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Review Article

Phytotherapies for diabetes

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Abstract

Plant medicines (phytotherapies) have a long history as treatments for diabetes. With a disturbing rise in the prevalence of this metabolic disease and associated healthcare costs, interest in alternative or complementary therapies has grown. Over the last 10-20 years, data from controlled investigations in animal models and patients have validated the therapeutic value of numerous phytotherapies for diabetes. Phytotherapies and their combinations demonstrate multiple beneficial antidiabetic mechanisms, including modulation of carbohydrate metabolism, restoration of β-cell integrity and function, insulin-releasing activity, improvements in glucose uptake/utilization, antioxidant properties and a reduction in the risk of cardiovascular disease. However, there is also a misconception that natural remedies are entirely safe. This article summarizes several of the most extensively studied phytotherapies for diabetes and its complications, indicating important associated adverse effects that should be considered when using natural therapies. More than 170 antidiabetic constitutents isolated from over 170 plants are presented.

Introduction

Diabetes mellitus is a complex metabolic disorder characterized by a decrease in or cessation of insulin secretion in response to physiological stimuli, or reduced responsiveness of peripheral tissues to insulin. Type 1 diabetes, or insulin-dependent diabetes, is characterized by selective, immune-mediated destruction of over 90% of insulin-secreting pancreatic β-cells. This autoimmune response means that type 1 diabetic patients are dependent on insulin injections to control blood sugar. Type 2 diabetes, or non-insulin-dependent diabetes, causes hyperglycemia as a result of impaired insulin secretion in response to glucose and decreased insulin effectiveness (insulin resistance). Type 2 diabetes is far more common and accounts for 90-95% of all cases (1). However, the treatment of type 2 diabetes is complicated by several factors inherent to the disease process, such as insulin resistance, hyperinsulinemia, impaired insulin secretion and reduced insulin-mediated glucose uptake and utilization (2). While some cases of type 2 diabetes can be controlled by weight loss and diet alone, in some instances the use of insulin or oral hypoglycemic drugs, such as sulfonylureas and biguanidines, is necessary to help normalize blood glucose. If untreated, diabetes can lead to severe complications, including atherosclerosis, retinopathy and neuropathy, as well as ulceration and gangrene of the extremities. Recent figures from the Centers for Disease Control and Prevention (CDC) indicate that the prevalence of diabetes in the U.S. during 2005 was 20.8 million (7% of the population; 14.6 million diagnosed and 6.2 million undiagnosed), with total estimated costs for 2002 arriving at an alarming USD 132 billion (3). Diabetes shows no signs of abating, with an aging population, unhealthy diet, obesity and sedentary lifestyles (4), and the WHO predicts that by the year 2025 the prevalence of this metabolic syndrome will be nearly 300 million.

Before the advent of insulin, diabetes was treated with plant medicines (phytotherapies). More than 1,200 species have been reported for the treatment of this metabolic disorder (5), although only a relatively small proportion of them have been subjected to scientific and medical evaluation, predominantly in type 2 diabetes. With regard to patient appeal, recent U.S. national sur-

veys have reported that the frequency of use of complementary and alterative phytotherapies among diabetic patients varies from 33% for the general population to 49% for the Hispanic population in South Texas (6). In the last 10-20 years, several studies have presented data on numerous phytotherapies that appear to be effective as glucose-lowering agents, with no or very few associated adverse effects (7). Phytotherapies demonstrate multiple beneficial antidiabetic mechanisms, including modulation of carbohydrate metabolism, restoration of the integrity and function of β-cells, insulin-releasing activity, improvements in glucose uptake/utilization, antioxidant properties and a reduced risk of cardiovascular disease. The following is a summary of several of the most extensively studied and commonly used phytotherapies for diabetes.

Allium spp.

Both *Allium cepa* (onion) and *Allium sativum* (garlic) have demonstrated glucose-lowering properties (8) that are thought to be due to the action of their sulfur-containing compounds allylpropyl disulfide (APDS) (9) and disulfide oxide (allicin) (10), respectively. However, flavonoids may also play an additional role in the observed effect (7). Experimental and clinical studies suggest that APDS lowers glucose levels by competing with insulin for insulin-inactivating sites in the liver, resulting in an increase in free insulin. Mechanisms of action include increased secretion or slowed degradation of insulin, increased glutathione peroxidase action and improved liver glycogen storage (11). Clinical evidence has also demonstrated the antioxidant properties and beneficial cardiovascular effects (*i.e.*, cholesterol- and blood pressure-lowering action) of these compounds (12).

Aloe vera

Aloe vera, a plant resembling the cactus, is widely used for the treatment of burns and wounds. However, aloe dried sap and aloe gel are also well-known remedies for diabetes in the Arabian Peninsula. Aloe gel (obtained from the inner portion of the leaves) contains glucomannan, a hydrosoluble fiber that may help to reduce sugar (13) and triglyceride levels (14).

Ginseng

Ginseng root, possibly the most widely reported among the phytotherapies, has been used for over 2,000 years (15). *Panax ginseng* (Asian ginseng) and *Panax quinquefolius* (American ginseng) are the most popular species, although chemical composition and potency may vary depending on the age of the root, the location grown, the season of harvesting and the method of drying. The principal components responsible for the hypoglycemic activity are the triterpenoid saponin glycosides, commonly referred to as ginsenosides or panaxosides. They reportedly act by modulating portal hepatic circulation by increasing glucose transport and uptake mediated by nitric oxide, and increasing glycogen storage and modulation of insulin secretion (11). Ginseng is reported to reduce the dose of insulin needed by patients, prolong the action of a dose of insulin and improve psychophysiological performance and physical activity, elevating mood and reducing body weight (16).

