

Chapter

Phenolic Compounds and Antioxidant Activities of Eight Species of Fabaceae That Are Commonly Used in Traditional Medical Practices in the Republic of Suriname

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Abstract

The consumption of diets rich in antioxidants may minimize the chances of developing debilitating diseases such as cardiovascular, diabetic, inflammatory, neoplastic, and cognitive disorders. The Fabaceae or pea family is the third most species-rich plant family on Earth and includes more than 19,000 species in over 700 genera. Many species of Fabaceae are ingredients of staple diets and medicinal substances. This may be attributable to the presumably high content of antioxidants in these plants, particularly phenolic compounds. The Republic of Suriname (South America) harbors over 400 species of Fabaceae in more than 100 genera and has a rich ethnopharmacological tradition that also involves a number of Fabaceae species. In this chapter, we evaluated the literature to determine whether the traditional use of eight of the medicinally most commonly employed Surinamese species of Fabaceae may be associated with their phenolic content and antioxidant activity. Our results suggest that this may hold true for *Caesalpinia pulcherrima*, *Cajanus cajan*, *Clitoria ternatea*, *Desmodium adscendens*, *Lablab purpureus*, and *Tamarindus indica* but not for *Copaifera guyanensis* and *Dipteryx odorata*, the bioactivities of which mainly seem to be determined by terpenoids and coumarins, respectively, without an apparent involvement of antioxidant effects.

Keywords: Suriname, Fabaceae, traditional medicine, pharmacological activity, phytochemical composition, phenolic content, antioxidant activity

1. Introduction

Reactive oxygen species (ROS) are chemically unstable oxygen-containing molecules such as superoxide anions and hydroxyl radicals that are able to readily react with and inflict damage to cellular constituents such as nucleic acids, proteins, and lipids [1–3]. ROS are continuously formed in the body during metabolic reactions involving oxygen such as the mitochondrial electron transport chain, in activated white blood cells in order to eliminate bacteria and other invaders, and as products of various intracellular enzymatic reactions such as those catalyzed by nitric oxide synthase and xanthine oxidase, which yield nitric oxide radicals and superoxide radicals, respectively [1–3]. ROS are also produced following exposure of the body to various noxious agents ranging from car exhaust and cigarette smoke to γ -radiation and certain medical drugs [1–3].

ROS play important roles in the cells of the body, for instance, as elements of intracellular signaling pathways for several normal physiological functions including those associated with the regulation of immunity, cell differentiation, and longevity [4–6]. However, a buildup of these species may cause oxidative stress, cell and tissue injury, and cell death [4–6] and is probably at the basis of several ailments such as heart conditions, Alzheimer's disease, and cancer, as well as premature aging and cerebrovascular accidents [7–11]. For this reason, the body has a variety of innate antioxidant defense mechanisms to its disposal to mitigate potential damage by ROS, including enzymatic antioxidant systems (for instance, superoxide dismutase, catalase, and glutathione peroxidase) and non-enzymatic systems (for instance, bilirubin, glutathione, and certain vitamins) [12]. In addition to these innate defense systems, exogenous antioxidants provided through the diet and/or nutritional supplements may help protect the body from oxidative stress [13]. Thus, the consumption of compounds rich in antioxidants may decrease the risk of developing the abovementioned diseases [14–16].

An important class of plant-derived antioxidants is represented by phenolic compounds, secondary plant metabolites made up of one or more aromatic ring(s) coupled to one or more hydroxyl group(s) [17]. Phenolic compounds help protect plants from pathogens, animal and insect attack, as well as ultraviolet radiation; provide plants their characteristic colors; and contribute to the organoleptic properties of plants [18]. There are tens of thousands of plant phenolic compounds including the main dietary constituents flavonoids, phenolic acids, and tannins, in addition to coumarins, naphthoquinones, stilbenes, anthraquinones, and lignans [13, 17]. Their mitigating effect on oxidative stress has been attributed to their ability to eliminate potentially harmful oxidizing free radical species by acting as reducing agents, hydrogen donors, quenchers of singlet oxygen, or chelators of metal ions that catalyze oxidation reactions [13, 17].

The pea family Fabaceae is a large family of flowering plants that include various economically important plants such as the soybean *Glycine max* (L.) Merr., the cowpea *Vigna unguiculata* (L.) Walp.), and the peanut *Arachis hypogaea* L. [19, 20]. The Fabaceae family also includes many species that represent important sources of a wide variety of ethnobotanical medicines against a myriad of diseases (see, for instance, references [20, 21]). This may be attributable to their relatively high contents of various pharmacologically active constituents including phenolic compounds with antioxidant properties [22, 23]. In addition, the Fabaceae is considered a plant family that hyperaccumulates selenium, a key constituent of selenoproteins such as the antioxidant enzyme glutathione peroxidase [24].

The Republic of Suriname (South America) has a land area of roughly 165,000 km², about 80% of which consists of sparsely inhabited, dense, pristine, and highly biodiverse tropical rain forest [25]. Conversely, about 80% of the country's population of just over 600,000 lives in the relatively narrow northern coastal zone of the country [26]. Mostly because of the variety of habitats and the humid tropical temperature, the biodiversity in Suriname is high, encompassing roughly 5100 different plant species [27]. As in other parts of the world, the Fabaceae plant family represents a substantial part of Suriname's plant diversity, with estimations of over 400 different species in more than 100 genera from the northern coast all the way up to the expansive forested mountain ranges [28]. The Fabaceae are also ingredients of a large variety of traditional medicines in Suriname. So far, it is not clear whether this is because of their remarkably high phenolic content and antioxidant activity. In this chapter, we have addressed this topic by assessing whether the traditional uses and pharmacological activities of eight medicinally commonly employed Fabaceae in Surinamese traditional medicine may be associated with their phenolic content and antioxidant activity.

2. ROS and oxidative stress

ROS can be defined as oxygen-containing reactive species and include oxygen-free radicals with unpaired electrons such as superoxide, hydroxyl, peroxy, and alkoxyl radicals, as well as non-radical species such as hydrogen peroxide, peroxyxynitrite, hypochlorous acid, and ozone [1–3]. Reactive nitrogen species (RNS) such as nitric oxide, peroxyxynitrite, and nitrogen dioxide radical, as well as reactive chlorine species (RCS) such as hypochlorous acid, are also classified as ROS [1–3]. As mentioned in the preceding section, ROS are able to readily react with and cause damage to biomolecules including proteins, lipids, and nucleic acids, leading to cell and tissue injury [4–6]. The high reactivity of ROS derives from the presence of a single unpaired electron in their outer orbit formed as a result of incomplete reduction of the oxygen metabolites [4–6].

ROS can be generated from either endogenous or exogenous sources. Endogenous sources of ROS are cellular organelles where oxygen metabolism is high, such as mitochondria, phagocytic cells, endoplasmic reticulum, and peroxisomes [12]. For instance, during oxidative phosphorylation in the mitochondria, the electron transport chain produces electrons for the reduction of molecular oxygen into superoxides. The superoxides are transformed into the much less reactive hydrogen peroxide by superoxide dismutase. However, when hydrogen peroxide interacts with ions of transition metals such as Fe²⁺ and Cu²⁺, the most reactive ROS, hydroxyl radicals are formed through Fenton's reaction [29]. And phagocytized bacteria, bits of necrotic tissue, other harmful cells, and foreign particles are destroyed by macrophages and neutrophils by the so-called respiratory burst (or oxidative burst), involving the rapid release of superoxides and hydrogen peroxide following the supply of electrons by NADPH [30].

