

# Herbal Medicines for the Management of Diabetic Mellitus in Ethiopia and Eretria including their Phytochemical Constituents

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## ABSTRACT

**Background:** Diabetes mellitus (DM) is a serious metabolic disorder which causes blood glucose to rise in blood streams abnormally emanating from the difficulty in insulin secretion, its action or the two. The absence of effective modern treatments, the lifelong treatment with modern medicine their associated health side effects and their expensive prices etc. are among the challenging existing realities which devastate/worsen the health and economic burdens of the disease, especially in developing nations. In light of these, the search for cheaper, safe and potential drugs from medicinal plants is very crucial.

**Objective:** The aim of this review is to document existing information on Ethiopian and Eretrian medicinal plants used to treat DM from various sources.

The following documents (published scientific papers, MSc thesis, books and research reports on ethno-botany as well as different on-line sources) using the search words, diabetics, medicinal plants and ethno botanical studies, are used in order to compile this review article.

One hundred five plant species claiming to have anti-diabetic activity were reported in this study. *Moringa stenoptela*, *Allium sativum*, *Caylusea abyssinica*, *Ajuga remota*, *Calpurnia aurea*, and *Psidium guajava* are among them which are the most frequently mentioned medicinal plant species. Only few numbers of medicinal plants were scientifically evaluated for their anti-diabetic effects in animal models in the countries, whereas the majority of them are not yet evaluated. Next to leaf, root is the second most frequently employed part in the anti-diabetic herbal preparations.

**Conclusion:** The prevalence of diabetes mellitus carries on escalating all over the World and no effective treatments that can manage diabetes have ever been discovered till present. Medication with commercial oral hypoglycemic drugs is getting very difficult due their expensive costs and associated adverse side effects on the health of the patient. Hence, the search for effective and safe drugs from the available medicinal plants should be consolidated in order to alleviate the above mentioned problems. Moreover, the indigenous knowledge of medicinal plants has to be documented in order to initiate or motivate interested researchers to find out anti-diabetic promising candidate drug from folk medicine that might cure or manage the cases and enable self-reliance in the future.

**Keywords:** Diabetics, Prevalence, Medicinal plants, Ethnobotany, Phytoconstituents, Efficacy, Safety.

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**Abbreviations:** CVD: Cardiovascular Disease; BP: Blood Pressure; NCD: Non-Communicable Disease; WHO: World Health Organization; GC: Gas Chromatography; GC-MS: Gas Chromatography Mass Spectrometer; DM: Diabetes Mellitus; IDDM: Insulin Dependent Diabetes Mellitus; NIDDM: Non-Insulin Dependent Diabetes Mellitus; ASCVD: Atherosclerotic cardiovascular Disease; MI: Myocardial Infarction; IGT: Impaired Glucose Tolerance, HIV-1: Human Immunodeficiency Virus type 1; HIV-2: Human Immunodeficiency Virus type 2; NMR: Nuclear Magnetic Resonance, TC: Total Cholesterol; TG: Triglyceride, DEMLWE : Department of Environment, Ministry of Land, Water and Environment

**INTRODUCTION**

Diabetes mellitus (DM) is a common endocrine disorder characterized by hyperglycemia manifesting often with symptoms and signs of osmotic diuresis such as polyuria, polydipsia, calorie loss, generalized weakness, polyphagia and weight loss resulting from either an absolute deficiency (Type 1) or a relative deficiency (Type 2) of the hormone, Insulin<sup>1,2</sup>. Type 1 diabetes which formerly known as insulin dependent DM which usually occurred in childhood or in early adult age is caused by  $\beta$ -cell destruction, with absolute deficiency in insulin which is multifactorial causes such as genetic predisposition resulting from an autoimmune reaction to proteins of the islets cells of the pancreas. The other type of DM is Type 2 diabetes, also referred to as non-insulin dependent DM usually occur in people >40 years of age occurs with intact beta islet cell but there is peripheral tissue resistance to insulin<sup>1,2</sup>. These disorders associated with reversible and acute complication such as ketoacidosis become fatal if treatment is delayed<sup>3</sup>.

Disabling chronic complication affecting vision, kidneys, the nerves, blood vessels and heart are common in those who diagnosed very late or those who are in improper medical follow up or care<sup>4</sup>. Even though the exact cause of this disorder is not clearly known yet there are common factors that contribute to the on-set diabetes. This factor is called predisposing or risk factors. Environmental factors such as diet, overweight or obesity and physical inactivity and genetic predisposition such as familial aggregation are among common mentioned risks particularly for the rise of type 2 DM<sup>4-6</sup>.

Diabetes also puts people at a much higher

risk of developing cardiovascular problems such as atherosclerotic cardiovascular disease (ASCVD) myocardial infarction (MI), stable or unstable angina, coronary or other arterial revascularization, stroke, transient ischemic attack, or peripheral arterial disease presumed to be of atherosclerotic origin which is the leading cause of morbidity and mortality among individuals with diabetes and is the largest contributor to the direct and indirect costs of diabetes. The common conditions coexisting with type 2 diabetes (e.g., hypertension and dyslipidemia) are clear risk factors for ASCVD, and diabetes itself confers independent risk<sup>6</sup>.

According to the World Health Organization (WHO) report, about 422 million adults were diabetic patients in 2014 globally, which increased by four times within three decade years who were only 108 million in 1980. This metabolic disorder is the cause of death for 1.5 million in 2012. Number of diabetic patients increased twice from 4.7% to 8.5% in adult population since 1980. This is the results of increase in obesity which is one of the predisposing factors for the on-set of DM. Form the past ten years on ward diabetes prevalence increased largely in undeveloped and under developed countries compared to developed counties<sup>7</sup>.

Diabetes and its associated health problems are the main global health burdens that challenge mankind globally despite discovery and utilization of hypoglycemic drugs to manage the case<sup>8</sup>. Besides affecting the quality of life, the patients do not perform their daily usual business as they visit health facilities so many times. This has decreased their income directly and created high economic loss of the country indirectly as it impedes the development of nation at large<sup>9</sup>. It is

also expected to happen to be one of the major disablers and killers worldwide within the next 25 years<sup>5</sup>. Managing DM has become a global problem in recent times due to the absence of successful treatments<sup>10</sup>. The currently existing therapies for diabetes which include insulin and the various oral hypoglycemic agents caused unnecessary side effects like hepatocellular injury; exacerbate renal diseases, lactic acidosis and diarrhea<sup>11</sup>.

### Epidemiology of Diabetics

The prevalence and incidence of diabetes has been reported to vary among populations and among age groups of the same population. According to the IDF 2015 estimate, the world wide prevalence is 1 in 11 adults; more than 415 million of people have diabetes which will rise to 642 million in 2040. Among these Africa account a 14.2 million people with diabetes which is likely to increase 34.2 million in 2035 and death of 5.0 million from diabetes in 2015<sup>6</sup>. In Ethiopia, the number of people aged 20-79 years living with diabetes was estimated to be 1.3 million adults with diabetes, and the prevalence was 2.9%<sup>6</sup>. This figure is projected to reach 1.8 million by 2030<sup>12</sup>.

According to the recent community based study, the prevalence of diabetics in Ethiopia was 6%<sup>13</sup>. Several risk contributing factors to type 2 diabetes include: family history of diabetes, the demographic and behavioral factors (age group, area of residence, alcohol consumption, adding salt to food, not engaged in vigorous physical activity, chewing chat) and biological risk factors (raised BP or currently on medication or impaired glucose tolerance (IGT)) were significantly associated ( $p < 0.001$ ) with raised blood glucose, being overweight, history of gestational diabetes and poor nutrition during pregnancy to name a few<sup>5,13,14</sup>.

### Adherence Challenge for the Management of Diabetics

Different studies in the world have shown that adherence to diabetes treatment has been highly varied and may range from 1.4 to 88.0%<sup>15-17</sup>. Low adherence to prescribed diabetes medications accounts for 30% to 50% of treatment failures, leading to worse treatment outcomes and which cause damages to vital organs. Treatment failure is in turn associated with reduced treatment

benefits and can have a negative financial burden on both individual patients and the society at large<sup>18,19</sup>. Strictly follow-up the prescription of medical treatment by the patient becomes a challenge for the health care deliverer and scientific community. Hence a number of patients do not benefited from medical treatment resulting. This brings a profound negative effect on their quality of life and social impacts in many aspects<sup>20-23</sup>. In Ethiopia, the anti-diabetic medication adherence found to be 68.8 to 85 due to poor economic status, low education level and inadequate knowledge about the disease and its medication<sup>24-28</sup>.

