants and their phytoconstituents used in the treatment of cardiovascular diseases are widely covered. Medicinal and aromatic plants

in Africa and their bioactive components have been used to manage or treat conditions such as CVDs. Medicinal and aromatic plants such as *Elettaria cardamom, Crataegus monogyna, Citrus medica, Curcuma longa*, *Salvia miltiorrhiza, Fucus vesiculosus*, *Allium sativum, Terminalia bellerica*, *Piper longum*, *Zingiber officinale*, *Moringa oleifera*, *Ginkgo biloba*, *Nigella sativa, etc.* are used to treat various cardiovascular diseases, including coronary artery diseases, myocardial infarction (heart attack), angina, venous thrombosis, thromboembolic disease, peripheral artery disease, aortic aneurysms, carditis, valvular heart disease, congenital heart disease, abnormal heart rhythms, cardiomyopathy, rheumatic heart disease, hypertensive heart disease, stroke, and heart failure. The bioactive compounds in these plants responsible for their medicinal activities include chebulagic acid, corilagin, digalloyl-hexahydroxydiphenonyl-hexoside, zingerone, gingerols, paradols, galloyl punicalagin, gallic acid, kaempferol, ethyl gallate, phyllemblin, galloyl glucose, ellagic acid, lignan, steroid, alkaloids, thymoquinones, resveratrol, catechin, volatile oils, flavonoids, curcumin, quercetin galloyl-glucoside, quercetin rutinoside, epigallocatechin-3-gallate (EGCG), piperine, salvianolic acid, miltirone, tanshinone IIA, daucosterol, ursolic acid, β-sitosterol, etc. These plants and their phytochemical have properties that are beneficial to the cardiovascular system, including blood pressure lowering, improving lipid profile, antioxidant, antidiabetic, anti-obesity, anti-inflammatory, antithrombotic, free radical scavenging, anti-glycemic, antihypertensive, and antilipidemic properties. Plant oil (e.g., essential fatty acids, such as docosahexaenoic acid, eicosapentaenoic acid, omega-3 fatty acid, linolenic acid, linoleic acid, oleic acid), sterol, stanol esters, lignans, fiber, and plant protein (e.g., soy protein) have properties against cardiovascular diseases.

1. Introduction

Cardiovascular diseases (CVDs) are a group of diseases involving the blood vessels or heart. CVDs include coronary artery diseases (CAD), e.g., myocardial infarction (heart attack) and angina. Other cardiovascular diseases include venous thrombosis, thromboembolic disease, peripheral artery disease, aortic aneurysms, carditis, valvular heart disease, congenital heart disease, abnormal heart rhythms, cardiomyopathy, rheumatic heart disease, hypertensive heart disease, stroke, and heart failure. The basic action mechanisms differ according to the diseases. Stroke, peripheral artery disease, and coronary artery disease usually involve atherosclerosis (arteriosclerotic vascular disease). This can result from poor sleep, excessive alcohol consumption, poor diet, high blood cholesterol, obesity, lack of exercise, diabetes mellitus, smoking, high blood pressure, etc. CVDs can be generally categorized into vascular and heart diseases as shown in Figure 1.

Medicinal and aromatic plants in Africa and their bioactive components have been used to manage or treat conditions such as CVDs. The therapeutic potentials and efficacies of medicinal plants for the treatment of CVDs is popular not only in Africa but worldwide, whether for treating the diseases or helping the body system cope with them. Although traditional medicines in Africa are generally considered safe since they are obtained from natural sources, however, several adverse effects can manifest due to the use of herbal medicines in treating diseases such as CVDs. Excessive use and overdose of herbal medicines have notable side effects that may complicate the occurrence of other

diseases. Care should be taken when using medicinal plants and their extracts for the treatment of diseases such as CVDs. Seeking the advice of an expert is strongly recommended. For CVDs treatment in Africa, many people traditionally use complementary and alternative medicine (CAM) and natural bio-based therapies, including medicinal plants (herbs). Herbal medicine includes aromatic plants, herbal extracts and materials, herbal extracts and preparations, and herbal-based products. There are hundreds to thousands of medicinal and aromatic plants in Africa used in the treatment of many diseases such as CVDs, and are also valuable sources of novel drugs for the modern medicines.