Other important endogenous (enzymatic) sources of ROS are the cytochrome P450 superfamily of enzymes that produce ROS during the detoxification and excretion of xenobiotics [31], cyclooxygenase and lipoxygenase that generate ROS from arachidonic acid [32], and xanthine oxidoreductase that produces superoxide anions during the breakdown of purines to uric acid [33]. And as mentioned before, in the Fenton and Haber-Weiss reactions, molecular oxygen is reduced to form superoxide

anions, which dismutates to form hydrogen peroxide that can react with traces of iron or copper to form more highly reactive hydroxyl ions and subsequently hydroxyl radicals [34].

Exogenous sources of ROS are γ -radiation and UV radiation; air pollutants such as car exhaust, cigarette smoke, and industrial contaminants; peroxides, aldehydes, oxidized fatty acids, and transition metals in foods; a large variety of xenobiotics including toxins, pesticides, and herbicides; as well as various medical drugs such as narcotics, anesthetizing gases, and antineoplastic agents [1–3]. Gamma radiation, for instance, interacts with water molecules to form water radical cations and free electrons, which react with other water molecules to form highly active hydroxyl radicals, superoxides, and organic radicals. These ROS are then converted into organic hydroperoxides and hydrogen peroxide, which subsequently react with Fe^{2+} and Cu^{2+} ions, generating even more ROS, eventually resulting in massive damage to cellular biomolecules such as DNA, proteins, and lipids [35].

Iron and copper, along with cadmium, nickel, arsenic, and lead, not only generate ROS by Fenton or Haber-Weiss type reactions, but also by direct reactions with cellular constituents, producing, for example, thiol-type radicals [36]. For instance, arsenic induces the production of peroxides, superoxides, and nitric oxide and inhibits antioxidant enzymes such as glutathione-transferase, glutathione-peroxidase, and glutathione-reductase by binding to the sulfhydryl group [37]. And lead triggers lipid peroxidation and increases glutathione peroxidase concentration in brain tissue [38]. The free radicals generated from these reactions can affect DNA, with substitutions of some DNA bases such as guanine with cytosine, guanine with thymine, and cytosine with thymine [39].

An example of a medical drug that generates ROS is the antitumor antibiotic doxorubicin, both the antineoplastic activity and the cardiomyopathy of which are probably based on its reduction to a semiquinone-derivative that can autoxidize in the presence of oxygen and then produces superoxide anions following electron donation by oxidases such as mitochondrial NADPH and nitric oxide synthases [40].

3. Defenses against oxidative stress

At non-cytotoxic levels, ROS and their secondary electrophilic species perform important functions in the human body, among others, by acting as redox signaling messengers required for the normal physiological functioning of cells [41]. In general, ROS are messengers in the transduction of certain metabolic and environmental cues, which affect diverse signaling pathways, culminating in the activation of transcription factors and other proteins, determining cell fate [5]. A well-described example is redox signaling involving the oxidation of cysteine residues of proteins by hydrogen peroxide, and converting a thiolate anion in cysteine (Cys-S^-) into the sulfenic form (Cys-SOH), causing the protein to undergo allosteric changes that alter its function [42]. The sulfenic form can be reduced to thiolate anions by the disulfide reductases thioredoxin and glutaredoxin, to return the protein function to its original state [43]. Comparable reversible ROS-operated mechanisms are involved in the regulation of several key signal transduction pathways such as the PI3K-AKT and RAS-MEK-ERK pathways involved in the promotion of cell proliferation, nutrient uptake, and cell survival [44, 45].

Whether ROS cause oxidative stress and cellular damage is determined by the net result of their production and elimination by antioxidant defenses. Thus, oxidative

stress is a consequence of “a disturbance in the prooxidant to antioxidant balance in favor of the former, leading to potential damage” [3]. The antioxidant defenses prevent the formation of ROS or interrupt their propagation, eliminate ROS by scavenging them, slow down redox reactions by removing free-radical intermediates, inhibit oxidation reactions by being oxidized themselves, and repair the oxidized molecules [46]. These mechanisms can be distinguished into innate defense systems and exogenous antioxidants provided through the diet and/or nutritional supplements.

3.1 Innate antioxidant defenses

The innate antioxidant defenses of the body comprise enzymatic and non-enzymatic systems. The main enzymatic antioxidant systems are superoxide dismutase, catalase, and glutathione peroxidase. The metalloprotein superoxide dismutase catalyzes the dismutation of superoxides, that is, the formation of one molecule of oxygen and one molecule of hydrogen peroxide from two superoxides [47, 48]. Hydrogen peroxide can subsequently be converted into highly reactive hydroxyl radicals in the presence of transition metal ions such as Fe^{2+} or Cu^{2+} in the Fenton reaction, propagating the damage inflicted to cellular DNA, proteins, and lipids [47, 48]. Superoxide dismutase prevents this process through its three isoforms, cytosolic copper/zinc-superoxide dismutase (Cu/Zn-SOD, SOD₁), mitochondrial manganese superoxide dismutase (Mn-SOD, SOD₂), and extracellular copper/zinc-superoxide dismutase (Cu/Zn-EC-SOD, SOD₃) [47, 48]. The isoforms are located in distinct cellular compartments and/or have different metal components, but all three convert and neutralize superoxides as mentioned above [47, 48].

Catalase acts as a catalyst for the conversion of hydrogen peroxide into oxygen and water. It mitigates the effect of intracellular hydrogen peroxide [49]. Glutathione peroxidases are a family of at least eight oxidoreductases that contain seleno-cysteine in the active site [50, 51]. These enzymes catalyze the reduction of organic hydroperoxides into alcohol and water groups using reduced glutathione as a co-substrate [50, 51]. They can also catalyze the reduction of hydrogen peroxide to water and oxygen by oxidation of reduced glutathione to its disulfide [50, 51]. Oxidized glutathione can be reduced to glutathione by the enzyme glutathione reductase by using NADPH as a reducing substrate [50, 51]. In this way, glutathione peroxidase protects cells from oxidative damage and helps detoxify hydrogen peroxide [50, 51].

Non-enzymatic endogenous antioxidant mechanisms are, among others, bilirubin and albumin. Bilirubin is produced from the enzymatic degradation of hemoglobin and other heme proteins to first yield biliverdin, and then bilirubin following reduction of biliverdin by the enzyme biliverdin reductase [52]. Bilirubin prevents lipid oxidation by removing peroxy radicals whereby it is oxidized itself to biliverdin, after which it is rapidly reduced by biliverdin reductase to bilirubin [52]. And serum albumin represents an abundant circulating antioxidant defense system [53]. It is able to bind transition metals such as copper and iron, preventing the formation of hydroxyl radicals *via* the Fenton reaction after their interaction with hydrogen peroxide, directly scavenge hydroxyl radicals, and bind and transport bilirubin, which then acts as an inhibitor of lipid peroxidation [53].

3.2 Exogenous defenses: dietary nutrients

Exogenous antioxidants are mainly derived from dietary sources and include, among others, a variety of phenolic compounds, essential minerals, vitamins, small

peptides, and certain fatty acids [13]. Their health-promoting and preventive effects against diseases associated with oxidative stress are now well established [7–11]. The most common phenolic compounds in the diet are phenolic acids and various sub-classes of flavonoids, which together account for on average 60 and 30%, respectively, of the total dietary intake of phenolic compounds [54].