### Herbal Medicines for the Management of DM in Ethiopia

Diabetic mellitus prevalence rise globally and will expected to reach 642 million by 2040. Lifestyle change, consume carbohydrate rich dish and overweight are the main factors contribute for the growth number of diabetic patient. From time to time the use of traditional medicine throughout world increases due to the locally availability, easily accessible, simple to use and assumed to be safe<sup>25-29</sup>. As in the other cases people from different parts of the world use herbal medicines to treat diabetes mellitus and its complications<sup>30</sup>. World health organization gives recognition for the treatment of herbal medicine for variable communicable and non-communicable chronic disease like DM<sup>31</sup>. The paradigm shift of diabetic treatments from conventional drugs to herbal medicine might be due to the belief that herbal medicines have low or no side effects and the fact that users feel that they able to control their choice of medication<sup>32</sup>. This review article aims to document the medicinal plants that have been used for the management of diabetic mellitus from the Ethiopian and Eritrean flora<sup>33</sup>. It also covers the traditional uses, efficacy, safety and phyto-constituents of the anti-diabetic medicinal plants which have been evaluated scientifically.

### TRADITIONAL USES, EFFICACY, SAFETY AND PHYTO CONSTITUTENTS STUDIES FOR MOST COMMONLY USED PLANTS

**Plant name:** *Stevia rebaudiana*

**Family:** *Asteraceae*

**Local name:** (not stated)

**Part used:** Leaf

**Traditional uses:** The product has been added to tea and coffee, cooked or baked goods,

processed foods, beverages<sup>34</sup> and used safely in herbal medicines, tonics, for diabetes and in the daily usage products like mouthwashes and toothpastes<sup>35</sup>. It can be used in chocolates and candies for diabetes and tooth decay<sup>35,36</sup>.

**Efficacy data:** A study showed that both the aqueous and 70% ethanolic leaf extracts of *Stevia rebaudiana* resulted in a fall in blood glucose level in alloxan-induced diabetic mice as a function of concentration. However, the aqueous extract showed a better reduction towards blood glucose level as compared with the ethanol extract<sup>37</sup>.

**Safety and toxicity profile:** Acute toxicity conducted on overnight fasted Swiss albino mice of both sexes for three consecutive days clearly showed that no significant changes in behaviors such as alertness, motor activity, breathing, restlessness, diarrhea, convulsions, coma and appearance of the animals as well as mortality were seen up to the maximum of 5000 mg/kg doses of both solvents' leaf extracts, indicating the non-toxic effect of plant extracts<sup>37</sup>.

**Phytochemical constituents:** The leaves contain diterpene glycosides (Figure 1) namely, stevioside, steviolbioside, rebaudioside A-F and ducloside A, which are responsible for the typical sweet taste<sup>38</sup>. Labdanediterpene (e.g. sterebins I-N), triterpenes, sterols and flavonoids are some of the non-sweet secondary metabolites that have also been identified from the leaves<sup>39</sup>. An experiment demonstrated that steviol glycosides possesses activities like antioxidant, mutagenic and bactericidal, antiviral, gastro protective, and their effectiveness on renal function, blood pressure and blood glucose<sup>40</sup> (Figure 1).

Tesso and Konig<sup>41</sup> have also reported the phytochemical contents of *O. integrifolia* (Figure 2). From the dried leaves of the plant 40 constituents have been isolated by hydro-distillation. A class of terpenes such as monoterpenes, sesquiterpenes, diterpenes and their derivatives were reported to be present in the distillate. *Trans*-Sabinol [A],  $\beta$ -cyclocitral [B], dihydroedulan [C], theaspirane [D] and (+)-axinyssene [E] (prenylbisabolane diterpenes) were identified as the marker compounds. The prefuranic and furanic labdane diterpenoids, otostegindiol [F] and preotostegindiol [G] along with pentatriacontane and stigmasterol were also reported in the chloroform extract of the dried

leaves of *O. integrifolia*<sup>41</sup> (Figure 2).

**Plant name:** *Ajuga remota* Benth

**Family:** *Lamiaceae*

**Local name:** Akorarach (A)

**Part used:** Leaf

**Traditional uses:** In the Ethiopian traditional medicine, the fresh or dried leaves of *A. remota* was infused with water and sometimes with Alcohol, locally called "Arekie" and the infusions were used as remedy to heal diseases such as diabetes, malaria, pain and fevers, toothache, hypertension, stomachache, pneumonia etc<sup>42-44</sup>. Sometimes honey is added in to the preparation to make it palatable, since it has a bitter taste, and to store for longer periods for later use<sup>37</sup>.

**Pharmacological activities:** The plant was found to have most of the traditionally claimed activities including antiviral activity against Human Immunodeficiency Virus type 1, (HIV-1) and Type 2 (HIV-2), antipyretic, antifeedant, antihypertensive, insecticidal, antifungal, antimalarial activities<sup>37</sup>.

**Phytochemical constituents:** Five different neo-clerodane diterpenes namely (Figure 3): Ajugarin I, II, III, IV and V and clerodin were isolated and characterized from the leaves of *A. remota*. Bioactive compounds namely ajugalactone, ergosterol-5, 8-endoperoxide and 8-O- acetylharpagide were also reported from this plant<sup>44-46</sup> (Figure 3).

**Efficacy profile:** A study showed that both the aqueous and 70% ethanolic leaf extracts of the plant resulted in a fall in blood glucose level in alloxan-induced diabetic mice as a function of concentration. However, the aqueous extract showed a better reduction towards blood glucose level as compared with the ethanol extract<sup>37</sup>.

**Safety and toxicity profile:** Acute toxicity conducted on overnight fasted Swiss albino mice of both sexes for three consecutive days clearly showed that no significant changes in behaviors such as alertness, motor activity, breathing, restlessness, diarrhea, convulsions, coma and appearance of the animals as well as mortality were seen up to the maximum of 5000 mg/kg doses of both solvents' leaf extracts, indicating the non-toxic effect of plant extracts<sup>47</sup>.

**Plant name:** *Otostegia integrifolia* Benth

**Family:** *Lamiaceae*

**Local name:** Tinjute [A]

**Part used:** Leaf

**Traditional uses:** In Ethiopian folk medicine, the leaves of the stated medicinal plant have been utilized to diabetes mellitus by the community. As cited by a study, several studies also confirmed the uses of the various species of the genus *Otostegia* as having an ophthalmic, mosquito repellent, antimicrobial, anti-diabetic as well as antioxidant activities both in nature as well as scientifically<sup>48</sup>.

**Phytochemical constituents:** Results of the general phytochemical investigations reported the presence of phenolic compounds, saponins, reducing sugars and flavonoids but the lack of alkaloids, tannins and steroidal compounds in the 80% methanol leaf extract of this plant<sup>48</sup>. An investigation on the essential oil and chloroform extract of air-dried leaves gas chromatography (GC), GC-mass spectrometry (MS) and NMR techniques confirm the identification of many constituents belonging to the class of terpenes and their derivatives. The major component isolated includes (+)-1-methyl-4-(5, 9-dimethyl-1-methylene-deca-4, 8-dienyl)-cyclohexene<sup>41</sup>.

Two labdane type diterpenoids, (15, 16-epoxy-3a, 9a-dihydroxy-labda-13(16) & 14-diene and 9(13), 15(16) - diepoxy-3a-hydroxy-16-dihydrolabda-14-ene] as well as saturated hydrocarbon called as pentatriacontane and stigmaterol were also isolated from the chloroform extract of the leaves (Tesso&König, 2004). Isolation and structural elucidation of a prenylbisabolane type diterpene, (+)-axinyssene and two labdanediterpenes, otostegindiol, preotostegindiol and pentatriacontane from the air-dried leaves of the medicinal plant *O. integrifolia* Benth are reported (Figure 4)<sup>41</sup>.

**Efficacy profile:** An experiment has reported that 80% *O.integrifolia* leaf methanol crude extract reduces blood glucose level in normal and diabetic mice as well as in glucose induced hyperglycemic rats. As their study 200 mg/kg has shown maximum anti-diabetic, hypoglycemic and oral glucose tolerance activities in treated mice. Thus 200 mg/kg is the dose that lowered the high glucose level in streptozotocine-induced diabetic mice which is close to the normal range like the standard drug glibenclamide<sup>48</sup>.

**Safety and toxicity profile:** The methanolic leaf extract of the plant, up to the maximum dose of

500mg/kg, resulted in no mortality or any adverse side effects up on the experimental animals<sup>48</sup>.

**Plant name:** *Croton macrostachys*

**Family:** *Euphorbiaceae*

**Local name:** Bisana [A]

**Part used:** Root

**Traditional uses:** Several ethno botanical studies done on different parts of Ethiopia have reported the medicinal uses of the plant for the management of malaria, skin diseases, urinary retention, intestinal parasites, hepatitis, amoebas and bronchitis<sup>49-51</sup>.

**Phytochemical constituents:** The general chemical screening tests on the hydro-ethanolic root extract *Croton macrostachys* confirm the presence of alkaloids, phenolic compounds, tannins, terpenoids, saponins, phlobatannins and Flavonoids<sup>52</sup>. A compound (Figure 5), named as crotepoxide was isolated and characterized from the CH<sub>2</sub>Cl<sub>2</sub> extract of the berries of this plant using various chromatographic and spectroscopic techniques<sup>53</sup>.