Gymnema sylvestre (Gurmar)

This woody climber, which is native to the tropical forests of India, is commonly used in East Indian healing systems (Ayurveda) as a treatment for diabetes. It has also appeared on the U.S. market as a “sugar blocker”. *Gymnema* extract has been shown to positively control both type 1 and 2 diabetes (7). It has been postulated that its active constituent, gymnemic acid, enhances the production of endogenous insulin, and both animal and human studies (17, 18) appear to support the possibility of pancreatic regeneration (7, 19).

Momordica charantia

Momordica charantia, also known as bitter melon, balsam pear or karela, is a tropical fruit grown in Asia, Africa and South America. It is the most popular plant used worldwide for diabetes (20). Daily dietary karela supplements have been shown to improve glucose tolerance (21), and several of its active constituents, such as charantin, vicine and polypeptide-P, demonstrate antidiabetic properties. Charantin, which is composed of mixed steroids, has been reported to have stronger hypoglycemic properties than the orally administered hypoglycemic agent tolbutamide (22). Insulin-like polypeptide-P, or plant insulin, with a similar effect to bovine insulin, has been shown to decrease blood sugar levels after subcutaneous injections in type 1 diabetic patients (15). The proposed mechanisms of action include increased insulin secretion, tissue glucose uptake, liver glycogen synthesis and glucose oxidation, and decreased hepatic gluconeogenesis (11).

Cinnamon

Cinnamon is a spice derived the dried bark of a tropical evergreen busy tree. *In vitro* studies have indicated cinnamon-mediated improvement in insulin secretion (23, 24). A clinical study in type 2 diabetic patients also revealed that after 40 days of daily cinnamon supplements, mean fasting serum glucose, triglyceride, LDL cholesterol and total cholesterol levels were significantly reduced (25).

Opuntia spp.

Opuntia spp. is known as nopal in Mexico or prickly pear cactus in the United States and produces both a vegetable called nopal and a fruit called tuna (20). Nopal is a common food source in Mexico. The proposed

mechanism of hypoglycemic action is partly due to the plant's highly soluble fiber and pectin content, which may affect intestinal glucose uptake. Furthermore, in addition to its positive effects on glucose control, both animal and human studies have demonstrated a significant *Opuntia*-associated reduction in total cholesterol levels (26-29).

Trigonella foenum-graecum (fenugreek)

Fenugreek, a widely grown legume, is a common condiment in Indian cooking. It has been used as an appetite stimulant and to treat diabetes, migraines, allergies, elevated cholesterol and constipation (15, 20). The active constituents in fenugreek seeds are the alkaloid trigonelline, which has a hypoglycemic effect, and the amino acid 4-hydroxyisoleucine (ID-1101), which increases glucose-induced insulin release (20). In addition, fenugreek seeds contain over 50% fiber, which may indicate another potential mechanism for its beneficial effects in diabetes, as described below. Significant reductions in total cholesterol and triglycerides have also been documented with the use of fenugreek (30, 31).

Pterocarpus marsupium

Commonly used in India for the treatment of diabetes, *Pterocarpus marsupium* contains epicatechin (extracted from the bark of the plant), which has been shown to prevent pancreatic β-cell damage (7, 15, 32). In addition, both epicatechin and the crude alcohol extract from the plant have been shown to regenerate functional β-cells in diabetic animals (33). The different forms of catechin and epicatechin constitute a group of flavanones that are very strong antioxidants, particularly against hydroxyl radical-induced lipoperoxidation, characteristic of diabetes induced by alloxan and many hepatotoxins.

Silybum marianum

Silybum marianum, also known as milk thistle, is a member of the aster family. It has been studied primarily for its effect in alcoholic and viral hepatitis (11). Silymarin, an extract from the fruit of *S. marianum*, is rich in flavonoids, which are potent antioxidants, and has been shown to induce recovery of pancreatic function after alloxan-induced pancreatic damage in rats (34). Therefore, *S. marianum* might have a beneficial effect in patients with insulin resistance secondary to hepatic damage.

Vaccinium myrtillus (bilberry)

The leaves of bilberry, a shrubby plant grown in Europe, have been widely used as treatments for diabetes. The anthocyanoside myrtillin is probably the most active constituent (15). Extracts from the berries provide a long-term hypoglycemic effect (35). Furthermore, anthocyanosides derived from this plant have affinity for blood vessels of the eye and retina and show beneficial effects in diabetic retinopathy, macular degeneration, cataracts, retinitis pigmentosa and nightblindness (7, 36).

Catharanthus roseus

Also known as Madagascar periwinkle, or *Vinca rosea*, this plant, originally native to the island of Madagascar, has been used as a folk remedy for diabetes in Europe for centuries. *C. roseus* contains an abundant source of useful alkaloids, some of which, including catharanthine, leurosine sulfate, lochnerine, tetrahydroalstonine, vindoline and vindolinine, lower blood sugar levels, thus relieving the symptoms of diabetes. Evaluation of these antidiabetic effects has been carried out in animal models of the metabolic syndrome using leaf juice and an aqueous extract (37-39). All studies indicated the added advantage of control over lipid levels and enhanced antioxidant potential (39).