Phenolic compounds are able to act as antioxidants in multiple ways, among others, because of their redox properties, which enable them to adsorb and neutralize free radicals, quench singlet and triplet oxygen, or decompose peroxides [55, 56]. These processes are accomplished by hydrogen atom transfer, transfer of a single electron, sequential proton loss electron transfer, or chelation of transition metals [55, 56]. In addition, phenolic compounds are able to act synergistically with other antioxidants such as ascorbic acid, β -carotene, and α -tocopherol [57] and are presumably also involved in the regulation of intracellular glutathione levels [58].

Other dietary constituents with antioxidant properties are certain essential minerals, vitamins, small peptides, and fatty acids. Copper, iron, manganese, zinc, and selenium are indirectly involved in the body's antioxidant defenses by enhancing the activities of antioxidant enzyme. For instance, selenium is a cofactor of glutathione transferase and other selenoproteins [59]. It has notable antioxidant activity [60] and may be beneficial in chronic conditions such as cancer [61], heart disease [62], and cognitive disorders [63]. And copper, zinc, and manganese are cofactors of superoxide dismutase [64].

Antioxidant vitamins such as ascorbic acid are able to quench ROS by donating electrons to them; α -tocopherol inhibits ROS generation, preventing lipid peroxidation of cellular membranes; thiamin is a cofactor of NADPH that is required for the production of glutathione reductase and the activity of catalase; and the retinol precursor β -carotene reacts with peroxy, hydroxyl, and superoxide radicals [65, 66]. The common dietary small peptide glutathione is able to directly scavenge ROS [67]. And polyunsaturated fatty acids in, for instance, fish oil, are able to eliminate ROS and inhibit cellular processes that generate ROS, decreasing the risk of cardiovascular diseases by reducing triacylglycerol production in the plasma [68].

4. Fabaceae

4.1 Taxonomy

The pea family Fabaceae, also known as Leguminosae, is the third largest family of flowering plants after the Orchidaceae (orchid family) and the Asteraceae (aster family), representing about 7% of the global number of flowering plant species [69]. The Fabaceae consists of more than 700 genera and about 20,000 species of annual, biennial, or perennial trees, shrubs, herbaceous plants, vines, and lianas, which are encountered in all ecosystems throughout the world except Antarctica and the high Arctic [69, 70]. Most woody trees are found in tropical regions, while the herbaceous plants and shrubs are predominant outside the tropics [70]. Fabaceae members are readily recognizable by their fruits known as legumes or pods, which split open as they dry, releasing the seeds, and by their compound, stipulated leaves [71].

The leaves of many species (such as those of the common vetch *Vicia sativa* L.) have glands that produce nectar (extrafloral nectaries) through which they attract ants, which protect them from attacks by herbivores [72]. In other species (such as some in the genus *Acacia*), the stipules (outgrowths on both sides of the base of the

leafstalk) are modified to tiny chambers called domatia, which accommodate “body guard” ants [73]. Many Fabaceae (such as species of groundnut in the genus *Apios*) also host symbiotic bacteria in their roots—called rhizobia—which convert atmospheric nitrogen into a form that they can use for their metabolism (such as nitrate or ammonia) in a process referred to as nitrogen fixation [74]. The flowers of most species are conspicuous and colorful to attract pollinator insects [71]. The ovary itself matures into a legume or pod that encloses the seeds [71].

The Fabaceae includes six subfamilies [75], namely the Faboideae (or Papilionoideae), Caesalpinioideae, Detarioideae, Cercidoideae, Dialioideae, and Duparquetioideae [75]. The largest subfamily is that of the cosmopolitan Faboideae that harbors 503 genera and about 14,000 species including species of milkvetch in the genus *Astragalus*, species of lupin in the genus *Lupinus*, and species of pea in the genus *Pisum* [75]. The pantropical subfamily Caesalpinioideae includes about 4400 species in 148 genera such as the peacock flower *Caesalpinia pulcherrima* (L.) Sw., the candle bush *Senna alata* (L.) Roxb., the shy plant *Mimosa pudica* L., and the soap pod *Senegalia tenuifolia* (L.) Britton & Rose [75].

The subfamilies Detarioideae and Cercidoideae are mainly tropical and include 84 genera and about 760 species, and 12 genera and about 335 species, respectively [75]. Well-known examples in the Detarioideae are the ornamental pride of Burma *Amherstia nobilis* Wall and the tamarind *Tamarindus indica* L. that bears edible fruit. Renowned species in the Cercidoideae are well-appreciated ornamentals such as the pom pom orchid tree *Bauhinia divaricata* L. and the Judas tree *Cercis siliquastrum* L. [75]. The 85 species in 17 genera of the subfamily Dialioideae are widespread throughout the tropics [75]. A well-known example is the western African velvet tamarind *Dialium cochinchinense* Pierre, the velvety black pods of which contain a vitamin-rich acidic pulp that is chewed to relieve thirst or macerated in water to produce a beverage [75]. The subfamily Duparquetioideae is the smallest, consisting of one genus and one species, the liana *Duparquetia orchidacea* Baill that is native to western and central Africa [75].

The five largest genera of the Fabaceae family are *Astragalus* (milkvetches, subfamily Faboideae; over 3000 species), *Acacia* (acacias, subfamily Caesalpinioideae; over 1000 species), *Indigofera* (true indigos, subfamily Faboideae; around 700 species), *Crotalaria* (rattlepods, subfamily Faboideae; around 700 species), and *Mimosa* (sensitive plants or touch-me-nots, subfamily Caesalpinioideae; around 400 species), which constitute about a quarter of all legume species [75].

4.2 Economic value

Together with cereals, some vegetables and fruits, roots and tubers, oil-bearing crops, and sugar crops, various Fabaceae have been a staple food for humans for millennia, and their use and subsequent domestication and cultivation have been critical to the development of human civilization settlements [76, 77]. There are records dating the use of several species and varieties of beans in Asia, the Americas, and Europe to about 6000 BC, when they were becoming an essential staple as a source of protein (see, for instance, references [78, 79]). Contributing to the importance of the Fabaceae to human civilization were their extraordinary diversity and abundance and the broad variety of other uses they can be put to, ranging from ornamentals to medicines [69, 70]. In fact, species of Fabaceae are still among the economically and culturally most important plants in the world, providing foods, natural fertilizers, and forage; medicines; ornamentals; as well as materials for the pharmaceutical, cosmetic, and textile industries (see, for instance, reference [80]).

Examples of Fabaceae that are food crops of global importance are *G. max* (soybean), *Phaseolus* (beans), *Pisum sativum* (pea), *Cicer arietinum* (chickpeas), *Medicago sativa* (alfalfa), *A. hypogaea* (peanut), *Ceratonia siliqua* (carob), and *Glycyrrhiza glabra* (liquorice) [81]. Notably, the Fabaceae plant family is the second most important economic producer of crop plants after the Poaceae, the rice family [80]. Furthermore, the ability of Fabaceae to fix atmospheric nitrogen makes them very suitable as natural fertilizers to replenish soil that has been depleted of nitrogen [82]. A few species used for this purpose are leadtrees (*Leucaena* spp.) and riverhempes (*Sesbania* spp.) [82]. The additional nitrogen they receive increases their protein content, making some of them (such as the alfalfa *M. sativa* L. as well as clovers (*Trifolium* spp.), vetches (*Vicia* spp.), and peanut-like species (*Arachis* spp.) suitable as fodder for livestock [83].