**Efficacy profile:** According to a study, the hydro alcoholic root extract of *C. macrostachys* had shown a significant blood glucose lowering effect and improved glucose tolerance after administration of oral glucose solution. It is reported that the crude extract has maximum pharmacological effect at the dose of 300 mg/kg and it is comparable with the standard drug glibenclamide<sup>52</sup>.

**Safety and toxicity profile:** Results of toxicity study on experimental mice for the first 24 hrs as well as 14 consecutive days indicated that the root extract of *Croton macrostachys* did not result in mortality as well as Physical and behavioral signs on the test subjects at 2000 mg and 5000 mg doses of the extract per kg of B.W. This shows the plant extract is safe up to the maximum dose being administered<sup>52</sup>.

**Plant name:** *Justicia schimperiana*

**Family:** *Acanthaceae*

**Local name:** Sensel [A]

**Part used:** Leaf

**Traditional uses:** In Ethiopia, *Justicia Schimperiana*, belonging to the family acanthaceae, is locally utilized to heal ailments

such as stomachache, burning, constipation, skin lesion, tooth ache and Scabies. The leaf macerate *Justicia Schimperiana* is claimed to have anti-diabetic activity around Wolayta Sodo<sup>54</sup>.

**Phytochemical constituents:** Phytochemical analysis results confirmed the detection of secondary metabolites such as alkaloids, polyphenols, flavonoids, glycosides, phytosterols, saponins, triterpenes, and quinines as a major class of compounds<sup>55</sup>. Phytochemical analysis indicated the presence of saponins and alkaloids in chloroform, methanol and aqueous fractions of the leaf extract of *J. schimperiana*, while terpenoids were detected only in the chloroform fraction and flavonoids in methanol and aqueous fractions<sup>56</sup>.

**Efficacy data:** An investigation on the effect of the aqueous leaf extract of *Justicia Schimperiana* on normal and diabetic mice uncovered that the plant extract at two doses of [200 mg/kg and 400 mg/kg] post oral administration has shown a fall in blood glucose in all experimental models for the treatment periods<sup>54</sup>.

**Toxicity profile:** The median lethal concentration of the water leaf extract of the plant was concluded to be greater than 2000 mg/kg as no mortality or physical and behavioral signs up on the experimental rats were seen during the test periods<sup>54</sup>.

**Plant name:** *Moringa stenopetala*

**Family:** *Moringaceae*

**Local name:** Shiferaw [A]

**Part used:** Leaf

**Traditional uses:** The different parts of this medicinal plant have locally been utilized by the Ethiopian communities to manage diseases like malaria, hypertension, asthma, diabetes, stomach pain<sup>57,58</sup>.

**Pharmacological properties:** Various literatures reported the uses of *Moringastenopetala* as anti-malarial, antileishmanial and anti-fertility<sup>59</sup>, hypotensive<sup>60</sup>, anti-hypertensive<sup>61</sup>, vasodilatory<sup>61</sup>, hypoglycemic<sup>62</sup>, and anti-diabetic effects<sup>58,63</sup>.

**Efficacy data:** An efficacy study illustrated that oral administration of the aqueous ethanol and n-butanol extracts of *Moringastenopetala* leaves (500 mg/kg body weight) and metformin (150 mg/kg) significantly reduced blood glucose level

( $P < 0.05$ ), improved serum lipid profiles, liver enzymes and kidney functions in diabetic rats after 14 days<sup>63</sup>.

The effect of n-butanol fraction of ethanol leaf extract *Moringa stenopetala*, at 500 mg oral dose administration per kg body weight, on blood glucose levels of alloxan induced diabetic mice were evaluated over a period of one month. The findings of this study revealed that a large decrease in BGL was recorded all rats treated with the fraction at third week treatment period and later. On the last day of the month, the butanol fraction treated groups showed a net reduction in BGL of 5.14% over those which received the standard drug, Glibenclamide. At the same time, the administration of butanol fraction caused Serum total cholesterol (TC) and triglyceride (TG) levels to decline a large extent.

A study also added that the ethanol and aqueous extracts as well as the various solvents' fractions of ethanol crude extracts and aqueous residue, each at 300 mg/kg single and repeated doses administration showed a huge fall in blood glucose level in both hypoglycemic and anti-hyperglycemic mice. All the above studies confirm the blood glucose lowering effect of moringa stenopetala leaves as well as the traditional claims.

**Phytochemical constituents:** Phytochemical screening tests on the crude aqueous leaf extracts and butanol fraction of *Moringa stenopetala* detect the presence of alkaloids, saponins, polyphenols, flavonoids, coumarins, terpenoids, anthraquinones, tannins, phytosterols and cardiac glycosides and the presence of all the secondary metabolites except saponins in 70% alcohol fractions<sup>58,64</sup>.

Rutin (Figure 6), which is the marker component, was isolated from the leaves of *M. stenopetala* leaves<sup>65</sup>.

The other four compounds (Figure 7) are isolated from acetone extract of root wood of *Moringa stenopetala* by subjecting the extract to column chromatographic separation. Based on the physical properties and spectroscopic (IR and NMR) data as well as literature reports, the chemical structures of the compounds were found to be cholest-5-en-3-ol, palmitic acid, n-octacosane and oleic acid, respectively. Three of the isolated compounds, namely cholest-5-en-3-ol, palmitic acid and oleic acid pro-

duced the highest activity against *E.coli*<sup>66</sup> (Figure 7).

Three glycoside compounds were also detected in ethanol leaf extract and identified as rutin, 4-(4'-O-acetyl-rhamnosyloxy)-benzyl isothiocyanate and 4-(4'-O-acetyl-rhamnosyloxy)-benzaldehyde. Two glycerides named as 1, 3''dilinoleoyl-2''olein and 1, 3''dioleoyl-2''linoleic were characterized from root extract of *Moringastenopetala* that showed good activity on *aethiopica* intracellular amastigotes<sup>67</sup>.

**Toxicity:** For this study, the test animals were orally given ascending concentrations (300, 2000, 5000 mg/kg) of the fraction and the result indicated that no detectable changes in behaviors such as alertness, motor activity, breathing, restlessness, diarrhea, convulsions, coma and appearance of the animals were observed. Similarly, no mortality was recorded at the above higher limit dose.

**Plant name:** *Vernonia amygdalina*

**Family:** *Asteraceae*

**Local name:** Grawa [A]

**Part used:** Leaf

**Traditional uses:** As compiled by a study, *Vernonia Amygdalina*, belonging to the Asteraceae family, is generally utilized for the management of various ailments including malaria schistomiasis, amoebic dysentery, headache, fever, venereal diseases, wounds, hepatitis, high blood pressure, hyperglycemia, and gastrointestinal problems. Furthermore, its leaf is eaten as vegetables to facilitate digestion besides washing vessels employed for the aim of fermentation<sup>68</sup>.

**Phytochemical constituents:** Preliminary screening of ethanolic extracts of both young and old *V. amygdalina* leaves revealed the presence of alkaloids, tannins, saponins, cardiac glycosides, terpenes, and steroids despite the absence and presence of flavonoids in the young and old leaves of the plant extract respectively<sup>69</sup>. A study showed that a large number of isolated bioactive compounds belonging to the various secondary metabolites have been obtained from the leaf part this plant by many investigators. Vernodalol (Sesquiterpene lactone), Epivernodalol (Sesquiterpene lactone), Vernomygdin (Ses-

quiterpene lactone), Vernoniosides (Steroid Glucosides) and flavonoids such as luteolin, luteolin 7-O-glucosides, luteolin 7-O-glucuronide etc are among the compounds being isolated<sup>70</sup>.

Another study also confirmed that two compounds, named as epivernodalol and elemanolide, were isolated and characterized in the dichloromethane fraction of this medicinal plant<sup>71</sup>. In an experiment, a compound called 3-amino-5-methylhex-5-enyl 3-amino-6-methylhept-6-enyl terephthalate was isolated from the leaf of given medicinal plant<sup>68</sup>.

**Efficacy data:** The ethanolic extracts from both the old and young leaves of the given medicinal plant resulted a significant ( $p<0.05$ ) anti-hyperglycemic activity<sup>69</sup>.

**Plant name:** *Aloe camperi*

**Family:** *Asphodelaceae*

**Local name:** Ere [T]

**Part used:** Leaf

**Traditional uses:** The latex or leaf extract of *Aloe camperi* is traditionally utilized for the management skin burns, dandruff, stomach pain, hypertension, hair fall as well as diabetes by communities living in the Central and Southern Zones of Eritrea<sup>72,73</sup>.

**Phytochemical constituents:** A study reported that alkaloids, phenols, terpenoids, phenols, tannis saponins, flavonoids, glycosides, carbohydrate and proteins were contained in the methanol extract of the plant where as saponins steroids, terpenoids and coumarines were present in the hexane extract<sup>73</sup>.