Galega officinalis

This plant, also known as goat's rue or French lilac, has been known for centuries to have natural benefits for diabetics, but its toxicity has prevented medicinal use (40). Guanidine, a chemical that is very similar to the active ingredient in goat's rue, galegin, was the inspiration for many conventional diabetic drugs, such as metformin hydrochloride. Metformin acts at multiple sites to increase tissue sensitivity to insulin (41) and targets the enzyme dipeptidyl-peptidase IV (DPP-IV), which cleaves and terminates the glucose-lowering effect of glucagon-like peptide-1 (GLP-1) (42). Metformin is now widely accepted as a safe oral treatment for type 2 diabetes, as monotherapy or in combination with insulin secretagogues and thiazolidinediones, and it can be of particular value for obese patients (for review, see 43).

Cyamopsis tetragonoloba

This vegetable, commonly consumed in southern India, is 20% guar gum, a soluble dietary fiber that has been suggested to be useful for the treatment of diabetes. High fiber intake can reduce and slow sugar absorption, and bulking agents are popular natural treatments for diabetes (44, 45). Both preclinical and clinical studies have demonstrated the hypoglycemic and hypolipidemic effects of guar gum (46-48). Furthermore, the cereal fiber *Hordeum disticum* (barley) and products containing high barley content have also been shown to reduce blood sugar and lipids and enhance insulin responses in animals and patients (49-52). The high chromium content of barley has also been postulated to play a role in the effects on these symptoms of diabetes (53). *Cichorium intybus* (chicory), a perennial plant, has also been shown to be beneficial for diabetic patients because of its high fiber content. Dietary insulin-type fructans extracted from chicory root promote the secretion of GLP-1 and its precursor proglucagon mRNA (54).

Multiple herb combinations and Chinese medicine

Chinese medical treatment of diabetes appears to date back to around 100 B.C. and includes herbal prescriptions, acupuncture and dietary recommendations. Combinations of herbs for the treatment of diabetes are widely used in traditional Chinese, Native American and Tibetan medicine (11, 15, 55). In modern China and Japan, there are now approximately 200 standard prescriptions reported to be suitable for treating diabetes. The majority of these may be viewed as combinations that rely primarily on about two dozen antidiabetic ingredients plus a small number of auxiliary herbs. The main traditional prescriptions include Rehmannia Eight Formula and its simplified version Rehmannia Six Formula, Ginseng and Gypsum Combination, and Ophiopogon and Trichosanthes Combination (56).

Other plants with hypoglycemic activity include *Acacia arabica, Artemisia herba-alba, Artocarpus heterophyllus, Atriplex halimu, Bauhinia forficata, Cleome drosifolia, Coccinia indica, Eugenia jambolana, Ficus bengalensis, Ficus carica, Ginkgo biloba, Glassostemon bruguieri, Lagerstroemia speciosa, Lythirum salicaria, Myrcia uniflora, Ocimum sanctum, Phaseolus vulgaris, Swertia chirayita, Swertia japonica, Tecoma stans, Teucrium polium* and *Vaccinium myrtillus* (11, 15, 57). In addition to the treatment of hyperglycemia, several natural products are used as complementary treatments for different diabetic complications. For example, evening primrose oil, extracted from the seeds of *Oenothera biennis*, as well as capsaicin, an ingredient in chilli pepper, have both received attention for their use in diabetic neuropathy (58-60). Potent inhibition of aldose reductase, the key enzyme of the polyol pathway, by tannoids of *Emblica officinalis* (amla) has been demonstrated to modulate the etiopathology of diabetic complications such as neuropathy, cataracts, nephropathy and retinopathy (61).

Adverse effects

Natural therapies are often misconceived to be entirely safe. However, ample evidence has been reported detailing the adverse effects of alternative remedies. For example, *M. charantia* can induce hypoglycemic coma and convulsions in children, reduced fertility in mice, a favism-like syndrome, increases in γ-glutamyltransferase and alkaline phosphatase levels in animals, and headache (62). Furthermore, *C. roseus* is better known for its cytotoxic anticancer alkaloids vinblastine and vincristine (63), and is therefore often associated with detrimental effects.

Alternative remedies can also negatively interact with conventional medicines (for reviews, see 64 and 65). Perhaps the most frequently reported example is that of ginseng, which has been shown to significantly and dangerously decrease the anticoagulant effects of warfarin (66). The limited anticoagulant properties of garlic or trigonella can also be contraindicated when co-administered with warfarin (67, 68).

Nowadays, more and more patients are seeking alternative or complementary therapies to manage their diabetes. Although studies demonstrate that several of these natural remedies have potential for diabetes, there is insufficient evidence to actively recommend or discourage use. Product standardization and well-designed, rigorous clinical validation of safety, efficacy and the therapeutic risk/benefit ratio associated with the use of phytotherapies are essential. Several products derived from natural sources and targeted for diabetes are described in more detail below.

