

## Review Article

# Anti-diabetic Plants used in Sudanese Folk Medicine and their Phytochemical Constituents: A Review

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## I N F O

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## A B S T R A C T

Diabetes is a chronic metabolic disease that affected 451 million people worldwide on 2017. According to W.HO. The global health care expenditure on diabetic people was estimated to be 850 billion \$ on 2017. Many medicinal plants have proven to be a good alternative to chemical medications. In this work 24 medicinal plants from different families used traditionally in Sudanese folk medicine for treatment of diabetes are reviewed based on scientific evidence. Their taxonomy, part used, life form, sources of collection, distribution, phytochemical screening and pharmacological activities have been identified.

It is reported that the most abundant plant families were found to be Caesalpiniaceae, followed by Asteraceae and Euphorbiaceae and then Anacardiaceae. 45 % were found to be herbs and 63 % of them were wild not cultivated. Phytochemical components of these plants were reviewed. Their anti-diabetic activities were reported in alloxinized and streptozotocin diabetic rats and in normoglycemic ones. LD<sub>50</sub> of these plants was determined. Medicinal plants in this review article showed a confirmed anti-diabetic activity and have been assessed for their safety which proposes them as herbal medications for treatment of diabetes.

**Keywords:** Ethno Pharmacology, Phytochemical Screening, Hypoglycemic, Medicinal Plants

**Introduction**

In 2011, Sudan split into two countries with one third of the country being proclaimed a new country named "Republic of South Sudan" leaving behind the remaining area retaining the older name "The Republic of Sudan".<sup>1</sup> The diversity of climates in Sudan results in a rich variety of flora species corresponding to the wide range of ecological habitats and vegetation zones. Thus the intersection of cultures and the unique geographical position of Sudan potentiate research in many fields, the most important of

which is research in the field of medicinal and aromatic plants. The flora of Sudan consists of 3137 documented species of flowering plants belonging to 170 families and 1280 genera. It is estimated that 15% of these plants are endemic to Sudan.<sup>2</sup>

Medicinal plants and their derivatives represent an integral part of life in Sudan and communities in different regions of Sudan use traditional medicine for the treatment of various ailments.

Diabetes mellitus, is a complex disorder characterized

by hyperglycemia resulting from malfunction in insulin secretion and/or insulin action is the most common serious metabolic disease in the world.<sup>3</sup> The number of people with diabetes has arisen from 108 million in 1980 to 451 million in.<sup>4</sup> Many indigenous medicinal plants have been reported by various authors to have hypoglycemic effects. Some of these hypoglycemic medicinal plants have been shown to significantly reduce blood glucose concentration in normal and diabetic animals. Informed knowledge of the effects of medicinal plants as well as their safety is necessary to understand their appropriate medical applications. Reviews of medicinal plants studies provide platforms for multidisciplinary information about their beneficial activities.<sup>5</sup>

The present work is designed to collect data about the mostly used hypoglycemic plants among Sudanese communities, in order to provide knowledge about their taxonomical properties, distribution, phytochemical components, anti-diabetic effects and safety studies. This effort may highlight the most promising hypoglycemic plants in this field.

## Materials and Method

The current review was done by collecting data on 24 medicinal plants native to Sudan, which have been reported to possess potential hypoglycemic activity. This was carried out by reviewing various research papers, review papers, short communications and published books. The sources of data were initially gathered from the major scientific databases such as science web of Knowledge, Science Direct, Pubmed and Google. The data were tabulated according to plant species names and families (Both arranged alphabetically), vernacular names of plant species used locally in Sudan. The plant part used traditionally for treatment of diabetes is also recorded in addition to life form of the tree, sources of collection and distribution.<sup>6,7,8,9</sup> The hypoglycemic activities for each species were summarized and the references were cited.

## Result and Discussion

### Anti-diabetic activity

In the current study 24 plant species belonging to 15 families were reviewed for their anti-diabetic effects in the literature. They were chosen according to their traditional use among local communities in Sudan.<sup>6,7,8,9</sup> They were screened for their hypoglycemic activities during the period of (1983-2017). Family Caesalpiniaceae was the most screened family followed by Asteraceae. Other families reported were: Poaceae, Balanitaceae, Capparaceae, Poaceae, Cyperaceae, Cyperaceae, Euphorbiaceae, Combretaceae, Malvaceae, Brassicaceae, Anacardiaceae, Apocynaceae, Lamiaceae, Zygophyllaceae, Myrtaceae, Solanaceae and Asclepiadaceae. Data collected about the sources of collection of these plants showed that almost 60% of

them were wild versus 33% to be cultivated (figure 1). 50% were herbs and 25% equally were shrubs and herbs (figure 2). According to their distribution in Sudan, most of them were found widely distributed in a wide range of Sudanese areas with at most in Western Sudan (figure 3).