**Efficacy data:** Studies have evaluated the anti-diabetic activities of methanol leaf extracts of this medicinal plant by administering 200 and 400 mg/kg doses of the extract orally in diabetic induced experimental rats. The methanolic extract resulted in a dose-dependent lowering of FBG levels and the result exhibited very significant ( $P<0.001$ ) decreases in FBG level by the end of the experimental day as compared to the diabetic control. The extract at 400 mg/kg concentration produced significant anti-hyperglycemic effect which is comparable to standard drug. An Oral glucose tolerance test (OGTT) on normal rats also indicated that the hyperglycemia with glucose challenge was significantly brought down ( $P<0.001$ ) by the

plant extract at 60 and 120 min relative to the negative control<sup>74</sup>. The methanol leaf extract of *Aloe camperi* also showed a fall in blood glucose after oral administration of the extract in normal rats<sup>74</sup>. This might be attributed to the presence of hypoglycemic bioactive molecules like flavonoids, terpenoids, alkaloids or saponins contained within the leaf plant<sup>73</sup>.

**Toxicity data:** Acute toxicity test confirmed non-toxic nature of the methanolic leaf extract of this medicinal plant the median lethal concentration of extract is shown to be beyond 2000 mg/kg per body weight<sup>74</sup>.

**Plant name:** *Meriandra dianthera*

**Family:** *Lamiaceae*

**Local name:** Nehiba/Mezeguf (T)

**Part used:** Leaf

**Traditional uses:** *M. dianthera* has wider applications in the treatment of diabetes and other ailments in the traditional medical practices of the communities in the Central and Southern Zones of Eritrea<sup>72</sup>. An ethnobotanical study in Saharti samire, Southern part of Tigray, Ethiopia showed the uses of this plant for management of hypertension and diarrhea<sup>75</sup>.

**Phytochemical constituents:** A study by reported that phenols, terpenoids, phenols, tannins, saponins, glycosides, carbohydrate and proteins were contained in the methanol extract of the plant where as saponins steroids, terpenoids and coumarines were present in the hexane extract<sup>73</sup>.

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*Meriandra dianthera* also showed a fall in blood glucose after oral administration of the extract in normal rats<sup>74</sup>. This might be attributed to the presence of hypoglycemic bioactive molecules like flavonoids, terpenoids, alkaloids or saponins contained within the leaf plant<sup>73</sup>.

**Toxicity data:** Acute toxicity test confirmed non-toxic nature of the methanolic leaf extract of this medicinal plant the median lethal concentration of extract is shown to be beyond 2000 mg/kg per body weight<sup>74</sup>.

**Plant name:** *Pentas schimperiana* (A. Rich) Vatke

**Family:** *Rubiaceae*

**Local name:** Woinagrefet

**Part used:** Leaf

**Traditional uses:** In Ethiopia, its fresh dry root bark powder mixed with water is taken orally for epilepsy<sup>51</sup> and the leaf decoction for management of diabetes mellitus<sup>76</sup>.

**Phytochemical constituents:** The results of general phytochemical analysis confirmed the detection of saponins, flavonoids, tannins, steroidal and phenolic compounds in the 80% methanolic leaf extract of the medicinal plant.

**Efficacy profile:** Both the hydro-methanolic fresh leaf extract as well as the hydro-methanolic and aqueous dried leaf extracts of *P. schimperiana* resulted in the reduction of blood glucose as a function of time and concentration in alloxan-induced diabetic mice. Similarly, the effect of oral administration of various solvent fractions of the plant on alloxan-induced diabetic mice each at a dose of 500 mg/kg also revealed that only the methanol and aqueous fractions caused a significant reduction blood glucose level where as the chloroform and acetone fractions did not<sup>76</sup>.

**Acute toxicity test:** The study results demonstrated that the total aqueous and hydro alcoholic extracts of *P. schimperiana* resulted in no physical and behavioral signs such as restlessness, breathing, diarrhea etc. as well as caused no mortality up to 5000 mg/kg administered which also showed a median LD50 is above the tested dose<sup>76</sup>.

We used the following documents: published papers, MSc theses, books and research reports on ethno botany as well as different on-line sources in order to compile this review article<sup>77-108</sup>.



## RESULTS

Diabetes is a metabolic problem that contributes to major economic decline, there by hampering the growth of nations. Besides, unmanaged diabetes results in several chronic complications such as blindness, heart failure, and renal failure. In order to prevent this increasing health burdens, the development of research into new hypoglycemic and potentially anti-diabetic agents from plant origin is of great interest in recent times. Thus, this review article lists a total of one hundred five medicinal plants which are utilized for the management of diabetics in Ethiopia (Supplementary table 1).

[A]=Amharic, [O]=Affan Oromo, [T]=Tigrigna, [Sm]=Somaligna, [Sd]=Sidamigna

(Figure 8) shows the common plant part used were leaf followed by root.

Also, (Supplementary table 2) shows that *Allium sativum*, *Cayluseabyssinica*, *Calpurnia aurea*, *Moringastenoptela*, *Psidiumguajava* and *Thymus schimperi* were are the most commonly used medicinal plants for the management of diabetics in Ethiopia.

## CONCLUSION

The prevalence of diabetes mellitus carries on escalating all over the World and no effective treatments that can manage diabetes have ever been discovered till the present. Medication with commercial oral hypoglycemic drugs is getting very difficult due their expensive costs and associated side effects on the health of the patient. Herbal medicines have recently been gaining increasing popularity by both developing and developed nations for the management of diseases, including diabetes. In this review, a total of one hundred five medicinal plants have been identified and documented for their use in management of diabetics. This article also presents the traditional medicinal uses, efficacy, toxicity as well as the bioactive compounds of some anti-diabetic plants found in Ethiopia and Eretria.

Most of these medicinal plants are widely utilized in different parts of the country; only the safety and efficacy of *Moringa stenopetala*, *Stevia rebaudiana*, *Pentas schimperiana*, *Meriandra dianthera*, *Vernonia Amygdalina*, *Justicia Schimperiana* and *Otostegia integrifolia* were scientifically tested in animal models. As demonstrated by many scholars, the bioactive

compounds contained within the plants have shown beneficial effects that can delay the onset of diabetic problems and adjust the metabolic disorders. Nevertheless, the pharmacological actions and chemistry of many of the medicinal plants have not been well studied scientifically. Therefore, further characterization of the active compounds, efficacy, evaluation of the mechanism of action and toxicity of the medicinal plants should be carried out. A research that can strengthen the documentation of the indigenous knowledge which contributes for the drug development and for self-reliance in the future is also recommended.

## COMPETING INTERESTS

All authors declare that they have no competing interests.

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Table 1. List of medicinal plants used to manage diabetes mellitus