Caiapo (*Ipomoea batatas*) is a white sweet potato native to the Brazilian Amazon that is traditionally eaten raw as a treatment for anemia, high blood pressure and diabetes. In patients with type 2 diabetes, it has demonstrated long-term beneficial effects on plasma glucose, body weight, glycated hemoglobin and cholesterol levels (69, 70) by decreasing insulin resistance (69, 71). Caiapo is currently under phase II investigation at Fuji Sangyo and at the Universitaet Wien.

Preclinical studies have shown that LL-2113AD (GluDibit), an herbal adjuvant developed from dry extracts of five botanicals (*Gymnema sylvestre, Pterocarpus marsupium, Enicostemma littorale, Azadirachta indica* and *Salacia chinensis*), induces hypoglycemic effects in rats with streptozotocin-induced diabetes. A recent clinical trial evaluated the therapeutic benefits of add-on therapy with an oral formulation of LL-2113AD in adult patients with type 2 diabetes and uncontrolled hyperglycemia despite receiving oral hypoglycemic drugs for more than 6 months. After 4 weeks of LL-2113AD therapy, the average fasting and postprandial plasma glucose levels decreased by 49.3% and 42.7%, respectively. LL-2113AD was also well tolerated and no serious adverse events or side effects were reported (72). LL-2113AD is available from Lupin.

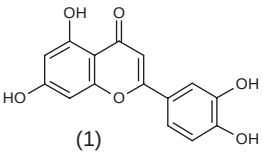
ID-1101 (4-hydroxyisoleucine), an amino acid extracted from fenugreek seeds, has demonstrated insulinotropic effects in the rat and improvements in insulin sensitivity (73). Innodia has reported the completion of a phase Ia trial that indicated that ID-1101 given orally as escalating single doses was well tolerated, with an excellent safety profile and dose-proportional pharmacokinetics. Regulatory approval from Health Canada was recently granted to Innodia to commence a multiple-dose phase Ib trial with ID-1101 (74).

At present, a natural substitute for insulin seems unlikely, although traditional phytotherapies may provide valuable clues for the development of new oral hypoglycemic agents and simple dietary adjuncts. Antidiabetic products originating from natural sources are indexed in Tables I and II.

Table I: Chemical structures of active antidiabetic constituents from plants (from Prous Science Integrity®).

Flavonoids

1. Luteolin	*Brassica oleracea var. italica*
	Lactuca indica
	Cynara scolymus L.
2. Centaureidin	*Brickellia veronicifolia*
	Tanacetum parthenium
3. Fisetin	*Toxicodendron vernicifluum*
4. Silibinin	*Silybum marianum*
5. Myricetin	*Morella rubra*
	Camellia sinensis
6. Tectorigenin	*Belamcanda chinensis*
	Pueraria montana
7. Myrciacetin	*Myrcia multiflora* DC
8. Glycyrin	*Glycyrrhiza uralensis*
9. Epicatechin	*Pterocarpus marsupium* Roxb.
	Camellia sinensis
	Waltheria indica
10. Ellagic acid	*Vitis vinifera* L.
	Phyllanthus urinaria
11. Quercetin	*Hypericum perforatum*
	Ficus racemosa L.
	Oryza sativa L.
	Euphorbia lunulata
	Waltheria indica
	Phellodendron japonicum
	Opuntia ficus-indica
12. Quercetin-3-*O*-methyl ether	*Opuntia ficus-indica*
	Cistus laurifolius
13. 2-(2,3,6-Trihydroxy-4-carboxyphenyl)ellagic acid	*Caesalpinia ferrea*
14. Capillarisin	*Artemisia capillaris*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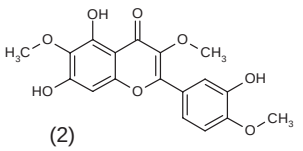
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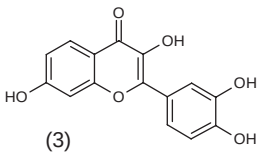
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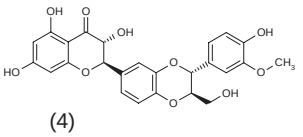
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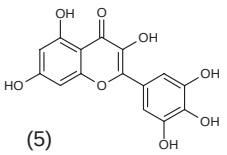
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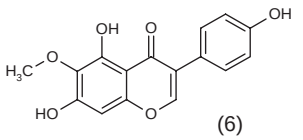
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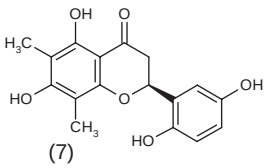
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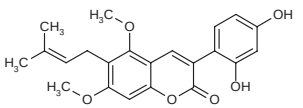
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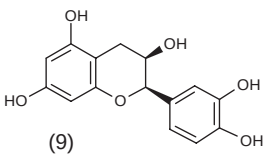
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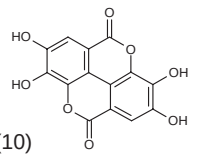
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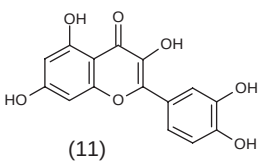
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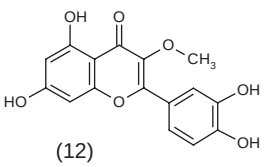
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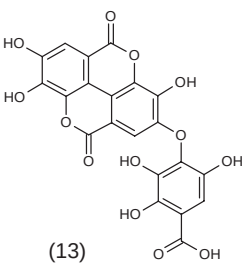
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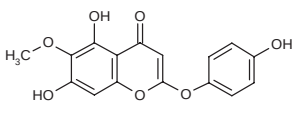
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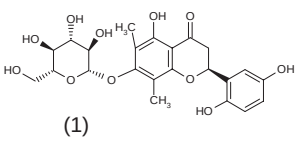
Glycoside-Flavanoids