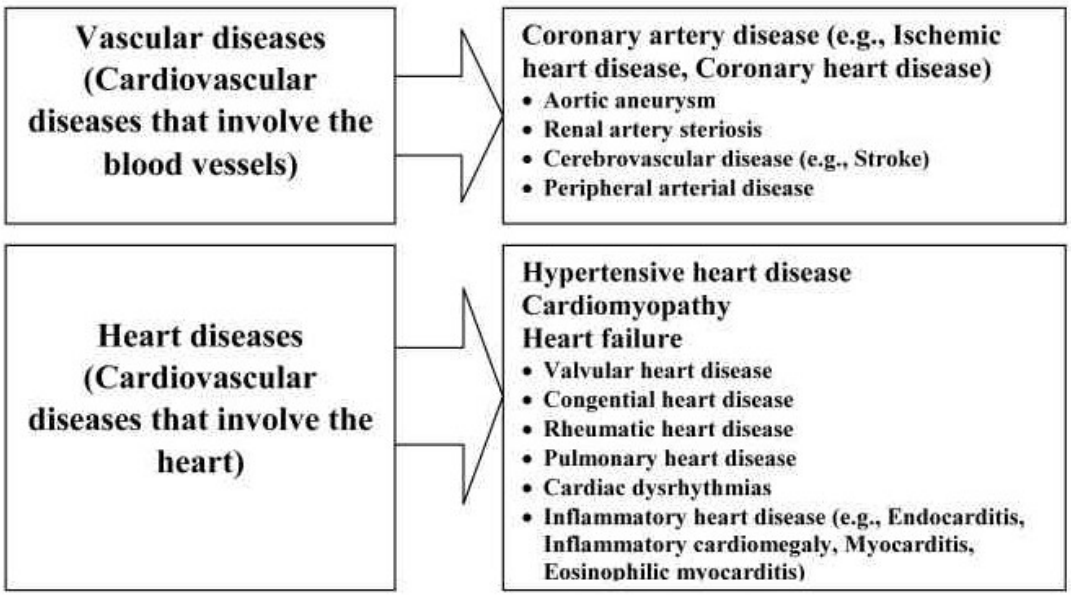

Figure 1. Types of cardiovascular diseases

It is estimated that high blood pressure, tobacco, diabetes mellitus, lack of exercise, and obesity are responsible for around 13%, 9%, 6%, 6%, and 5% of deaths linked to CVD, respectively. Rheumatic heart diseases can ensue if strep throat is not treated. In general, cardiovascular diseases have remained the leading cause of deaths globally, with the exception of Africa. Within 2015 to 2019, CVDs resulted in an average of 17.9 million deaths (32.1%) per year, an increase from 25.8% (12.3 million) in 1990. Over ¾ of CVD death occur in low- and middle-income countries. It has been estimated that by 2030, at least 23 million individuals will die per year from cardiovascular diseases. In many countries in Africa and other continents, a significant population still die from CVDs and related diseases. Stroke and coronary artery disease are responsible for 80% and 75% of deaths due to CVDs in males and in females respectively, and mostly affect the older populations. While the average age of coronary artery disease death in the developed countries is about 80, it is approximately 68 in the developing countries such as countries in Sub-Saharan Africa.

Medicinal plants and their parts, including their leaves, stem, bark, root, etc., are used to return health abnormalities back to normal, allay symptoms, and/or prevent illnesses, including CVDs. These plants and their parts/materials contain bioactive compounds and nutrients, including polyphenolic compounds, terpenes, glycosides, alkaloids,

essential oils, etc., which are typical responsible for their healing, medicinal, and therapeutic properties. A bioactive compound is any compound with detectable effect on a living organism, cell, or tissue. This chapter presents the medicinal and aromatic plants and their bioactive compounds used in the treatment of cardiovascular diseases in Africa. Their therapeutic efficacy, clinical significance, interactions with other drugs, medicinal properties, and challenges are sufficiently provided. Recent scientific and empirical evidence have shown that some bioactive compounds obtained from medicinal and aromatic plants in Africa play important roles in the prevention and treatment of cardiovascular diseases. Oral administration of formulations of bioactive compounds together with normal healthy diet can make available the nutrients and substances known to have therapeutic and clinical benefits for treating CVDs. In addition, these bioactive compounds also occur in the normal foods we eat. Bioactive compounds and their plant sources form the basis of the development of many novel drugs for the treatment of CVDs and other diseases, including nervous system diseases such as central nervous system disorders.