S. No	Scientific name	Family	Local name	Parts used	Method of preparation	Other Medicinal Uses	Reference
1.	<i>Aloe pulcherrima G</i>	Xanthorrhoeaceae	Set-eret (A)	Latex	water and sugar boiled together and given orally	Asthma, diabetes dandruff	[79]
2.	<i>Thymus schimperi Ronniger,</i>	Lamiaceae,	Tosign (A)	Stem, leaf, Whole plant	Dried stem and leaf powder boiled with tea is given orally	Diabetes	[80, 79]
3.	<i>Croton macrostachys</i>	Euphorbiaceae	Bisana (A)	Root		Anti diabetic activity, malaria, purgative and anti-inflammatory effects,	[52, 81]
4.	<i>Aloe vera</i>	Asphodelaceae	Eret (A)	Fresh leaf	Not specified	Diabetes	[82]
5.	<i>Euphorbia sp. Gmel</i>	Euphorbiaceae	Kulkual (A)	Latex	The plant is cut and squeezed until enough is collected, a cup and half is drunk three times a day before food	Diabetes, Homorroids, ascaries	[83]
6.	<i>Asparagus africanus Lam</i>	Asparagaceae	Sereti (A)Sarritt/ qastanticha	Root, Leaf	Give the dikus with food and drinks Powdered and taken orally	Diabetes, nekera, urine retention, chest pain, sleeping, Snake bite, poisoning, diabetes	[79,84]
7.	<i>Discopodium penninervum Hochst</i>	Solanaceae	Ameraro (A)	Leaf	Eat the boiled leaf as a cabbage	Diabetes	[84]
8.	<i>Caylusea absyssinica (fresen)</i>	Resedaceae	Rench (A)	Leaves	Not specified	stomachache , skin diseases, diabetes mellitus and amoeba	[43, 85-87]
9.	<i>Ajuga integrifolia Ham-Buch. Labiatae</i>	lamiaceae	Harmagusa[O] Akorarach (A)	Leaves, Root	Aqueous and sometimes "Arekie" (alcohol) infusion of the fresh or dried leaves	Malaria, toothache, skin disease whooping cough, pneumonia, hypertension, diabetes etc...	[37,43, 84,87]
10.	<i>Solanum marginatum L.f</i>	Solanaceae	Zerch embuay, (A)	seeds	Seeds taken out ,washed, dried and drunk with goats kebe or milk after boiling	Cough, lung problem, diabetes	[84]
11.	<i>Podocarpus gracilis</i>	Podocarpaceae	Zigba (A)	Gum and shoot	Betazma mar lewuso meblat(1/2 spoon)	Cough, lung problem, diabetes,	[43,84]
12.	<i>Crinum abyssinicum(Hochst) ex A. Rich</i>	(Amaryllidaceae)	Yejib shinkutrt (A)	Shoot tip-fresh	Squeezed, mixed with water, drink	Hypertension, diabetes	[88]
13.	<i>Psidium guajava</i>	Myrtaceae	Zeytun (A)	Leaves	Boil with the leaves of camellia sinesis and drink	Wounds, ulcers, bronchitis, hypoglycemic , anti hyperglycemic, anti-inflammatory effect etc..	[73,88, 89]
14.	<i>FoeniculumVulgare Miller.</i>	Apiaceae	Ensilsl (A)	Fresh leaves	Boil and drink	Hypertension, diabetes, gonorrhea	[88]
15.	<i>Argemone thiopia .L</i>	papaveraceae	Wajo uta (Sd)	leaves	Dry or fresh leaves crushed, pounded, and filtered then infusion drunk in the middle of night	Diabetes	[90]
16.	<i>Delonix regia (Boj.ex Hook)</i>	Fabaceae	Mimi (Sd)	leaves	Dry or fresh leaves crushed, pounded, and filtered then infusion drunk in the middle of night	Diabetes	[90]
17.	<i>Moringa- stenoptela</i>	Moringaceae	Shiferaw (A)	Fresh leaves	Fresh leaves cooked as food and eaten or Boil and drink its soup	Hyperglycemia, kidney infection, cold, malaria	[58,87,88, 90-92]
18.	<i>Calpurnia aurea</i>	Fabaceae	Digita (A)	Leaf	Not specified	Malaria, diarrhea, diabetes, rabies, hypertension amoebiasis , giardiasis etc	[49,93, 111]
19.	<i>Lens culinaris Medik</i>	Fabaceae	Misir [A]	seed	Not specified	Diabetes	[49]
20.	<i>Acacia nilotica (L.) seed, stem bark</i>	Fabaceae	Ghered (T)	seed, stem bark	Decoction of the seed or bark is used or Regularly fruits are given in spoonful before break fast	Malaria, cough, dysentery, insect repellent Diabetes, diarrhea, hemorrhage, tooth	[73,94]

21.	<i>Ambrosia maritima</i> L	Asteraceae		Whole plant	Not specified	Reheumatic pains, asthma, bilharziasis, diabetes and to expel renal stones	[94]
22.	<i>Bryonia cretica</i> L.	Cucurbitaceae		Not specified	Not specified	Bitter tonic, ameliorate the condition of diabetic persons, whooping cough, bronchitis and tonsillitis	[94]
23.	<i>Centaurium pulchellum</i> (Swartz) druce	Gentianeae			Infusion of the herb is used for diabetes	Gastric and abdominal pain, diabetes, hypertension, renal colic, rheumatic pains etc...	[94]
24.	<i>Cleome droserifolia</i> (Forssk)Delile	Cleomaceae			5 gm of paste powder is topically used before meal for treatment	Hyperglycemia (diabetes), wounds and for dermatitis	[94]
25.	<i>Glinus lotoides</i>	Molluginaceae		Fruit	Not specified	Anti-diabetic	[95]
26.	<i>Stevia rebaudiana</i> Bertoni	Asteraceae		Leaf	Aqueous leaf extract	diabetes, hypertension, antimicrobial, anti obesity and antioxidant activities	[37]
27.	<i>Aloe camperi</i> Schweinfurth	Aloaceae	Sandai-ere (T)	fresh leaves, latex	Extract of the latex or leaf is used regularly	Skin burns, dandruff, stomach pain, hypertension, hair fall	[73,74]
28.	<i>Meriandra dianthera</i> (Roth) Briq.	Lamiaceae	Nehiba/Mezeguf (T)	fresh leaves	Extract of the leaf is taken 1 cup daily	Hypertension, diarrhea, diabetic gastritis, bronchial asthma, purgative, diarrhea,	[73,75]
29.	<i>Otostegia integrifolia</i> Benth.	Lamiaceae	Ch'endog (T)	Leaf	Extract of the leaves taken in the evening	Gynecological problems, inflammation, insecticidal, antioxidant, anti diabetic activity, etc...	[48,73]
30.	<i>Pentas schimperiana</i> Subsp.		Woina grefet	Leaves	decoctions of leaves	diabetes, epilepsy	[ 76]
31.	<i>Allium sativum</i>	Lilliceae	Shiguerti-tsada (T)	bulb	Fresh bulb is eaten raw or added in sauce The powdered bulb is dispersed in decocted root.	Asthma, antiseptic, diuretic, hypertension, expectorant	[73,87, 93,96,97]
32.	<i>Sesbania sesban</i> (L)	Papilionoideae,	girangire (A)	Seeds and leaves	Not specified	Anti-diabetic, antioxidant effect, antimicrobial activity, anti fertility agent, ethno veterinary use	[98]
33.	<i>Satureja punctata</i> Benth. Briq	Lamiaceae)	Lomishet (A)	leaves	leaves are cooked and the extract drank	treatment of liver diseases, hypertension, diabetes and other disorders	[99]
34.	<i>Datura stramonium</i> L.	Solonaceae	Asangra (O)	Root	The root is decocted overnight and mixed with rancid butter	Toothache, asthma, hypertension, diabetes mellitus	[97]
35.	<i>Lagenaria abyssinica</i> (hook.f.) C.Jeffrey	Cucurbitaceae	Buqe setena (O)	Flower	The powdered flower is dispersed in water	Diabetic Mellitus, rabies	[97]
36.	<i>Guizotia Schimperii</i>	Asteraceae	Adey Abeba (A)	Whole part	It is crushed with whole part of Cucumis ficifolius, boiled in the water and one glass is taken orally until recovery.	Diabetes	[100]
37.	<i>Indigofera spicata</i> Forssk.	Fabaceae	Reencii (O)	leaves	Leaves powdered and mixed in water and taken when need arises	Diabetes	[101]
38.	<i>Cineraria abyssinica</i>	Asteraceae)	'Esemefirh'(G)	Leaves,aerial parts	The aqueous decoction of the leaves and aerial parts	cancer, liver and kidney diseases, hypertension, diabetes	[102]
39.	<i>Myrts commuis</i>	Myrtaceae	Ades (A)	Leaves Fruit	Not specified	Anti-hyperglycemic	[103]
40.	<i>Allium Cepa</i>	Alliaceae	Qey-shnkurt (A)	bulb	Freshly cut bulb is often used	Hypoglycemic, anti-hyperglycemic activity in normal and STZ induced diabetic rats etc...	[73, 87]
41.	<i>Curcuma longa</i>	Zingiberaceae	Ird (A)		Not specified	Antihyperglycemic effect in STZ induced diabetic rats	[87]
42.	<i>Coriandrum- sativum</i>	Apiaceae	Dimbelal (A)		Not specified	Hypoglycemic effect in normal rats	[87]