1. Myrciacitrin I	*Myrcia multiflora* DC
2. Myrciacitrin II	*Myrcia multiflora* DC
3. Puerarin	*Pueraria montana*
4. Cynaroside	*Angelica keiskei koizumi*
	Carthamus tinctorius
	Cynara scolymus L.
	Firmiana simplex
	Lactuca indica
	Olea europaea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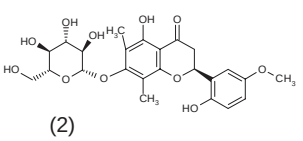
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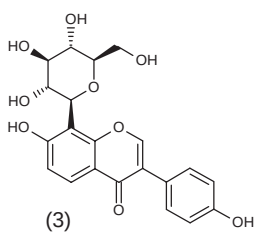
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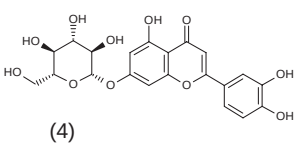
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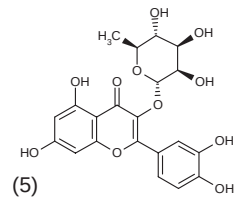
Table I: Chemical structures of active antidiabetic constituents from plants (from Prous Science Integrity®).

Glycoside-Flavanoids

5. Quercitrin	*Hypericum perforatum*
	Myrcia multiflora DC
6. Guaijaverin	*Myrcia multiflora* DC
7. Myricitrin	*Myrcia multiflora* DC
	Morella rubra
8. Mearncitrin	*Myrcia multiflora* DC
9. Desmanthin-1	*Myrcia multiflora* DC
10. Tectoridin	*Pueraria montana*
11. Luteolin-5-*O*-β-rutinoside	*Salvia lavandulifolia* Vahl
12. Kaempferitrin	*Bauhinia forficata*
	Cinnamomum osmophloeum
13. Myrtillin	*Hibiscus sabdariffa*
	Vaccinium myrtillus
	Glycine max
14. Astragalin	*Eucommia ulmoides*
	Crassocephalum crepidioides
	Diospyros cathayensis
15. Antirrhinin	*Prunus cerasus*
	Ribes nigrum
	Rubus idaeus
16. Isoquercitrin	*Sedum sarmentosum*
	Diospyros kaki
	Crassocephalum crepidioides
	Diospyros cathayensis
	Vicia monantha
17. Rutin	*Vicia monantha*
18. Isorhamnetin-3-*O*-β-D-glucopyranoside	*Descurainia sophia*
19. Quercetin 3-*O*-(2'',3''-digalloyl)-β-D-galactopyranoside	*Euphorbia lunulata*
20. Quercetin 3-*O*-(2''-galloyl)-β-D-galactopyranoside	*Euphorbia lunulata*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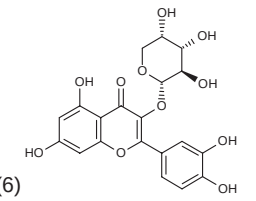
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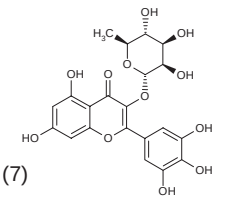
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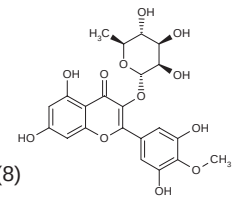
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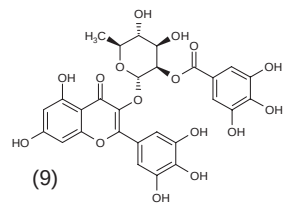
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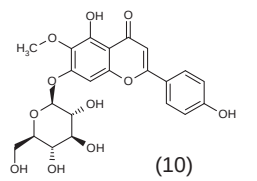
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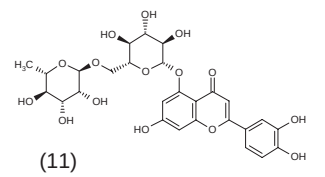
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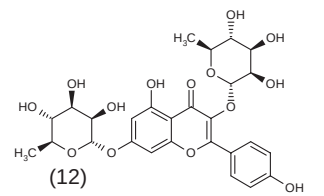
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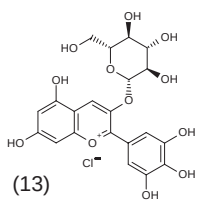
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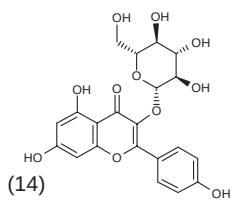
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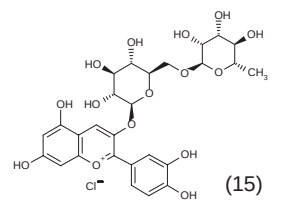
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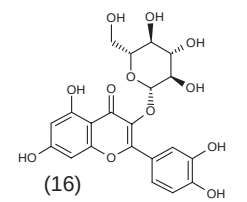
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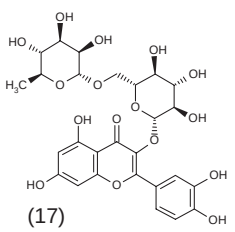
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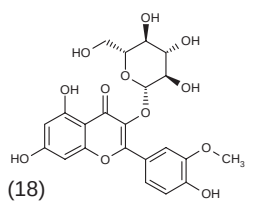
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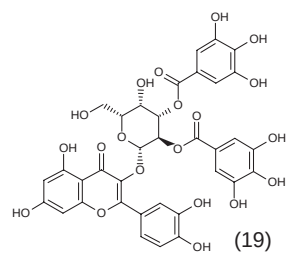
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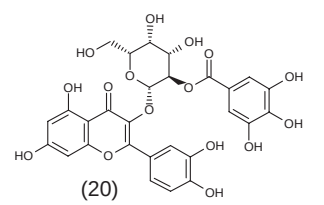
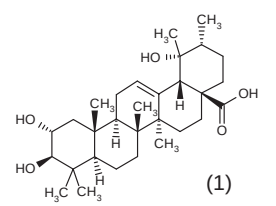