Examples of Fabaceae with therapeutic properties are gum Arabic from the gum acacia *Senegalia senegal* (L.) Britton that has antitussive and anti-inflammatory properties [84] and tragacanth from *Astragalus gummifer* Labill that can be used as a demulcent in burn wounds [85]. Other species of Fabaceae are used for the production of vegetable oils for cooking. Well-known examples are the oils extracted from the soya bean *G. max* [86] and the peanut *A. hypogaea* [87].

Still other Fabaceae members are industrially farmed to produce dyes. Examples are the logwood *Haematoxylon campechianum* L., the heartwood of which produces red and purple dyes such as the histological stain hematoxylin [88], and the true indigo *Indigofera tinctoria* L., the leaves of which give the blue dye indigotin [89]. Furthermore, the roots of species in the genus *Derris* such as *D. elliptica* found in Southeast Asia and the southwest Pacific islands are a source of the strong insecticide rotenone [90]. And well-known ornamentals are the cockspur coral tree *Erythrina crista-galli* L., the national tree of Argentina, and the national flower of Argentina and Uruguay [91], and the Chinese wisteria *Wisteria sinensis* (Sims) DC that is a much appreciated ornamental vine [92].

4.3 Phenolic compounds and antioxidant activity

In addition to the applications mentioned above, many species of Fabaceae are traditionally used for medicinal or invigorating purposes (as mentioned in Section 6 of this chapter). The pharmacological activities have been associated with the abundant presence in the plants of certain bioactive ingredients—particularly phenolic compounds such as phenolic acids, (iso)flavonoids, and anthocyanins—with relatively high antioxidant activity [93–96]. In fact, the phenolic compounds in many species of Fabaceae—mostly isoflavones such as genistein and daidzein—are involved in a variety of physiological and metabolic processes that are relevant to human health [97]. The seeds are often not only highly nutritious, but also contain the majority of the phenolics [97–102]. Several of the phenolics elicited high antioxidant potential, displaying the ability to scavenge free radicals, and the ability to interact with proteins [97, 98], as well as a diversity of pharmacological activities including, among others, anti-inflammatory, vasodilatory, analgesic, antimicrobial, anti-allergenic, cardioprotective, anti-atherogenic, anticarcinogenic, and immunomodulating activities [97, 98].

However, as mentioned before, the Fabaceae comprise almost 20,000 species, and much of the information on the antioxidant activity and phenolic content extrapolated to the entire plant family is based on investigations with a relative handful of species (see, for instance, references [22, 23, 103–106]). Nevertheless, despite variable antioxidant activities among species, these studies have suggested a good correlation between total phenolic content and antioxidant activity [22, 23, 103–106].

The Fabaceae also constitute the greatest number of selenium-hyperaccumulating species, *that is*, plants that accumulate selenium in their cells at concentrations in excess of 1000 mg per kg dry weight [107]. Many selenium hyperaccumulators in this family belong to the genus *Astragalus* (milkvetches, subfamily Faboideae), the largest Fabaceae genus with over 3000 species of herbs and small shrubs [108]. The members of the much smaller genus *Neptunia* (subfamily Caesalpinioideae) also hyperaccumulate selenium [109].

5. The Republic of Suriname

5.1 Generalities

The Republic of Suriname is located on the northeast coast of South America, bordering the Atlantic Ocean and surrounded by French Guiana, Brazil, and Guyana (**Figure 1**). Roughly 80% of the approximately 600,000 inhabitants live in the capital city of Paramaribo and other urbanized areas in the northern coastal zone of the country (**Figure 1**). The remaining 20% resides in the rural-coastal areas and the southern-rural interior, which comprises approximately 90% of the country's land surface and largely consists of sparsely inhabited savanna and undisturbed, dense tropical rainforest with a very high animal and plant biodiversity [25, 26] (**Figure 1**).

Suriname's most important economic means of support are crude oil drilling, gold mining, agriculture, fisheries, forestry, and ecotourism [110]. These activities

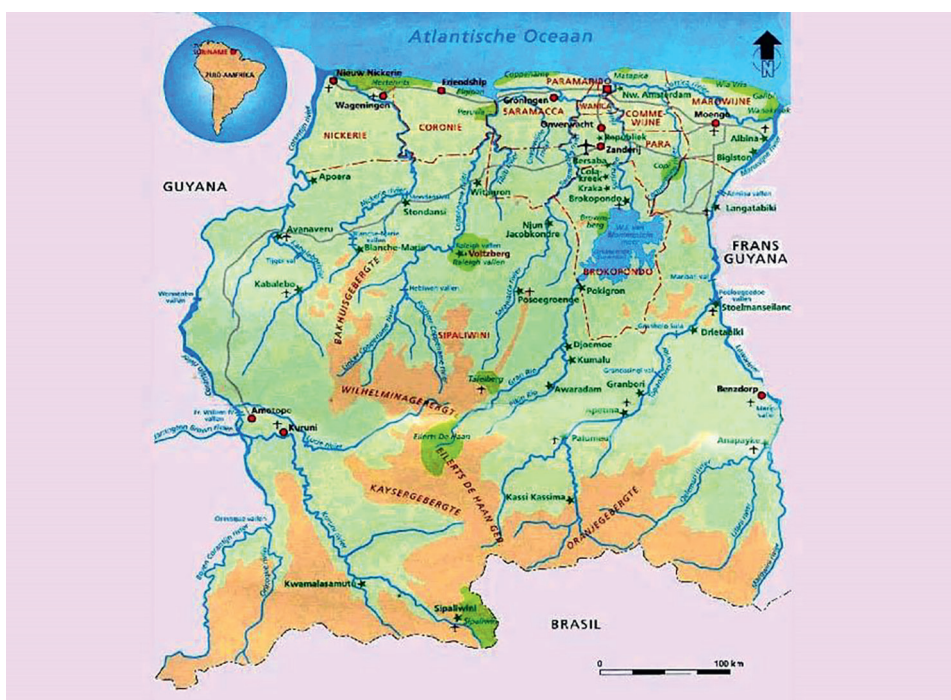


Figure 1.
 Map of the Republic of Suriname. Circle in top left: suriname's location in South America.

substantially contributed to the gross domestic product in 2020 of about USD 3 billion [111], positioning Suriname on the World Bank's list of upper-middle-income economies [112]. Suriname's population is among the most varied in the world, comprising Amerindians (the original inhabitants of the country) as well as descendants from enslaved Africans, indentured laborers from Asia, and European settlers, as well as immigrants from various Latin American and Caribbean countries [113]. All ethnic groups have preserved much of their original culture and identity, still practicing the religion they were raised with, speaking the language from their country of origin, maintaining their specific perceptions of health and disease, and adhering to their ethnopharmacological traditions [114, 115].

As a result, the use of various forms of traditional medicine is deeply rooted in the country, despite the broad availability of affordable modern health care [114, 115]. This inclination, together with the easy access to raw plant material from Suriname's rich biodiversity, probably accounts for the frequent use of traditional herbal medications in the country, either alone or in conjunction with prescription medicines [114, 115]. As in many other regions throughout the world, parts from Fabaceae members are often used for preparing the traditional medicines. The botanical knowledge to identify useful and edible plants has probably been obtained from ancient knowledge from the country of origin, by exchanging information with other cultures, by observing other peoples and animals, and by trial and error [114, 115].