43.	<i>Cuminum- cyminum</i>	Apiaceae	Ensilal (A)		Not specified	Antidiabetic influence in STZ induced Diabetic rats	[87]
44.	<i>Cymbopogon- thiopia Stapf</i>	Poaceae	Lomi sar (A)		Not specified	Hypoglycemic effect in normal rats	[87]
45.	<i>Linum- usitatissimum</i>	Linaceae	Telba (A)		Not specified	Antihyperglycemic effect in alloxan induced diabetic rats	[87]
46.	<i>Mangifera indica L.</i>	Anacardiaceae	Mangus (T)	leaf, stem bark	Decoction of leaf or stem bark is used regularly	Diuretic, diarrhea, dysentery, anemia, bronchitis, hypertension	[73,87, 104],
47.	<i>Nigella sativa L.</i>	Ranunculaceae	Abosoda (T) Tikur-Azmud (A)	Seed	Seeds added in bread or a spoon of powdered seeds taken orally before meal	Anti-hyperglycemic activity in diabetic rats, asthma, dysentery, hypertension, gastrointestinal problems	[73,87]
48.	<i>Trigonella foenum-graecum L.</i>	Fabaceae	Abe'ake (T) Abish (A)	Seed	Extract of the dried and powered seed is used regularly	Diuretic, antipyretic, stomachic, anemia, hypertension, diabetes gastrointestinal pains	[73,87]
49.	<i>Zingiber officinale Roscoe</i>	Zingiberaceae	Zingible (T)	Root	Tea of the rhizome frequently used	Digestive disorders, stimulant, bronchitis, throat infections, hypoglycemia	[73,87]
50.	<i>Solanum incanum L.</i>	Solanaceae	Uengule (T)	Fruit Root	Fruits boiled in hot water or mixed with yogurt or root is chewed and swallowed.	Expectorant, diabetes stomach ache, fever, snake bite, bronchitis.	[73,105]
51.	<i>Salvia lavandulifolia</i>	Lamiaceae			Not specified	Hypoglycemic activity	[106]
52.	<i>Salvia officinalis</i>	Lamiaceae			Not specified	Hypoglycemic activity	[106]
53.	<i>Salvia fruticosa Mill</i>	Lamiaceae			Not specified	Hypoglycemic activity	[106]
54.	<i>Salvia splenden</i>	Lamiaceae			Not specified	Hypoglycemic activity	[106]
55.	<i>Salvia tillifolia</i>	Lamiaceae		Aerial part	Methanolic extract of aerial part	Hypoglycemic activity, headache, stomach trouble and as memory enhancing herb	[106]
56.	<i>Ricinus communis</i>	Euphorbiaceae	Gulo (A)	Roots	Not specified	anti-diabetic	[81]
57.	<i>Securidaca longepedunculata Fresen</i>	Polygalaceae)		root bark	Malaria, rheumatism, gonorrhoea, palpitations, pneumonia, syphilis, asthma	diabetes, inflammation, insanity and epilepsy, wounds, cough, venereal diseases, snake bite etc	[107,108]
58.	<i>Balanites rotundifolia</i>	Balanitaceae	Alayto (Sm)	Leaves	Soaking crushed fresh leaves in water and the water is taken orally	Laxative, fevers , diabetes	[109]
59.	<i>Buxus hildebrandtii Baill.</i>	Buxaceae	Gaydarto	Leaves	Soaking crushed fresh leaves in water and the water is taken orally	Diabetes, infections, parasites	[109]
60.	<i>Lavandula coronopifolia L.</i>	Lamiaceae	Dananwada (Sm)	Plant parts without leaves	Soaking crushed plants without the leaves in water and the water is taken orally	Diabetes, sun burns, Kidney problems ,side ache problems	[109]
61.	<i>Melia azedarach L.</i>	Meliaceae	Dat caxa (Sm)	Whole plant	Soaking crushed whole plant in water and the water is taken orally	Diabetes, Wound infections	[109]
62.	<i>Nepeta azurea R.Br. Ex Benth.</i>	Lamiaceae	Simitri (Sm)	Leaves	Soaking crushed leaves in boiled water and the water is taken orally	Diabetes ,kidney diseases, asthma	[109]
63.	<i>Tarchonanthus thiopias L.</i>	Asteraceae	Galgaddo (Sm)		Soaking crushed leaves in water for 1 h and the water is taken orally	Diabetes, Bladder inflammations	[109]
64.	<i>Cinnamomumverum</i>	Lauraceae			Not specified	Diabetes	[110]
65.	<i>Azadirachta indica A. Juss.</i>	Meliaceae	Neem (T)	leaf, stem bark	Leaf or bark decoction used for drinking	Insect repellent, malaria, skin diseases, anthelmintic, diuretic	[73,110]
66.	<i>Aloe megalacantha</i>	Asphodeloideae			Not specified	Diabetes	[110]
67.	<i>Justicia Schimperiana</i>	Acantaceae		Leaves	Not specified	Diabetes	[54]
68.	<i>Lysimachia ruhmeriana vatke</i>	primulaceae			Not specified	Diabetes, haemorrhoids	[43]
69.	<i>Thymus serrulatus Hochst ex Benth.</i>	Labiatae			Not specified	Diabetes, hypertension, rheumatism, menorrhagia, amenorrhoea	[43]

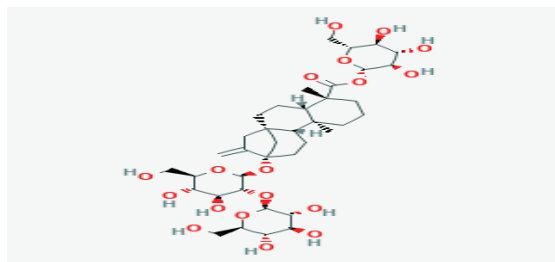
70.	<i>Verbascum sinaiticum Benth.</i>	Scrophulariaceae			Not specified	Diabetes, scabies, colic, anti-emetic, amoebiasis, diarrhoea, epilepsy, aphrodisiac, infertility	[43]
71.	<i>Verbena officinalis L</i>	Verbenaceae			Not specified	Anti-emetic, malaria, diabetes, burns, respiratory diseases	[43]
72.	<i>Rubus steudneri</i>	Rubiaceae	Enjori (A)	Leaf	Not specified	Liver disorders , diabetes, cough, gum pain, anti-oxidant	[43]
73.	<i>Arachis hypogeal l.</i>	Leguminaseae		flower	In prepared foodstuffs such as biscuits and sweetmeats	Diabetes	[43]
74.	<i>Coffea Arabica L.</i>	Rubiaceae	Buna [A]	Green seed	Not specified	Blood glucose level decreased in mice after oral administration of the substance	[43]
75.	<i>Cucurma domestic valeton</i>	zingibraceae		Rhizome	Not specified	Reduces or helps to control blood sugar	[43]
76.	<i>morus spp</i>	Moraceae			Not specified	Shows anti-hyperglycemic activity in vivo.	[43]
77.	<i>Ammi visnaga (L.) Lam.</i>	Apiacea	E'bna (T)	leaf	Leaf extract is used in the morning	Diabetes ,diuretic, hypotensive, hair-care, antispasmodic, asthma	[73]
78.	<i>Anethum graveolens Linn</i>	Apiacea	Shilan-maedo (T)	leaf	Tea of the leaves is taken twice daily	Diabetes, diarrhea, eye problems, indigestion, stomachache	[73]
79.	<i>Balanites aegyptica (L.) Del.</i>	Balanitaceae	Mekie (T)	leaf, fruit	Leaf extract or ripe fruit is taken	Purgative, insecticidal, laxative, stomach aches	[73]
80.	<i>Brassica nigra Koch.</i>	Brassicaceae	Adri (T)	Seed	Seed decoction is used regularly	Gastrointestinal disorder, stimulant, diuretic, bronchitis	[73]
81.	<i>Calotropis procera (Ait.)</i>	Asclepiadaceae	Ghinde'a (T)	stem bark, latex	Crushed bark or latex are mixed with butter	Skin diseases, anthelmintic, expectorant, wounds, diarrhea	[73]
82.	<i>Capparis thiopia (Forssk.)</i>	Caparidiacea	Sorob[T]	stem bark, leaf	Infusion of stem bark or leaf is used	Tooth ache, cough, arthritis, anthelmintic, malaria, inflammation	[73]
83.	<i>Carica papaya L.</i>	Caricaceae	Papaya (T)	leaf, seed	Decoction of seed or leaf is drunk 1 beaker in the morning	Amoebicide, hypertension, constipation, expel worms, laxative, Hypoglycemic and Antihyperglycemic effects	[73,87]
84.	<i>Carissa edulis (Forssk)</i>	Apocynaceae	Agam (T)	stem bark	Extract of stem bark is drunk regularly	Anthelmintic, inflammation, hypotensive, diuretics, headache	[73]
85.	<i>Cichorium endivia L.</i>	Asteraceae	Shikorja (T)	Leaf	Cooked properly and eaten with enjera	Appetizer, febrifuge, anti-allergic	[73]
86.	<i>Clerodendrum myricoides (Hochst)</i>	Lamiaceae	Sur-betri / Ugandense (T)	stem bark, leaf	Leaf or stem bark extract is drunk regularly	Abdominal pains, snake bites, hemorrhoids, eye disease	[73]
87.	<i>Clutia lanceolata (Forssk)</i>	Euphorbiaceae	Tish-belalito (T) /	Leaf	Leaf extract is taken twice a day	Malaria, diarrhea, colds, gynecological problems	[73]
88.	<i>Daucus carota L.</i>	Apiacea	Caroti (T)	tuber	Tuber is eaten in raw or with salad	Diuretic, inflammation, leprosy, worms troubles	[73]
89.	<i>Entada abyssinica Steud. Ex A.</i>	Fabaceae	Halke (T)	stem bark, leaf	Decoction of the stem bark or leaf	Gastrointestinal problems, cold, candidiasis	[73]
90.	<i>Eucalptus thiopia (Labill.)</i>	Myrtaceae	Tsaeda-kelamintos(T)	Leaf	Leaf extract is taken 1 cup per day	Insect repellent, tuberculosis, bronchitis, malaria, skin diseases	[73]
91.	<i>Ferula communis L.</i>	Apiacea	Diog (T)	seed, leaf	Decoction of fresh leaf or dried seed	Antispasmodic, diarrhea, expectorant ,dermatitis	[73]
92.	<i>Gymnema sylvestre Roxb.</i>	Asclepiadaceae	Shankuk (T)	Leaf	Leaf extract is taken	daily Cough, inflammations, constipation, haemorrhoids, bronchitis	[73]
93.	<i>Kigelia thiopia (Lam.) Benth.</i>	Bignoniaceae	Mederba/Zelzale (T)	Fruit	Fruits are eaten	Constipation, tapeworm, dysentery, gynecological disorders	[73]