2. Medicinal Plants Used to Treat Cardiovascular Diseases in Africa

Many medicinal and aromatic plants are used in many parts of Africa, including West, East, and Central Africa, to treat many conditions related to CVDs. Herbs such as *Elettaria cardamom, Crataegus monogyna, Citrus medica,* etc. have been used due to their medicinal potentials to treat some heart diseases. *Citrus medica* belong to the family Rutaceae. Many evidences support the use medicinal plants in treating CVDs mostly due to their cardioprotective potentials related to their medicinal properties, antioxidant activities, free radical scavenging activities, therapeutic effects, etc. The species of some plants such as *Crataegus* are effective, safe, and nontoxic in treating CVDs, including ischemic heart disease. The action mechanism of *Crataegus* species include direct reactive oxygen species (ROS) scavenging, as well as improved superoxide dismutase, antioxidant activity, catalase activities, caspase 3 gene downregulation, etc. Another plant, *Crataegus monogyna,* is a rich source of polyphenolic compounds; its parts such as fruit, flowers, and leaves have medicinal properties for treating diseases such as CVDs. Many of the medicinal plants in Africa, including *C. monogyna*, help to regulate high blood pressure and hypotension (low blood pressure), as well as for slow breakdown excessive fat deposits and cholesterol in humans. They also increase rates of low-density lipoprotein (LDL) (also called bad cholesterol) conversion into high density lipoprotein (HDL) (also called good cholesterol) in human liver, in addition to improving oxygen and blood supply to the muscles of the heart. For circulatory disorders and congestive heart failure, *Hawthorns* is commonly used for treatment, partly due to its role in alleviating swelling and irritation of blood vessels. *Elettaria cardamom,* small cardamom, can effectively boosts antioxidant status, increase fibrinolysis, and lower blood pressure in hypertensive patients under striglycerides e 1 with no effect on fibrinogen levels and blood lipids. A study done on rat showed that cardamom oil has lipid homeostasis restoration ability in hypercholesterolemia presence. A decrease in atherogenicity index can be achieved with cardamom oil/powder; cardamom has cardioprotective potentials. *Terminalia arjuna* bark has cardioprotective effects against cardiotoxicity induced by doxorubicin through increasing coronary artery flow and myocardium protection from ischemic damage. The pericarp of *Terminalia chebula* has also shown cardioprotective potentials.

Many modern medicines for treating CVDs are developed from medicinal and aromatic plants, including the ones in Africa, and are used in many African countries including Nigeria, Ghana, Uganda, South Sudan, Eritrea, Egypt, Algeria, Ethiopia, Central African Republic, DR Congo, Djibouti, Burundi, Cameroun, Senegal, Niger, Cape Verde, South Africa, Eswatini, Zambia, Sudan, etc., and all over the world. Many medicinal plants in Africa have medicinal, therapeutic, and preventive potentials against several cardiovascular diseases (see Tables 1a,b,c). The use these medicinal plants in treating CVDs, including arrhythmia, cerebral insufficiency, atherosclerosis, angina pectoris, systolic hypertension, congestive heart failure, etc., has in practice for centuries. Herbs (medicinal plants) are unending major source for novel drug development used for treating diseases such as CVDs; e.g., reserpine obtained from *Rauwolfia serpentina*; digitoxin extracted from *Digitalis purpurea*; paclitaxel (antineoplastic drug) obtained from *Taxus brevifolia*; among others. These medicinal plants have been widely applied directly or indirectly for cardiovascular diseases treatment.

Common name	**Botanical name**	**Parts commonly used**
Aam	*Magnifera indica linn.*	Fruit
Agarwood	*Aquilaria agallocha*	Stem Wood
Ajmoda	*Apium graveolens*	Fruits
Ajwain	*Trachyspermum ammi*	Fruits
Alfalfa leaves	*Medicago sativa*	Leaves
Aloe vera	*Aloe vera*	Leaves
Alpine strawberry	*Fragaria vesca L.*	Leaves, rhizome, fruit
Amla	*Phyllanthus emblica*	Leaves, barks, fruits, branches
Amlavettas	*Garcinia pedunculata*	Fruits
Amsul	*Garcina indica choisy*	Fruit, Peel
Anardana	*Punica granatum*	Flowers, Fruits, Seeds
Anchusa	*Anchusa italica*	Flowers
Arjuna	*Terminalia arjuna*	Fruit, Seeds, Bark, Stem
Ashwagandha	*Withania somnifera*	Roots, Whole Plant
Autumn crocus	*Crocus haussknechtii*	whole plants
Avon Bulbs	*Nectaroscordum*	Flowers
Badhar	*Gmelina asiatica*	Bark, Roots
Bans	*Bambusa arundinacea*	Leaves
Barberry	*Berberis darwinii*	Rhizomes
Basil	*Ocimum bacilicum*	Leaves, Roots, Fruit, Whole Plant, Seeds
Behen	*Centaurea behen*	Root
Bhringraj	*Eclipta prostrata*	Whole Plant
Black cardamom	*Amomum subulatum*	Leaves, Seeds, Fruit
Black cohosh	*Actaea racemose*	Leaves, stem
Black pepper	*Piper nigrum*	Stem, Fruit
Black-caraway	*Nigella sativa*	Fruit, Seeds
Breckland thyme	*Thymus serpyllum*	Aerial parts