5.2 Fabaceae in Suriname

The Fabaceae plant family is the most common family in tropical rainforests and dry forests of the Americas and Africa [116]. This plant family is also abundantly present in Suriname, and all growth forms—from dwarf shrubs and broadleaf evergreen trees to lianas and plants with bulbs or rhizomes—can be encountered between the northern coastal plain and the heavily forested and mountainous interior of the country. The exact number of genera and species in Suriname is not known, but according to the Checklist of the Venezuelan Guiana, there were 1032 species and 146 genera in the Guiana Shield in the year 2007 [28]. These figures are well in accordance with those from the National Herbarium of Suriname, which has 146 Fabaceae genera and 531 species from the Guiana Shield in its repository, 132 genera and 429 species of which have been collected in Suriname [28]. Thus, the Fabaceae species in Suriname can be estimated to constitute roughly 10% of the total number of approximately 5100 vascular plants in the country.

Like in many other parts of the world, several of the Surinamese Fabaceae species are used for a diversity of medicinal purposes. These species of Fabaceae have extensively been dealt with in several comprehensive publications on medicinal plants used in Suriname [117–125], and their total amounted to about 60 of the roughly 800 medicinal plant species. Thirty-nine of the medicinal Fabaceae species (about 65%) belong to the subfamily Faboideae, 16 (about 25%) to the Caesalpinioideae, 4 (about 7%) to the Detarioideae, and only 1 (about 2%) to the Cercidoideae. This distribution is more or less in accordance with that of the Fabaceae subfamilies throughout the world [75].

So far, scientific data to support the health claims of the Surinamese medicinal species of Fabaceae are scant. It is also not certain whether these claims may be based on the relatively high content of phytochemicals with antioxidant activity of these plants that, as mentioned above, seems to be one of the hallmarks of this plant family.

For this reason, we consulted the literature for evidence implicating the phenolic antioxidants in the plants in their traditional claims of beneficial health effects as well as their pharmacological activities. Fabaceae members that are mainly used for religious and ritual and spiritual purposes (such as the rosary pea or kokriki *Abrus precatorius* L., the bushillo shimbillo or yaraní *Zygia inaequalis* (Humb. & Bonpl. ex Willd.) Pittier, and the shining rattlepod or ogri-aypesi *Crotalaria micans* Link. [van Andel and Ruysschaert, 2011]) have been left out of our selection. From the remaining plants, eight that have been most frequently mentioned as sources of traditional medicines in the abovementioned publications [117–125] are in detail addressed hereunder (see also **Table 1**).

Plant species	Traditional uses	Pharmacological activities	Antioxidant phenolic compounds
<i>Caesalpinia pulcherrima</i> (L.) Sw. (peacock flower; krerekrere)	Oral complaints; gynecological, obstetric, and genitourinary conditions; colds and fevers; gastrointestinal disorders	Antimicrobial, analgesic, anti-inflammatory, cytotoxic, antioxidant activities	Yes; flavonoids
<i>Cajanus cajan</i> (L.) Millsp. (pigeon pea; loangopesi)	Oral complaints; skin problems; inflamed eyes; antiparasitic; analgesic; diabetes mellitus; labor induction; anti-emetic; gastrointestinal disorders	Anti-inflammatory, antioxidant activities	Yes; flavonoids
<i>Clitoria ternatea</i> L. (butterfly pea; kembang telang)	Aphrodisiac; inflamed eyes; memory-enhancing and improving of cognitive functions; sedative, anxiolytic, and antidepressant	Antimicrobial, antipyretic, analgesic, anti-inflammatory, analgesic, antidiabetic, antioxidant activities	Yes; flavonoids
<i>Copaifera guyanensis</i> Desf. (copaiba; hoepelhout)	Oral complaints; skin problems; respiratory ailments; wound healing-stimulatory; inflammations; microbial infections; parasitic infections; genitourinary conditions; gastrointestinal disorders; diabetes mellitus, hypertension	Antimicrobial, antiparasitic, anti-inflammatory, wound healing-stimulatory, antioxidant activities	No; terpenoids
<i>Desmodium adscendens</i> (Sw.) DC. (glue sticks; konkruman)	Respiratory ailments; fever; rheumatism; inflammation; epilepsy; genitourinary conditions; gastrointestinal disorders; diabetes mellitus; hypertension	Anti-asthmatic, anti-anaphylactic, antihypertensive, antioxidant activities	Yes; flavonoids, anthocyanins, tannins

Plant species	Traditional uses	Pharmacological activities	Antioxidant phenolic compounds
<i>Dipteryx odorata</i> (Aubl.) Willd. (tonka bean; tonkaboon)	Hair care; colds, fever, respiratory ailments; analgesic; gastrointestinal disorders; genitourinary conditions; parasitic infections; aphrodisiac	Antimicrobial, antiviral, anticoagulant, anticancer, anti-inflammatory activities	Yes; coumarin analogues, but no apparent antioxidant activities
<i>Lablab purpureus</i> (L.) Sweet (hyacinth bean; kulibontyi)	Alcohol intoxication; aphrodisiac; fungal skin infections; hypertension; high cholesterol; diabetes mellitus	Anti-inflammatory, analgesic, antidiabetic, antimicrobial, antihypertensive, anticancer, antioxidant activities	Yes; flavonoids
<i>Tamarindus indica</i> L. (tamarind; tamarinde)	Gastrointestinal disorders; skin problems; wound healing-stimulatory; microbial infections; parasitic infections, inflammations; hypertension; genitourinary conditions	Anti-inflammatory, analgesic, antimicrobial, antiviral, antihypertensive, antidiabetic, anticancer, antioxidant activities	Yes; phenolic compounds like tannins as well as selenium, ascorbic acid, and β -carotene

Table 1. Antioxidant compounds of eight Fabaceae members from Suriname and association with pharmacological activity.

6. Health effects of some Surinamese Fabaceae and relationship with phenolic antioxidants

6.1 *Caesalpinia pulcherrima* (L.) Sw

The peacock flower or krerekrere *C. pulcherrima* (L.) Sw. (**Figure 2**) is an evergreen shrub that grows to 3 m tall and likely originates from Mexico and the Caribbean, but can now be encountered in all tropical and subtropical parts of the Americas. Its beautiful inflorescence in yellow, red, and orange has made it a generally valued ornamental plant and the national flower of the Caribbean island of Barbados. The mature seeds contain cyanide and are poisonous, but the immature seeds are edible after roasting [126]. As the taste seems reminiscent of that of peanuts, another Surinamese vernacular for *C. pulcherrima* is “jodenpinda,” meaning “the peanut of the Jews,” in reference to the colonial masters from Jewish ancestry on whose plantations the enslaved Africans had come to know the plant [127].

Preparations from various parts of *C. pulcherrima* are used as a mouthwash for teeth and gums; as an emmenagogue, to accelerate childbirth, and as a strong abortifacient; for treating colds and fevers; against gastrointestinal complaints such as diarrhea, constipation, and gall bladder problems; and to remedy urinary tract problems such as kidney stones [128, 129]. In Suriname, *C. pulcherrima* is used for the same purposes [118, 120, 125] but also for good fortune and to honor Mama Aisa, an important deity in Afro-Surinamese Winti religion [130].

Phytochemical investigations have revealed the presence of various bioactive constituents in *C. pulcherrima* including a variety of flavonoid compounds along with glycosides,



Figure 2.
Flower of the peacock flower or krerekere *Caesalpinia pulcherrima* (L.) Sw. (from: <https://images.app.goo.gl/bqSv1gehtAQT11uk8>).

alkaloids, terpenoids, and sterols [131–133]. Some of these compounds have been associated with pharmacological activities such as antimicrobial, analgesic, anti-inflammatory, and cytotoxic activities, supporting some of the traditional uses of the plant [132–134].