(20)

Terpenoids

1. Tormentic acid	*Sanguisorba ancistroides*
2. Oleanolic acid	*Vitis vinifera* L.
	Catharanthus roseus
	Bassia scoparia
	Olea europaea
	Dracocephalum kotschyi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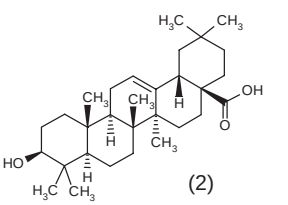
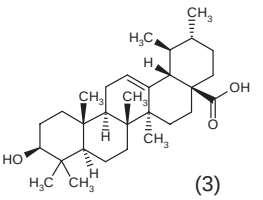

(2)

(Continuation)

Table I: Chemical structures of active antidiabetic constituents from plants (from Prous Science Integrity®).

Terpenoids

3. Ursolic acid	*Catharanthus roseus* *Coridothymus capitatus* *Dracocephalum kotschyi* *Centella asiatica*
4. 3β,29-Dihydroxylup-20(30)-en-2-one	*Salacia chinensis*
5. Corosolic acid	*Pseudocydonia sinensis* *Lagerstroemia speciosa* (L.) Pers. *Dracocephalum kotschyi* *Eriobotrya japonica* *Centella asiatica*
6. Andrographolide	*Andrographis paniculata*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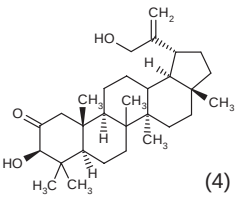
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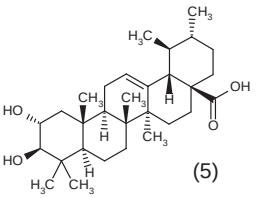
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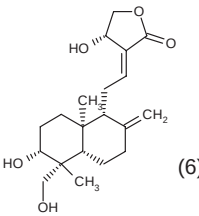
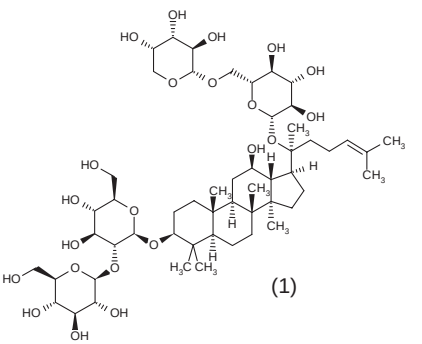

(6)

Glycoside-terpenoids

1. Ginsenoside Rb2	*Panax ginseng* C.A. Meyer
2. Glycyrrhizin	*Glycyrrhiza glabra*
3. Momordin Ic	*Bassia scoparia*
4. Momordin Ib	*Aralia elata* Seem.
5. Assamicin I	*Aesculus assamica* Griff
6. Assamicin II	*Aesculus assamica* Griff
7. Betavulgaroside II	*Beta vulgaris* L.
8. Betavulgaroside III	*Beta vulgaris* L.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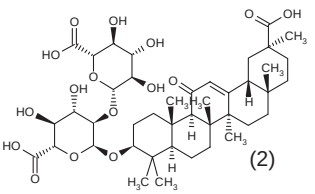
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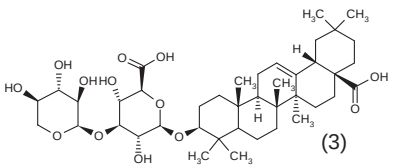
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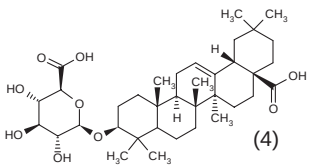
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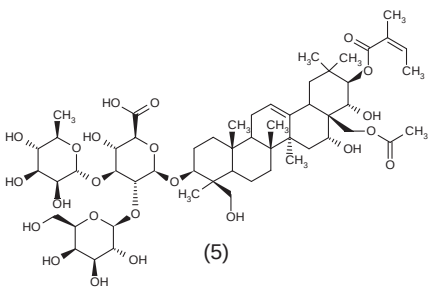
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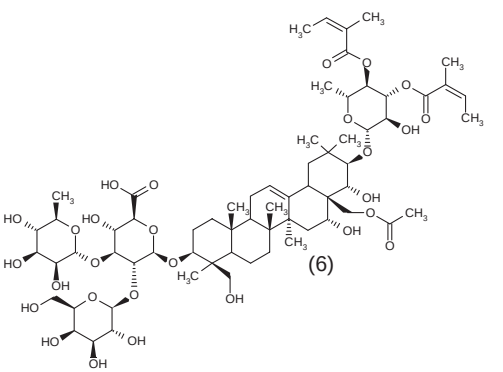
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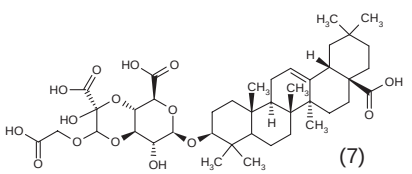
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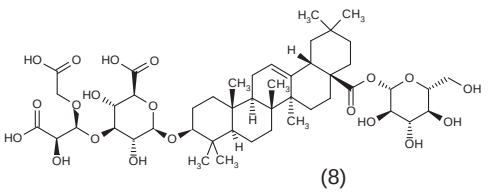
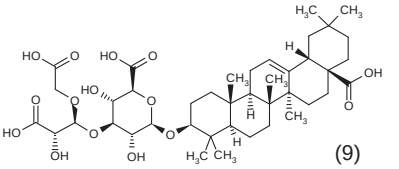