94.	<i>Lepidium sativum L.</i>	Brassicaceae	Shinfae (T)	Seed	The seed extract is taken before bed	Diuretic, cough, laxative, asthma, diarrhea, malaria, hypoglycemic effects	[43,73]
95.	<i>Moringa oleifera Lam.</i>	Moringaceae	Moringa (T) /	Leaf	Fresh leaf juice taken every morning in empty stomach	Asthma, constipation, skin diseases, diarrhea, stomach pain, hypertension	[73]
96.	<i>Plumbago zeylanica L.</i>	Plumbaginaceae	Aftooh (T)	root, stem	Decoction of stem or roots used trice a day	Stimulant, abortifacient, inflammation, bronchitis, itching	[73]
97.	<i>Psiada paniculata (DC.) Vatke -</i>	Asteraceae	Tshehaiferhet (T)	leaf, root	Decoction of the leaves or roots is used	Cough, anti-abortion, asthma	[73]
98.	<i>Rosmarinus officianilis L.</i>	Lamiaceae	Azmarino (T) y	Leaf, stem	A spoon of leaf or stem is added in daily food	Stomach pains, gynecological problems, bad breath, migraine	[73]
99.	<i>Steganotaenia araliacea Hochst.</i>	Apiaceae	Mewets denagl (T)	leaf, seed	Decoction of either leaf or seed mixed with milk is taken in the morning	Sore-throat, ulcer, diuretic, stomachache, dysentery, hypotensive	[73]
100.	<i>Tamarindus indica L. t</i>	Fabaceae	Humer (T)	fruit	Extract of the fruit is taken twice a day	Malaria, fever, stomach ache, wounds, purgative	[73]
101.	<i>Terminalia thiopi Fresen</i>	Combretaceae	weiba (T)	stem bark, leaf	Decoction of the stem bark or leaf	Wounds, malaria, dermatitis, tuberculosis	[73]
102.	<i>Trachyspermum ammi (L.)</i>	Apiaceae	Kamun/Tsakida (T)	Seed	Seed powder is soaked in water or milk	Hypertension, diarrhea, asthma, anti-helminthic, diuretic	[73]
103.	<i>Vernonia amygdalina Del.</i>	Asteraceae	Grawa (T)	leaf, stem bark	The extract of fresh leaves in water is used	Stomach ache, skin infections, tooth ache, cough, malaria,	[73]
104.	<i>Withania somnifera (L.)</i>	Solanaceae	Agol (T)	root, leaf	Roots are immersed in hot water and the juice of the leaves	Diabetes, constipation, skin infection, rheumatism	[73]
105.	<i>Zizyphus spina-christi (L.)</i>	Rhamnaceae	Gaba (T)	Leaf	Infusion of the leaves used regularly	Diarrhea, dandruff, skin infections, bronchitis, malaria	[73]

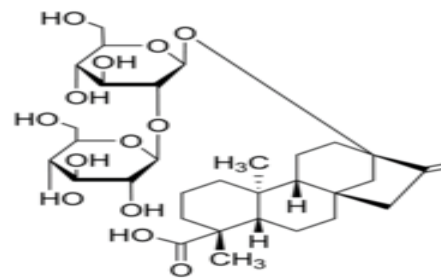
[A]= Amharic, [O] = Affan Oromo, [T]= Tigrigna, [Sm]= Somaligna, [Sd]= Sidamigna

**Table 2.** List of medicinal plants in terms of citation

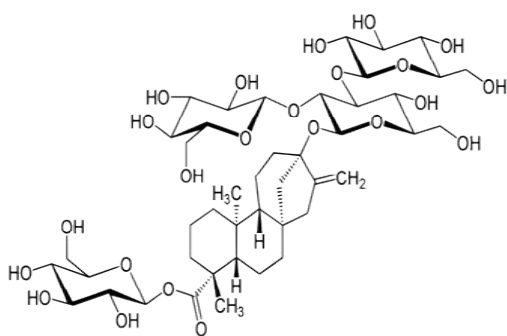
Plant name	N	%
<i>Moringastenopetaa</i>	6	5.7
<i>Allium sativum</i>	5	4.8
<i>Caylusea- abyssinica</i>	4	4.8
<i>Ajugaintegrifolia.</i>	4	4.8
<i>Psidiumguajava</i>	3	2.8
<i>Calpurnia aurea</i>	3	2.8
<i>Thymus schimperi</i>	2	1.9
<i>Acacia nilotica L.</i>	2	1.9
<i>Allium Cepa</i>	2	1.9
<i>Asparagus africanus</i>	2	1.9
<i>Azadirachtaindica</i>	2	1.9
<i>Carica papaya</i>	2	1.9
<i>Croton macrostachys</i>	2	1.9
<i>Glinuslotoides</i>	2	1.9
<i>LepidiumsativumL.</i>	2	1.9
<i>Mangiferaindica</i>	2	1.9
<i>Meriandradianthera</i>	2	1.9
<i>Nigella sativa</i>	2	1.9
<i>OstegiaintegrifoliaBenth</i>	2	1.9
<i>Podocarpusgeacilior</i>	2	1.9
<i>Securidacalolongepedunculata</i>	2	1.9
<i>Solanumincanum</i>	2	1.9
<i>Trigonella-foenumgraceum</i>	2	1.9
<i>Zingiber-officinale</i>	2	1.9
<i>Aloe camperi</i>	2	1.9
Rest	1	0.9
Total		105



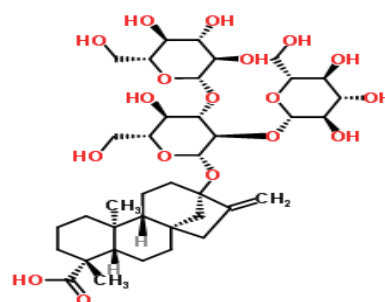
Stevioside



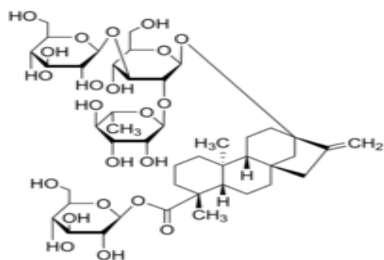
Steviolbioside



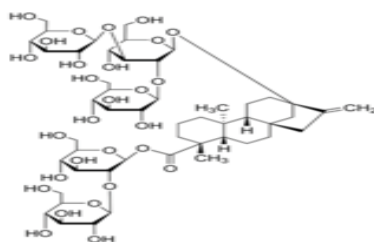
Rebaudioside A



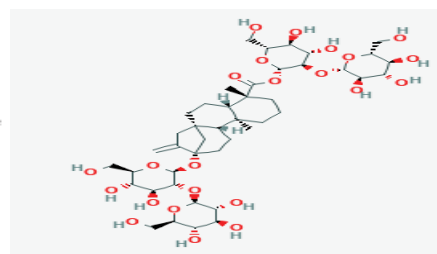
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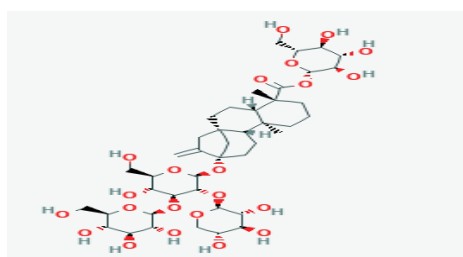
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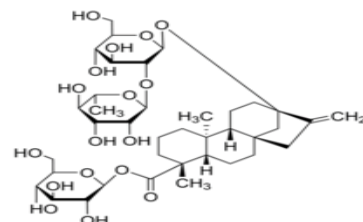
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Rebaudioside E

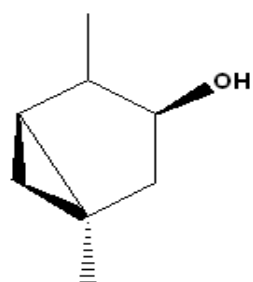
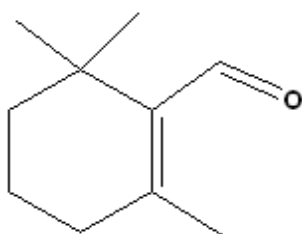
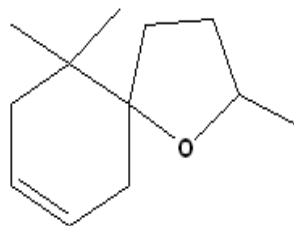


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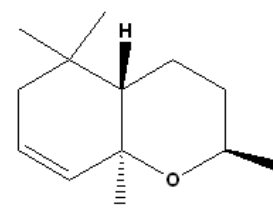