Preparations from several parts of *C. pulcherrima* also exhibited substantial antioxidant activity [134–136]. Studies with this plant and other species of *Caesalpinia* have suggested that this activity may be associated with, among others, anti-inflammatory activity [135, 136], the inhibition of prostaglandin biosynthesis [135], the inhibition of nitric oxide production [136, 137], and/or the stimulation of superoxide dismutase and catalase activity [137]. These activities might be attributed to the phenolic compounds in the plant [136, 138, 139], supporting a role of these substances and their antioxidant activities in its apparent health-promoting effects.

6.2 *Cajanus cajan* (L.) Millsp.

The pigeon pea or loangopesi *C. cajan* (L.) Millsp. (**Figure 3**) is an erect, woody shrub that grows to a height of about 4 meters and that is native to the Old World [140]. It is not known in the wild but has been cultivated for centuries in tropical and subtropical regions of the world for its edible, protein-rich seeds, its medicinal properties, as well as its usefulness as fuel, a green manure, and for soil stabilization [140]. This plant is believed to have reached the New World including Suriname by means of the Trans-Atlantic slave trade at the end of the seventeenth century [141]. It grows relatively fast, is rather resilient, easily adapts to different soil and climatic conditions, and is drought-resistant [142], which makes it of utmost importance for food security in areas where rainfall is not reliable and droughts are likely to occur [143]. Not surprisingly, *C. cajan* has become part of the daily staple meals of millions of people throughout the world [140].

Humans have also used *C. cajan* since long medicinally, among others, for oral hygiene and treating oral complaints such as gingivitis and stomatitis, and ulcers and inflammations in the oral cavity, skin problems, as well as various chronic diseases such as diabetes mellitus [144–146]. In Suriname, the fresh leaf is squeezed into inflamed eyes [117] and incorporated into an infusion to facilitate childbirth [117] and to stop severe vomiting [118]. The potential therapeutic efficacy of these



Figure 3.

Seedpods of the pigeon pea or loangopesi *Cajanus cajan* (L.) Millsp. (from: <https://images.app.goo.gl/k6pETr1KXfuioSte8>).

traditional remedies is partially supported by the results from pharmacological studies showing remarkable anti-inflammatory activity of preparations from several parts *C. cajan* in both cell culture and animal models [147–150].

These observations have been attributed to the prevention of lipid peroxidation, the stimulation of endogenous antioxidant enzyme activities, and/or a decrease in the production of inflammatory cytokines [148–150]. The phytochemicals that have been held responsible for these activities were flavonoids [148–150], which was in accordance with the high phenolic content of *C. cajan* that included a diversity of flavonoids, tannins, coumarins, and stilbenes [147, 151]. Notably, flavonoid and phenolic contents of the plant samples correlated well with their individual antioxidant activity [149, 152]. Based on these data, *C. cajan* has been proposed as a candidate for skin care research and development [151].

6.3 *Clitoria ternatea* L.

The butterfly pea *Clitoria ternatea* L. is a perennial herbaceous climber that is native to tropical equatorial Asia, but can now also be found in Africa, Australia, and the Americas including Suriname. The genus name “*Clitoria*” has been derived from the presumed resemblance of the strikingly blue flowers with light yellow markings to the shape of human female genitals (**Figure 4**). This is also captured in the Indonesian/Malay vernacular of the plant “kembang telang,” “kembang” meaning “blossoming,” “swollen,” or “extended,” and “telang” meaning “blue-colored flower.” The blue color of the flower is caused by its high content of ternatins, polyacylated derivatives of the anthocyanin delphinidin 3,3', 5'-triglucoside [153]. It is used in south-eastern Asia as a natural coloring for rice dishes, desserts, hot and cold beverages, and textiles for making clothing. The attractive flower also makes the plant a well-appreciated ornamental in many parts of the world. Other notable chemical components in *C. ternatea* are cyclotides, exceptionally stable macrocyclic peptides present in all tissues of this plant [154]. These compounds are the bioactive molecules in a commercial eco-friendly insecticide developed from this plant [155].



Figure 4.
Flower of the butterfly pea or kembang telang *Clitoria ternatea* L. (from: <https://images.app.goo.gl/dtytS8InGZBEzhPg9>).

In traditional Chinese medicine, *C. ternatea* is used to increase female libido [156]. And in Indian Ayurveda, preparations from the plant are believed to enhance memory, improve cognitive function, control or prevent seizures, relieve stress, prevent or treat anxiety and depression, and exert calming and sedative effects [157]. These effects might be associated with the modulation of serotonin and acetylcholine metabolism in the brain [158]. In Suriname, *C. ternatea* is mainly used by the Javanese, who pour the diluted sap from the macerated leaf into inflamed eyes [118].

A variety of preclinical studies have shown that extracts from *C. ternatea* display a wide range of pharmacological activities including antimicrobial, antipyretic, anti-inflammatory, analgesic, diuretic, local anesthetic, antidiabetic, insecticidal, blood platelet aggregation-inhibiting, and vascular smooth muscle-relaxing properties [157, 159]. Many of these activities have been attributed to the presence of flavonols (in the form of flavonol glycosides) and anthocyanins in the plant [159]. These compounds could elicit some of the abovementioned pharmacological activities through their well-documented antioxidant effects [160, 161] or by contributing to the pharmacological activities of other bioactive compounds in the plant [159].

For instance, the anthocyanin delphinidin 3-sambubioside (from the dried calices of the roselle *Hibiscus sabdariffa* L.; Malvaceae) elicited anti-inflammatory activity in both cell and animal models [162], the synthetic cyclotide [T20K]kalata B1 delayed disease progression and diminished symptoms in a mouse model of multiple sclerosis [163], and the pentacyclic triterpenoid taraxerol isolated and purified from extracts of the transformed root somaclones of *C. ternatea* displayed encouraging anticancer properties [164]. Interestingly, the antioxidant properties of *C. ternatea* have commercially been utilized by including extracts from the flower in antiaging cosmetic products [165].

6.4 *Copaifera guyanensis* Desf.

The copaiba or hoepelhoutboom *Copaifera guyanensis* Desf. is an evergreen tree with a thick trunk that grows to about 25 m tall and that is indigenous to the swamps and rainforests of northern South America including Suriname (**Figure 5**). *C. guyanensis* is much in demand for the oleoresin in the grayish-brown bark of the trunk.



Figure 5.

Seedpods of the copaiba or hoepelhout *Copaifera guyanensis* Desf. (from: <https://images.app.goo.gl/G6iLQWMFEFyPR8D8>).

The oleoresin is a transparent, yellow to light brown liquid consisting of a nonvolatile fraction and a volatile essential oil with a scent that has been described as woody, sweet, and balsamic [166, 167]. The oleoresin is harvested by drilling a hole in the trunk of the tree and collecting it with the help of a polyvinyl chloride pipe, after which the borehole is plugged in order for the tree to sufficiently recover to retap it a year later. The oleoresin is used in small amounts as a food additive and as a flavoring agent in foods and beverages and has officially been approved in the USA for these purposes (see, for instance, [168]). It is also an ingredient of perfumes, varnishes, and lacquers and used as a substitute for diesel oil [169–171]. Given the latter application, *C. guyanensis* is also called “diesel tree.” The flexible but tough heartwood has been used for preparing hoops to tightly press the staves of barrels against each other, achieving watertight containers to store sugar. Hence, the Surinamese vernacular “hoepelhout,” literally meaning “wood for constructing hoops” [125].