Butcher's broom	*Ruscus aculeatus*	Whole plant
Calamints	*Calamintha acinos.*	Aerial parts
Calamus	*Acorus calamus*	Roots, Rhizome
Camphor tree	*Cinnamomum camphora*	Camphor
Capsicum	*Capsicum annuum*	Fruit
Cardamom	*Elettaria cardamom*	Seeds, Fruit
Cardus marianus	*Silybum marianum*	Fruit, Seeds
Chicory	*Cichorium intybus*	Fruit, Seeds, Flower, Leaves, Roots
Chinese cinnamon	*Cinnamomum cassia*	Bark
Christ's thorn jujube	*Paliurus spina-christi*	Fruit
Cinnamon	*Cinnamomum verum*	Bark, Leaves, Stem
Citrin	*Garcinia cambogia*	Leaves, fruits
Citron	*Citrus medica*	Fruit
Common barberry	*Berberis vulgaris*	Fruit

Table 1a. Medicinal and aromatic plants used in the general treatment of cardiovascular diseases (heart diseases) (Page 1/3)

Common name	**Botanical name**	**Parts commonly used**
Common juniper	*Juniperus communis*	Fruit
Common mallow	*Malva neglecta*	Leaves, Stem
Common peony	*Paeonia officinalis*	Roots
Common polypody	*Polypodium vulgare*	Roots
Common purslane	*Portulaca oleracea*	Whole Plant, Fruit, Seeds
Common Yarrow	*Achillea millefolium*	Seeds, Fruit
Coriander	*Coriandrum sativum*	Fruit, Leaves
Curly dock	*Rumex crispus*	Fruit, leaves
Damask rose	*Rosa damascena*	Flowers
Dandelion	*Taraxacum officinale*	Roots, Rhizome
Date	*Ziziphus jujuba*	Fruit
Dill	*Anethum graveolens*	Seeds, Fruit
Dog rose	*Rosa canina*	Flowers
Elecampane	*Inula helenium*	Whole plant
English marigold	*Calendula officinalis*	Flowers
European dewberry	*Rubus caesius*	Fruit, Leaves
European pear	*Pyrus communis*	Leaves, bark, fruit
Fenugreek	*Trigonella foenum-graecum*	Fruit, Seeds
French lavender	*Lavandula stoechas*	Aerial parts, flowers
Garden lettuce	*Lactuca sativa*	Leaves
Garlic	*Allium sativum*	Roots
Ginger	*Zingiber officinale roscoe*	Roots, Whole Plant

Ginkgo	*Ginkgo biloba*	Leaves
Ginseng	*Genus panax*	Roots
Gotu kola	*Centella asiatica*	Leaves, Whole Plant
Grape vine	*Vitis vinifera*	Fruit
Gugglul	*Commiphora wightii*	Oleo-Gum Resin, Roots, Stem
Gundelia	*Gundelia tournefortii*	Leaves
Hawberry	*Crataegus pontica*	Fruit
Hawthorn	*Crataegus monogyna*	Flower, Leaves
Indian sandalwood	*Santalum album L.*	Bark, wood
Jatamamsi	*Nardostachys jatamansi*	Roots, Rhizome
Jhar ber	*Ziziphus nummularia*	Flower, leaves, Fruit
Karanda	*Carissa carandas*	Fruit
Katuka	*Picrorrhiza kurroa*	Roots
Lemon Balm	*Melissa officinalis*	Aerial parts, leaves
Lempoyang	*Zingiber zerumbet*	Pseudo-stem
Lesser burdock	*Arctium minus hill.*	Roots
Long pepper	*Piper longum*	Roots, Fruit
Mayweed	*Anthemis gayana*	Leaves, flower
Motherwort	*Leonurus cardiac*	Whole plant

Table 1b. Medicinal and aromatic plants used in the general treatment of cardiovascular diseases (heart diseases) (Page 2/3)