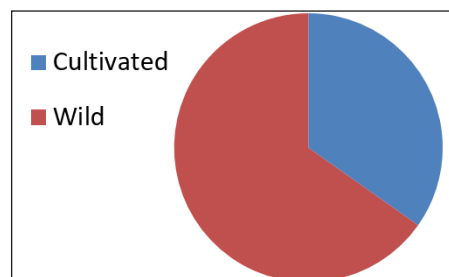


Figure 1. Sources of collection of the plants

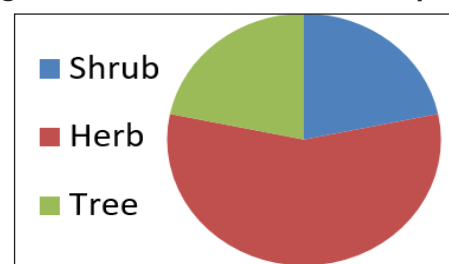


Figure 2. Life form of plants

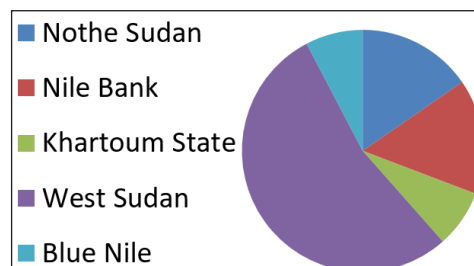


Figure 3. Distribution of the studied plants in Sudan

Review of these 24 plants showed that they all had anti-diabetic effects on streptozotocin and/or alloxan diabetic experimental animals (table 1). Some of them showed hypolipidemic activities on lipid profiles. Examples of these plants are: *Adansonia digitata*<sup>10,11</sup> *Bauhinia rufescens*,<sup>12</sup> *Cymbopogon citratus*,<sup>13</sup> *Guiera senegalensis*<sup>14</sup> and *Solanum nigrum*.<sup>15</sup> On the other hand, pharmacological actions of these plants underlining their hypoglycemic activities were elucidated, improvement of insulin production in *Hibiscus sabdariffa calyces*<sup>16</sup> and in *Nerium oleander*.<sup>17</sup> While *Nymphaea lotus* has caused regeneration of B-cells of pancreas.<sup>18</sup> *Ocimum basillicum* showed inhibitory effects on  $\alpha$ -glucosidase and  $\alpha$ -amylase enzymes.<sup>19</sup> Toxicity studies conducted on these plants determined their LD<sub>50</sub> are shown in table 2. Some of these plants were found to be non-toxic like *Cymbopogon citratus*<sup>20</sup> and *Solenostemma argel*.<sup>21</sup> Further studies on human subjects were carried out on *Cymbopogon citratus*<sup>20</sup> and *Vernonia amygdalina*.<sup>22</sup>