C. guyanensis oleoresin (as well as that of other *Copaifera* species) has a very long history of medicinal use. In fact, the Amazonian Indigenous peoples have known the healing properties of the oleoresins for centuries from their observation that injured animals rubbed themselves on the tree’s trunk to heal their wounds [169, 172]. This led to the use of the oleoresin against, among others, microbial infections and inflammations and as a disinfectant, styptic, and wound-healing stimulatory substance [166, 173]. Other indications of *C. guyanensis* oleoresin are a sore throat, tonsillitis, bronchitis, and tuberculosis; cystitis, kidney and bladder infections, vaginal discharge, and gonorrhea; stomach ulcers; as well as a variety of skin problems including insect bites, eczema, blisters, sores, and psoriasis [167, 169, 174]. *C. guyanensis* oleoresin has essentially the same traditional uses in Suriname, where, in addition, a tea from the bark is drunk against diabetes mellitus, hypertension, malaria, and jaundice [125].

The principle pharmacologically active ingredients in the volatile essential oil of *C. guyanensis* oleoresin are sesquiterpenes, most notably β -caryophyllene, while the nonvolatile fraction mainly consists of acid diterpenes such as copalic acid and kaurenoic acid [166, 173]. Particularly β -caryophyllene displayed substantial antiseptic, anti-inflammatory, and antimicrobial effects including activity against *Staphylococcus aureus* [166, 167, 175], a common cause of skin infections. For these

reasons, the cosmetic industry extensively uses *Copaifera* oleoresins in anti-acne creams, formulations for treating stretch marks and scars, as well as shampoos, capillary lotions, soaps, and bathing foams [176]. β -Caryophyllene also selectively binds to the cannabinoid receptor 2 [177], which makes it an interesting candidate to relieve pain and inflammation [176, 178]. The diterpenes from *Copaifera* oleoresins reportedly elicited *in vitro* antibacterial, anti-inflammatory, antileishmanial, antitrypanosomal, and wound-healing stimulatory activities [179]. These findings substantiate some of the traditional uses of *C. guyanensis*, but so far there are no convincing data on the usefulness of *Copaifera* oleoresins in the clinic (see, for instance, reference [178]).

There are also reports on antioxidant activity of *Copaifera* species. For instance, the oleoresin from *C. langsdorffii* Desf. elicited notable antilipoperoxidation, antioxidant, and anti-inflammatory activity in an experimental model of random skin flaps on rat dorsums [180]. In addition, the essential oil from *C. officinalis* L. seed reduced lipid oxidation, showing promise as a natural antioxidant to increase the shelf life of meat products [168]. This effect has tentatively been attributed to the phenolic compounds identified in the essential oil [168]. Phenolic compounds—particularly flavonoids—have also been detected in the fruit and leaf of several *Copaifera* species [181, 182]. However, at this moment, there is no hard evidence to associate phenolic compounds and their potential antioxidant activities with the traditional uses and pharmacological activities of *Copaifera* species.

6.5 *Desmodium adscendens* (Sw.) DC

The glue sticks *D. adscendens* (Sw.) DC is a creeping or ascending herbaceous perennial herb or low shrub that can grow up to 1 meter in height. It probably originates from Africa, but is now widespread in tropical areas of Asia, South and Central America, and the Caribbean. The presence of many small hooked hairs on the seedpods (**Figure 6**) makes them cling to clothing, body parts, as well as the feathers and coats of pollinating animals, ensuring a wide dispersal of the plant. Hence, the vernacular “glue stick” in English and “konkruman” (“informer”) in Suriname: the sticky pods attaching to



Figure 6.
Seedpods of the glue sticks or konkruman *Desmodium adscendens* (Sw.) DC. (from: <https://images.app.goo.gl/CoBQwXQrRHUgXq4e9>).

clothing betray the unapproved presence of the bearer “in the field,” that is, away from home [183]. The plant is also believed to attract and hold fortune and prosperity while at the same time capturing and removing bad luck and disease [125].

Leaf, stem, and root of *D. adscendens* (as well as parts of the closely related species *Desmodium barbatum* (L.) Benth. and *Desmodium incanum* (Sw.) DC) have probably been used for thousands of years by native peoples of the Americas for a variety of health issues, including asthma and allergies; muscle cramp and back pain, rheumatism; venereal diseases, vaginal infections, and ovarian inflammation; epilepsy; hypertension; and diabetes mellitus [184, 185]. In Suriname, preparations from *D. adscendens* leaf, stem, and root are taken to relieve abdominal pain, fever, and painful urination associated with venereal diseases and as a remedy against diabetes mellitus and hypertension [124].

D. adscendens is rich in phenolic compounds including flavonoids, anthocyanins, and tannins, as well as reducing sugars, alkaloids, (soya)saponins, triterpenes, and amines [185, 186]. The meaningful pharmacological activities displayed by some of these compounds—such as anti-asthmatic and anti-anaphylactic activity [187, 188] and antihypertensive activity [183]—may support some of the traditional uses of the plant.

There are also reports associating the appreciable content of phenolic compounds with its antioxidant activity and some of its pharmacological effects. For instance, astragalin, the 3-O-glucoside of the flavonoid kaempferol, displayed antioxidant, anti-inflammatory, and anti-atopic dermatitis activity and attenuated lipopolysaccharide-induced inflammatory responses by suppressing the NF- κ B signaling pathway [189]. Astragalin also elicited antibacterial activity [190], which may explain the abovementioned traditional uses of the plant for treating infections, venereal diseases, and wounds [124, 184, 185]. Moreover, leaf and whole-plant extracts from *D. adscendens* displayed ROS scavenging activity and antioxidant properties *in vitro* [186]. These preparations also protected an LLC-PK1 pig kidney epithelial cell line from glucose-induced oxidative stress [191] and hepatocytes from carbon-tetrachloride-induced injury and hepatitis C virus infection [192]. These observations support the possibility that the antioxidant properties and the phenolic compounds of *D. adscendens* may be associated with its potential therapeutic value.

6.6 *Dipteryx odorata* (Aubl.) Willd

The tonka bean or tonkaboon *D. odorata* (Aubl.) Willd. (**Figure 7**) is a large semi-deciduous tree with a small, rounded crown that generally grows up to 30 m tall and that is native to Central America and northern South America. The tree is sometimes cultivated but is mostly harvested from the wild for its seed that is rich in coumarin [193]. The tonka beans are black and wrinkled, and have a smooth, brown interior, and their high content of coumarin and several of its derivatives such as umbelliferone (7-hydroxycoumarin) give them a strong sweet and spicy fragrance that is reminiscent of vanilla and almond [193]. For this reason, coumarin is abundantly used in the perfume industry as a fragrance and in desserts and stews as a substitute for vanilla [194]. However, at large infused doses, coumarin may cause liver damage, hemorrhages, and paralysis of the heart [195]. It is therefore controlled as a food additive by many governments [194] and has even been banned in the USA [196]. Anticoagulant prescription drugs such as warfarin are based on 4-hydroxycoumarin that was initially isolated from *D. odorata* seed, but coumarin itself does not have anticoagulant properties [197]. Other non-medical applications of coumarins are their use as agrochemicals,



Figure 7.
 Flowering tonka bean or tonkaboon *Dipteryx odorata* (Aubl.) Willd. (from: <https://images.app.goo.gl/Yy9nodcjZhZr5mwvG9>).

materials for food processing, optical brighteners, and dispersed fluorescent and laser dyes (see, for instance, references [198, 199]).