Common name	**Botanical name**	**Parts commonly used**
Myrobalan	*Terminalia chebula*	Fruits
Myrrh	*Commiphora myrrha*	Oleo-Gum Resin
Nerium	*Nerium oleander*	Leaves, flower
Nettle	*Urtica dioica*	Leaves, branches
Nutmeg	*Myristica fragrans*	Fruit
Olibanum-tree	*Boswellia sacra*	Gum resin
Olive	*Olea europaea*	Seeds
Peppermint	*Mentha × piperita*	Leaves
Pistachio	*Pistacia vera*	Seeds
Puarnava	*Boerhavia diffusa*	Roots, Whole Plant
Red sandalwood	*Pterocarpus santalinus*	Bark, wood
Rhubarb of babilonia	*Rheum ribes*	Stem
Safflower	*Carthamus tinctorius*	Fruit, Seeds
Saffron	*Crocus sativus*	Flowers
Scotch elm	*Ulmus glabra*	Leaves
Senna	*Senna alexandrina*	Leaves, Fruit, Seeds
Sesame	*Sesamun indicum*	Leaves, Wood
Sicilian sumac	*Rhus coriaria*	Leaves, Fruit
Sickleweed	*Falcaria vulgaris*	Leaves, flower, Stem

Skullcap	*Scutellaria pekinensis*	Roots
Smyrnium	*Smyrnium cordifolium*	Seeds
Sondh	*Zingiber officinale*	Roots, Whole Plant
Spearmint	*Mentha spicata*	Leaves
Squirting cucumber	*Ecbalium elaterium*	Fruit
Suaeda	*Suaeda aegyptiaca*	Leaves
Sweet clover	*Melilotus indicus*	Leaves
Symplocos	*Symplocos racemosa*	Bark
Table apple	*Malus domestica Baumg.*	Peels, fruits
Tamarind	*Tamarindus indica*	Leaves, fruit
Tea	*Camellia sinensis*	Leaves
Terminalia	*Terminalia horrida*	Fruits
Thorn jujube	*Ziziphus spina-christi*	Leaves, Stem
Turmeric	*Curcuma longa*	Tuber, Roots, Rhizome
Usnea barbata	*Usnea barbata*	Filaments
Valerian	*Valeriana officinalis*	Fruit
Vishatinaduka	*Strychnos nux-vomica*	Seeds, Stem, Fruit, Bark
White nenuphar	*Nymphaea alba*	Flowers
Wild almond	*Prunus scoparia*	Seeds
Yellow salsify	*Tragopogon porrifolius*	Roots
Yew	*Taxus baccata*	Leaves
Zedoary	*Curcuma zedoaria*	Rhizome
Zerešk	*Berberis integerrima*	Fruit

Table 1c. Medicinal and aromatic plants used in the general treatment of cardiovascular diseases (heart diseases) (Page 3/3)

3. Bioactive Compounds in Medicinal Plants used for Treating Cardiovascular Diseases in Africa

As earlier said, the bioactive compounds, nutrients, and other natural substances in medicinal and aromatic plants in Africa usually form the basis of their pharmacological and medicinal properties. The therapeutic and medicinal effects of medicinal plants, including anti-atherogenic, antithrombotic, antioxidant, anti-glycemic, antihypertensive, and antilipidemic effects have been linked bioactive compounds in these plants. Epigallocatechin-3-gallate (EGCG), tannins, resveratrol, cinnamic acid, epigallocatechin (EGC), catechin, anthocyanins, etc. have been reported to ameliorate and prevent cardiovascular diseases; both vascular and heart related CVDs. Tables 2a,b shows common phytochemicals and bioactive compounds effective against cardiovascular diseases and their associated risk factors.

Phenolic acids, flavonoids, volatile oils, glycosides, alkaloids, etc., have been studied for their cardioprotective properties, with positive outcomes. Several bioactive compounds have shown to enhance endothelial injuries via various mechanisms of actions, including anti-apoptosis, anti-inflammatory, and antioxidant stress mechanisms, among others. Phenolic compounds, including stilbenes such as 3,5,4′-

trihydroxystilbene (resveratrol), are principally found in the skin of groundnut and grapes. Resveratrol is richly found in red wine and has been suggested to be responsible for the cardioprotective properties linked with moderate wine consumption. Under catechols, curcuminoids are naturally found in medicinal plants in Africa, and has shown promising anti-inflammatory and cardioprotective properties and naturally occur in parts of plants in Africa such as dried rhizomes of turmeric (*Curcuma longa*). These bioactive compounds have shown effectiveness in managing many CVD related conditions such high blood pressure, carbohydrate metabolism (insulin resistance, insulin, glucose regulation), lipid profile [HDL, LDL, cholesterol, triacylglycerol], endothelial function, inflammation, oxidative stress, etc.

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