Table I. Sudanese Medicinal plants with Potential Hypoglycemic activity

S.No.	Botanical name	Family	Part used	Hypoglycemic activities and Toxicity studies
1.	<i>Adansonia digitata</i> L.	Bombacaceae	Bulb, stem	Methanolic extract showed significant reduction of serum cholesterol, LDL and Triglycerides in alloxinized diabetic rats; LD 50 > 5000 mg/ kg <sup>10,11</sup>
2.	<i>Ambrosia maritima</i> L.	Asteraceae	Whole plant	200 mg/ kg showed a hypoglycemic effect on post prandial glucose level of hyperglycemic rats after 20 days 2 % in the diet is safe <sup>23, 45</sup>
3.	<i>Balanites aegyptiaca</i> (L.) Del.	Balanitaceae	fruits	1.5 g/ kg, hypoglycemic activity on STZ diabetic mice <sup>46, 47</sup>
4.	<i>Bauhinia rufescens</i> Lam.	Caesalpiniaceae	leaves	200, 300, 400 mg/ kg, hypoglycemic activity in alloxinized diabetic rats <sup>48</sup>
5.	<i>Cajanus cajan</i> (L.) Millsp.	Caesalpiniaceae	Leaves	400 and 600 mg/ kg, significantly suppressed the peak postprandial rise in blood glucose of normal rats, LD50 greater than 5g/ kg <sup>49</sup>
6.	<i>Capparis decidua</i> (Forssk.) Edgew.	Capparaceae	Stem, bark, fruit	250 and 500 mg/ kg, hypoglycemic activity in alloxanized diabetic rats <sup>50, 51</sup>
7.	<i>Cassia occidentalis</i>	Caesalpiniaceae	Arial parts	250 and 500 mg/ kg, significant hypoglycemic activity in normal and alloxanized diabetic rats LD 50 > 5 g/kg <sup>52, 53, 54</sup>
8.	<i>Cymbopogon citratus</i> (DC. ex Nees) Stapf	Poaceae	Whole plant	200 mg/ kg, significant hypoglycemic activity. Not toxic for humans (clinical trial) <sup>13, 20</sup>
9.	<i>Cyperus rotundus</i> L.	Cyperaceae	Whole plant	500 mg/ kg, significant anti-hyperglycemic activity. Safe up to 200 mg/ kg. <sup>55, 56, 57</sup>
10.	<i>Euphorbia hirta</i> L.	Euphorbiaceae	Leaves	300 mg/ kg, effect on streptozotocin diabetic rats. Up to 483.0 mg/ kg body was not toxic to rats <sup>58; 59</sup>
11.	<i>Gueira senegalensis</i> JF Gmel.	Combretaceae	Leaves	200, 400 mg/ kg, lowered blood-glucose level in glucose loaded rats. LD <sub>50</sub> > 5g/ kg <sup>14, 60, 61</sup>
12.	<i>Hibiscus sabdariffa</i> L.	Malvaceae	Calyces	200, 400, 600 mg/ kg, hypoglycemic activity on alloxanized diabetic mice and improve insulin production <sup>16, 62</sup>
13.	<i>Lepidium sativum</i> L.	Brassicaceae	Seeds	20 mg/ kg, significant decrease in STZ-diabetic rats <sup>63</sup>
14.	<i>Magnifera indica</i>	Ancardiaceae	leaves	350, 700 mg/ kg, significant anti-diabetic activity, no effect on normoglycemic rats. LD <sub>50</sub> of the extract was above 4.64 gm/ kg per os <sup>64, 65, 66</sup>
15.	<i>Nerium oleander</i> L.	Apocynaceae	Leaves	250 mg/ kg improved insulin and glucose levels in STZ diabetic rats <sup>17</sup>
16.	<i>Nymphaea lotus</i> L.	Nymphaeaceae	Rhizomes	100 mg/ kg, significant antihyperglycemic activity in alloxan induced diabetic rats and regeneration of $\beta$ -cells of pancreas. May be toxic, especially when used for a long period of time and at higher doses <sup>18,67</sup>

17.	Ocimum basilicum L.	Lamiaceae	Leaves	a-glucosidase and a-amylase inhibiting activities. LD 50 > 5 mg/ kg <sup>19</sup>
18.	Peganum harmala L.	Zygophyllaceae	seeds	30, 60, 120 mg/ kg, good antidiabetic activity in streptozotocin diabetic rats. Safe up to 1g/ kg body weight in rats <sup>68,69</sup>
19.	Phyllanthus reticulatus Poir.	Euphorbiaceae	Leaves	200, 400 mg/ kg had significant anti-diabetic effect in alloxanized mice <sup>70</sup>
20.	Psidium guajava L.	Myrtaceae	Leaves	1 g/ kg, remarkable hypoglycemic action in normal and alloxan-treated diabetic mice <sup>71</sup>
21.	Sclerocarya birrea (A. Rich.) Hochst.	Anacardiaceae	Stem bark	100 up to 800 mg/ kg produced dose-dependent, significant reductions in the blood glucose of both normal and diabetic rats <sup>72</sup>
22.	Solanum nigrum L.	Solanaceae	leaves	200, 400 mg/ kg, antihyperglycemic and hypolipidemic effects in alloxanized rats <sup>15</sup>
23.	Solenostemma argel	Asclepiadaceae	Leaves	1g/ kg, reduced fasting serum glucose in diabetic rats, no toxic effect <sup>21</sup>
24.	Vernonia amygdalina	Asteraceae	Leaves	50 g elicited significant reductions in blood glucose levels at most postprandial time points (clinical trial). LD <sub>50</sub> > 500mg/ kg <sup>73;22</sup>

### Phytochemistry

The present work revealed that the most abundant phytochemicals in the reviewed plants were the flavonoids followed by tannins and saponins, to a lesser extent were glycosides, alkaloids and triterpenes. While phenolic compounds, coumarins and anthraquinones were moderately present (table 1). Many previous studies confirmed that natural products and medicinal plants contain some active phytochemical components, which induce different biological activities, these phytochemicals produce definite physiological actions in the body.