(8)

(Continuation)

Table I: Chemical structures of active antidiabetic constituents from plants (from Prous Science Integrity®).

Glycoside-terpenoids

9. Betavulgaroside IV	*Beta vulgaris* L.
10. Elatoside E	*Aralia elata* Seem.
11. Gymnemoside B	*Gymnema sylvestre*
12. Gymnemasaponin V	*Gymnema sylvestre*
13. Ginsenoside Re	*Panax ginseng* C.A. Meyer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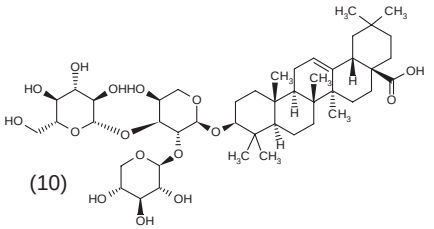
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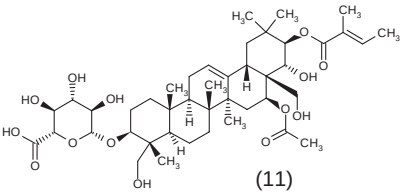
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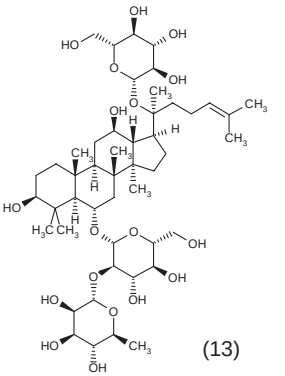
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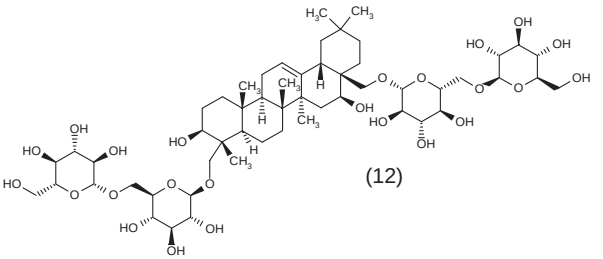
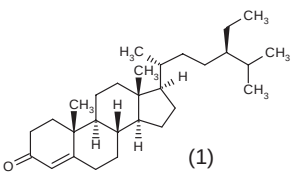

(12)

Steroids

1. 4-Stigmasten-3-one	*Salvia amplexicaulis* Lam.
2. Fucosterol	*Silvetia siliquosa*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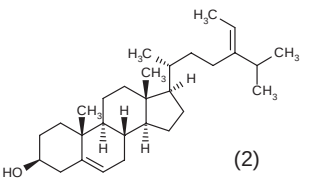
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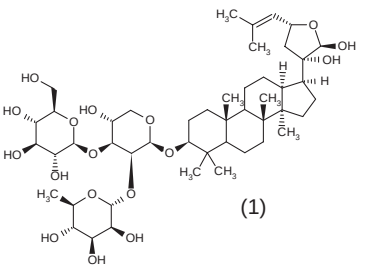
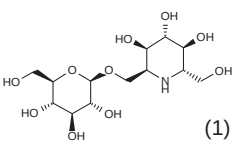
Glycoside-steroids

1. Phanoside	*Gynostemma pentaphyllum*


(1)

Glycosides

1. MDL-25637	*Hyacinthus orientalis* *Lobelia sessilifolia*
2. Myrciaphenone B	*Myrcia multiflora* DC
3. Paeoniflorin	*Paeonia lactiflora*
4. Mangiferin	*Anemarrhena asphodeloides*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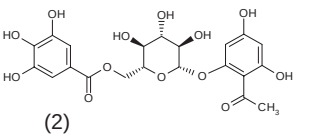
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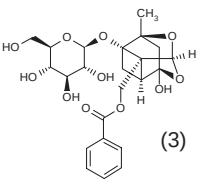
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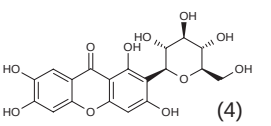
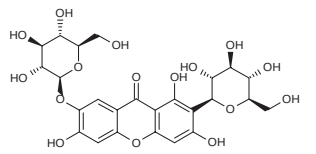

(4)

(Continuation)

Table I: Chemical structures of active antidiabetic constituents from plants (from Prous Science Integrity®).