Despite the safety concerns, the seed and various other parts of *D. odorata* are traditionally used, among others, to fortify the scalp and improve hair growth; as a remedy for colds, fever, coughing, asthma, and tuberculosis; for treating stomach pain and diarrhea; against dysentery and schistosomiasis; as an emmenagogue, and as an aphrodisiac [200, 201]. In Suriname, *D. odorata* seed is mainly used as an ingredient of products to treat hair loss, dandruff, and an itching scalp; against colds; and to command luck [125, 202].

Some of the traditional uses of *D. odorata* are supported by the results from studies with various coumarin analogues—from the seed as well as other parts of the plant—showing a wide range of pharmacological activities such as antimicrobial, antituberculosis, antiviral, anticoagulant, anticancer, anti-inflammatory, and antioxidant activities [194, 203]. In addition to coumarin, *D. odorata* seed contains various other bioactive flavonoids, particularly isoflavones [204], particularly in the endocarp [205] as well as some of its other parts [206, 207]. These compounds are known to elicit potent antioxidant activity [208] and are, similarly to coumarins, phenylpropanoid-derived natural products. However, so far, their presence in *D. odorata* has neither been associated with antioxidant activity nor with the traditional and pharmacological activities of preparations from the plant.

6.7 *Lablab purpureus* (L.) Sweet

The hyacinth bean *L. purpureus* (L.) Sweet (**Figure 8**) is an annual or short-lived perennial vine of approximately 6 m high that is presumably native to Africa and has been introduced in south-eastern Asia where it has been cultivated as early as 2500 BC [209]. Since then, it has been carried to many tropical and subtropical parts of the world including Suriname, where it has been brought by Hindustani indentured laborers around the end of the nineteenth century [124]. Hence, its Surinamese vernacular “kulibontyi,” literally meaning “the bean of the coolies,” the epithet used for Hindustanis in that period. *L. purpureus* is commercially cultivated as an edible



Figure 8.

Seedpods of the hyacinth bean or kulibontji *Lablab purpureus* (L.) sweet (from: <https://images.app.goo.gl/EpBr6jHWi2s63vEHA>).

plant, as forage for livestock, and as an ornamental. The seed is poisonous due to its high content of toxic cyanogenic glucosides and trypsin and must thoroughly be cooked to destroy the toxin before consumption [210].

Preparations from various parts of the plant are used for a wide range of medicinal applications, ranging from remedies for alcohol intoxication and insufficient libido to medications for hypertension, high cholesterol, and diabetes mellitus [211, 212]. In Suriname, this plant is mainly used by Hindustanis, who apply the macerated leaves as a poultice against the fungal skin infections pityriasis versicolor and ringworm [124]. Pharmacological studies have shown, among others, anti-inflammatory, analgesic, antidiabetic, antimicrobial, antihypertensive, and anticancer activities [213, 214]. These activities may be associated, at least in part, with the presence in the plant of a variety of pharmacologically active constituents including phenolic compounds such as the flavonoids isoflavone, kievitone, and genistein [212, 215, 216]. In studies with other plants, some of these compounds reportedly decreased the production and the release of arachidonic acid, the expression of cyclooxygenase-1, cyclooxygenase-2, and 15-lipoxygenase, as well as the production of downstream-situated inflammatory mediators such as nitric oxide and prostaglandin E₂, eliciting anti-inflammatory activities [217–220]. Whether the phenolic compounds in *L. purpureus* also elicit these activities is not certain. But should that be the case, they can account for the traditional uses of the plant as well as the interest of the pharmaceutical industry to develop them to medicinal foods, nutraceuticals, and pharmaceuticals [211, 221].

6.8 *Tamarindus indica* L.

The tamarind or tamarinde *T. indica* is a long-living fruiting tree with a dense, spreading crown that can reach a height of 30 m. It is probably indigenous to tropical Africa where it grows in the wild. The tree has been cultivated for centuries in the tropics and subtropics as an ornamental plant, for its edible seedpods (Figure 9), and for its many medicinal uses. It has presumably been introduced in Suriname by enslaved Africans in the seventeenth century in order to fight diseases such as fever,



Figure 9.
Seedpods of the tamarind or tamarinde *Tamarindus indica* L. (from: <https://images.app.goo.gl/FJZ5FyY8UrNma1QUA>).

diarrhea, and worm infections on the slave ships [141]. *T. indica* produces pods with a hard, brown shell that contain about 10 seeds surrounded by a sour pulp that is rich in tartaric acid, acetic acid, and citric acid and is used in cooking, to flavor foods, in refreshing drinks, and as a key ingredient of Worcestershire sauce.

Preparations from *T. indica* leaf, seed, fruit, stem bark, and root are extensively used in folk medicine, among others, for treating abdominal complaints, to stimulate wound healing, to treat microbial and parasitic infections, against various skin diseases, to fight various inflammatory ailments, and as a remedy for hypertension and diabetes mellitus [222, 223]. In Suriname, *T. indica* preparations are used for the same conditions but also against menstrual pain and excessive vaginal discharge [117, 121]. Some of the traditional uses are supported by the results from pharmacological studies showing anti-inflammatory, analgesic, antimicrobial, antiviral, antihypertensive, antidiabetic, and anticancer activities in several laboratory models (see, for instance, references [224–226]).

Some of these activities may be attributable to the presence in the plant of pharmacologically active ingredients with notable antioxidant properties such as phenolic compounds [224–227] including tannins [227, 228], as well as selenium [229], and ascorbic acid and β -carotene [228]. The antioxidant activity of *T. indica* preparations has been associated with, among others, their antidiabetic, hypolipemic, and antihypertensive effects in laboratory animals [230–232]. Thus, several of the traditional uses and pharmacological activities of *T. indica* may be partially associated with the presence in the plant of phenolic compounds with antioxidant activity.

7. Concluding remarks

Parts from species in the Fabaceae plant family are among the most commonly used ingredients in Surinamese traditional medical practices and are employed for a wide diversity of medical indications. In this chapter, we have determined whether the abundant medicinal use of these plants may be associated with their phenolic

content and antioxidant activity. This was based on the association of the Fabaceae family with these properties [93–102], even though phenolic antioxidants have been found in a relative handful of the roughly 20,000 plant species in this family that have scientifically been evaluated [93–102]. The plants assessed in the current chapter were *C. pulcherrima*, *C. cajan*, *C. ternatea*, *C. guyanensis*, *D. adscendens*, *D. odorata*, *L. purpureus*, and *T. indica* (**Table 1**). For six of these plants—*C. pulcherrima*, *C. cajan*, *C. ternatea*, *D. adscendens*, *L. purpureus*, and *T. indica*—the traditional uses and pharmacological activities could be attributed, at least in part, to their phenolic compounds (more specifically, their flavonoids) and the notable antioxidant activities of these substances (**Table 1**). However, the traditional uses and pharmacological activities of *C. guyanensis* mainly seemed to be determined by terpenoids which did not elicit antioxidant activity (**Table 1**). And those of *D. odorata* mainly seemed to involve coumarins, which, although classified as phenolic compounds, did not seem to act *via* antioxidant activity (**Table 1**). This argues against the characterization of the Fabaceae as “a plant family of antioxidant phenolic compounds” [93–102] and underscores the necessity to further explore this group of plants for other classes of phytochemicals and other so far unknown but potentially useful pharmacological activities.

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