One of the most proven activities of these phytochemicals

included the anti-diabetic effect which is mostly induced by terpenoids, flavonoids and coumarins.<sup>23</sup> Other biological activities associated with diabetes, include effects on cholesterol level, cardiac dysfunctions and cells free radicals. Previous studies indicated the influence of phytochemical compounds on these abnormalities. It is reported that the anti-oxidant activity was induced by flavonoids and polyphenols while treatment of congestive heart failure and cardiac arrhythmia was reported by cardiac glycosides.<sup>24</sup> Other influences of these phytochemicals on physiological actions were revealed by saponins and tannins as great anti-bacterials.<sup>25,26</sup> Alkaloids, flavonoids and steroids were stated to have analgesic activities.<sup>27</sup>

**Table 2. Medicinal plants used Traditionally in Sudan for Treatment of Diabetes Mellitus and their Phytochemical constituents**

S. No.	Botanical name	Family	Vernacular name	Phytochemical constituents	References
1.	Adansonia digitata L.	Bombacaceae	Tabaldi	tannins, saponin, flavonoids, steroids, terpenoids and cardiac glycosides	28
2.	Ambrosia maritima L.	Asteraceae	Damssisa	terpenoids, flavonoids and coumarins, sesquiterpene lactone ambrosin 1, damsin 2, $\beta$ -sitosterol 3 and stigmasterol 4	23, 29
3.	Balanites aegyptiaca(L.) Del.	Balanitaceae	Hegleeg	Cardiac glycosides, Phlobatannins, Polyphenols, Saponins, Alkaloids, Steroids	24
4.	Bauhinia rufescens Lam.	Caesalpiniaceae	Kul Kul	Cardenolides, cardiac glycosides, flavonoids, saponins, resins, tannins, phlobatannins and anthraquinones	25

5.	Cajanus cajan (L.) Millsp.	Caesalpinaceae	Adassia	Steroids, glycosides, flavonoids, phenolic compounds	30
6.	Capparis decidua (Forssk.) Edgew.	Capparaceae	Tundob	Alkaloids, glycosides,	31
7.	Cymbopogon citratus (DC. ex Nees) Stapf	Poaceae	Hashishat El Ieymoon	flavonoids, carbohydrates, tannins, alkaloids, steroids	32
8.	Cyperus rotundus L.	Cyperaceae	Seida	Essential oils (active compound Cyperone)	33
9.	Euphorbia hirta L.	Euphorbiaceae	Um lebena	Flavonoids, polyphenols, tannins, Triterpenes and phytosterols	34
10.	Gueira senegalensis JF Gmel.	Combretaceae	Ghubeish	flavonoids and tannins, steroids, cumarin and triterpenes	35
11.	Hibiscus sabdariffa L.	Malvaceae	Karkade	Flavonoids, carotenoids, triterpenoids, alkaloids, steroids, flavonoids, Anthocyanin and Anthocyanidin, saponins, phenolic compounds	36
12.	Lepidium sativum L.	Brassicaceae	Hab El Rashad	flavonoids, Saponoside, tannins, Alkaloid, Stereol and Polyterpene	37
13.	Mangifera indica L.	Anacardiaceae	Manga	Terpenoids, flavonoids, saponins, tannins	38
14.	Nerium oleander L.	Apocynaceae	Ward El Hameir	Alkaloids, Terpenoids, Cardiac glycosides, Saponins, Tannins, Carbohydrates	39
15.	Nymphaea lotus L.	Nymphaeaceae	Sotaib	saponins, cardiac glycosides, tannins, phenolics, anthroquinones, terpenoid, quinones, catechins	26
16.	Ocimum basilicum L.	Lamiaceae	Rehan	tannins, phenolic compound, triterpenoids steroids, sterols, saponins, flavones and flavonoids	40
17.	Peganum harmala L.	Zygophyllaceae	Harmal	alkaloids, steroids, flavonoid	27
18.	Phyllanthus reticulatus Poir.	Euphorbiaceae	Summeima	Alkaloids, Coumarins, Flavonoids, Phenols and sterols	41
19.	Psidium guajava L.	Myrtaceae	Gawafa	Terpenoids, flavonoids, tannins, saponins, cardiac glycosides	38
20.	Sclerocarya birrea (A. Rich.) Hochst.	Anacardiaceae	Himed	Cardenolides, cardiac glycosides, flavonoids, saponins, resins, tannins, phlobatannins and anthraquinones	25
21.	Senna occidentalis (L.) Link	Caesalpinaceae	Soreib	tannins, alkaloids, reducing sugar, phenols, anthraquinones, resins, saponins and glycosides	42
22.	Solanum nigrum L.	Solanaceae	Anab El Deeb	Tannins, proteins, alkaloids, Flavonoids, Saponins	43

23.	Solenostemma argel	Asclepiadaceae	Hargel	flavonoid, saponins cardiac glycoside	44
24.	Vernonia amygdalina	Asteraceae	Garb El wadi	Terpenoids, flavonoids, saponins, tannins, alkaloids, cardiac glycosides	38

## Conclusion

Sudanese flora is rich with medicinal plants used traditionally in the treatment of various ailments. Wide range of these plants is reported for the treatment of diabetes mellitus. These hypoglycemic plants are vigorously studied with the determination of their phytochemical components and safety margins. Thus, they may be ready to be prepared in pharmaceutical preparations and further use in human clinical trials.

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