Ducloside A

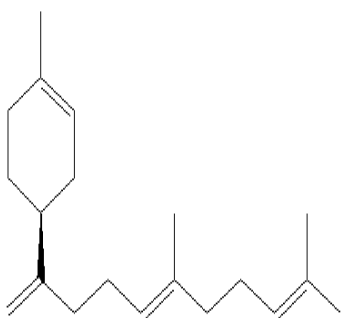
Figure 1. Structures of diterpene glycosides

*Trans*-Sabinol $\beta$ -cyclocitral

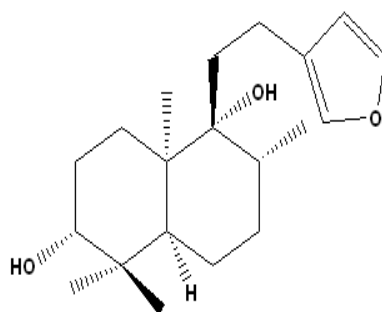
Dihydroedulan



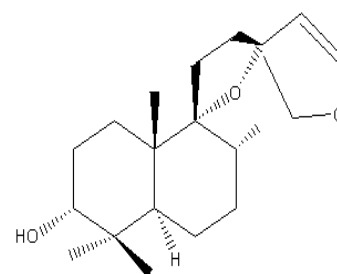
Theaspirane



(+) -axinysene

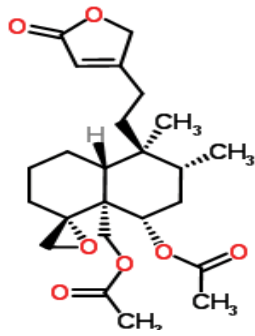


otostegindiol

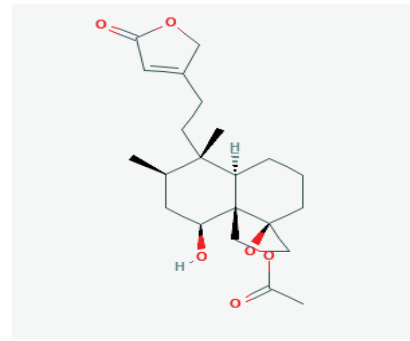


Preotostegindiol

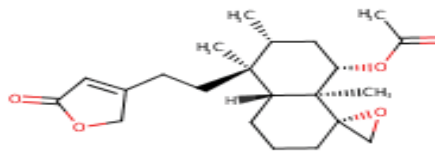
**Figure 2.** Compounds isolated from *Otostegia integrifolia*



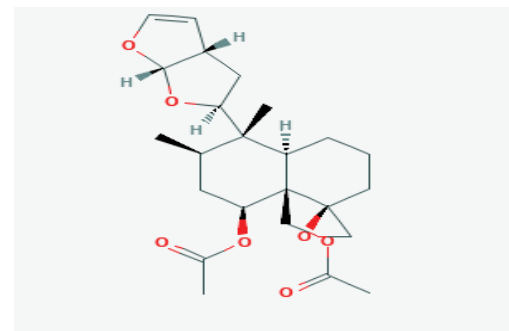
Ajugarin I



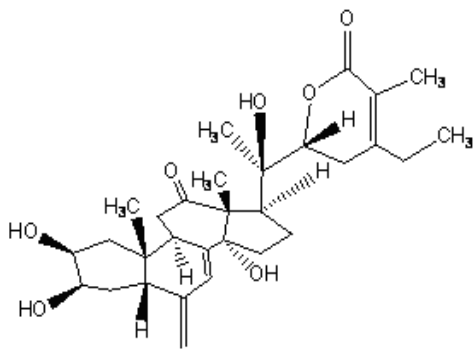
Ajugarin II



Ajugarin V

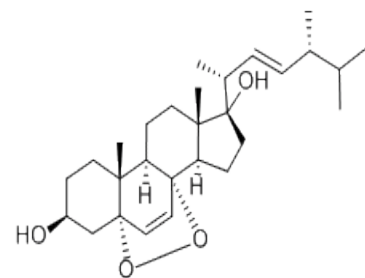


clerodin



16

Ajugalactone

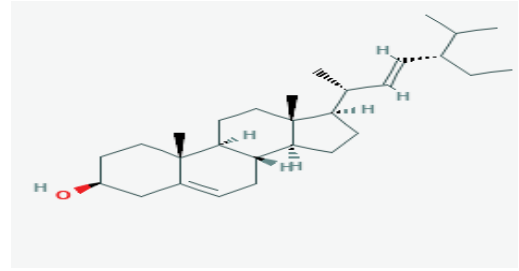


Ergosterol-5, 8-endoperoxide

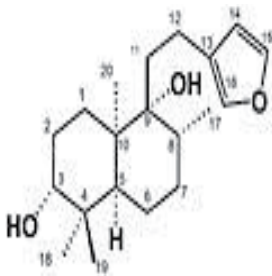
**Figure 3.** Compounds isolated from *Ajuga remota* Benth



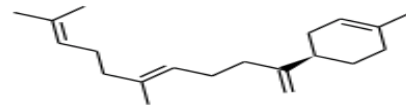
Pentatriacontane



Stigmasterol

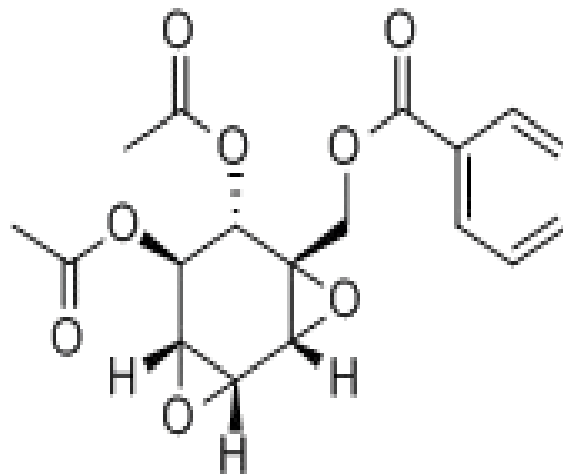


Otostegindiol



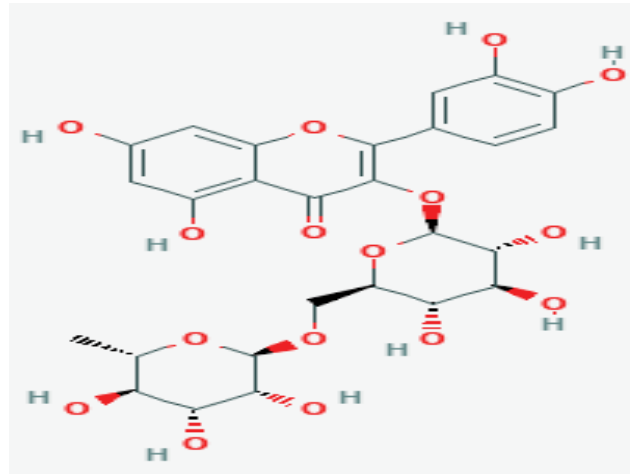
(+)-axinyssene

Figure 4. Some isolated compounds of *Otostegia integrifolia* Benth

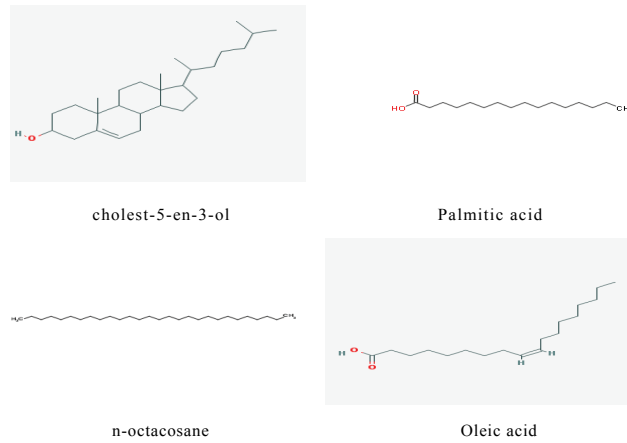


Crotepoixide

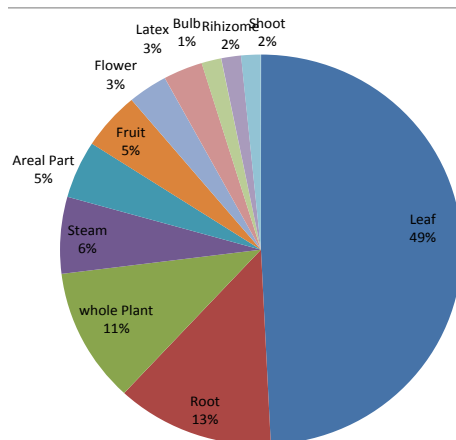
Figure 5. Some isolated compounds of *Croton macrostachys*



**Figure 6.** Chemical structure of Rutin



**Figure 7.** Some of the isolated compounds of *Moringa stenopetala*



**Figure 8.** Medicinal plant parts used for the management of diabetics in Ethiopia