Glycosides

5. Neomangiferin	*Anemarrhena asphodeloides*
6. Stevioside	*Stevia rebaudiana* Bertoni
7. Harpagoside B	*Scrophularia deserti*
8. Scropolioside D	*Scrophularia deserti*
9. Kotalanol	*Salacia oblonga* Wall
	Salacia reticulata Wight
10. Lactucaside	*Lactuca indica*
11. Vicine	*Momordica charantia*
12. Pentagalloyl glucose	*Pelargonium inquinans*
13. Rebaudioside A	*Stevia rebaudiana* Bertoni



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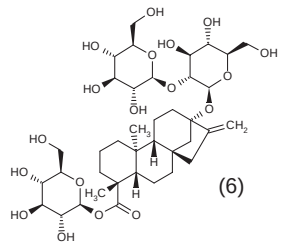

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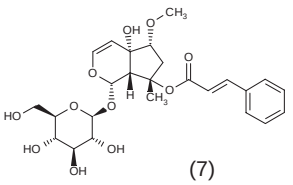

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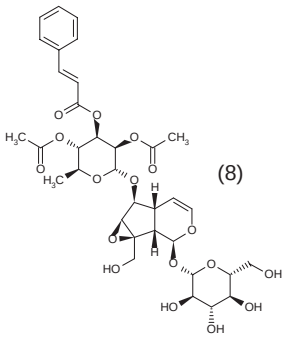

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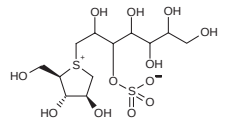

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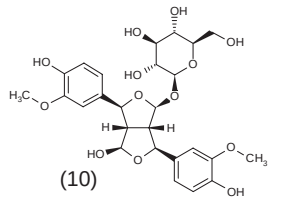

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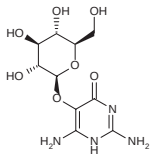

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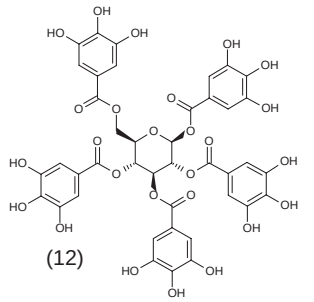

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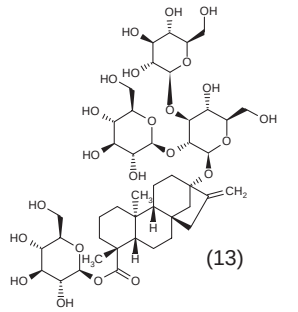
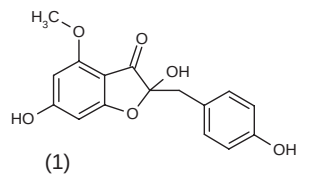


(13)

Benzofuranes

1. Marsupsin	*Pterocarpus marsupium* Roxb.
2. Cacalol	*Psacalium decompositum*
3. Achyrofuran	*Achyrocline satureioides*
4. Magnesium lithospermate B	*Salvia miltiorrhiza*
5. 245951	*Psacalium decompositum*



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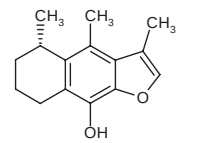

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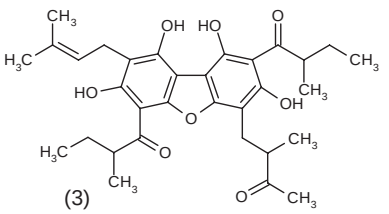

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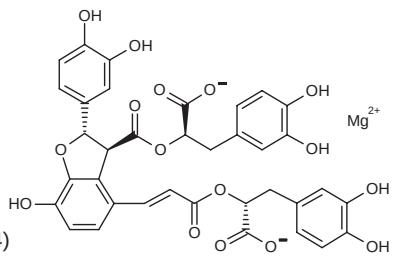

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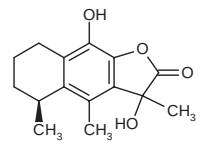
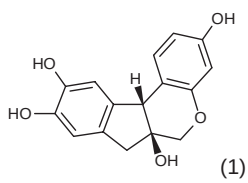


(5)

Benzopyranes

1. Brazilin	*Caesalpinia sappan* L.
2. Scoparone	*Artemisia capillaris*



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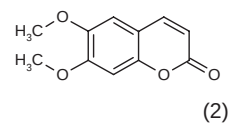


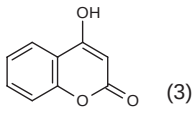
(2)

(Continuation)

Table I: Chemical structures of active antidiabetic constituents from plants (from Prous Science Integrity®).

Benzopyranes

3. 4-Monohydroxycoumarin — *Artemisia capillaris*
4. Tetraacetylbrazilin — *Caesalpinia sappan* L.
5. 3,7-Dihydroxycoumarin — *Euphorbia terracina*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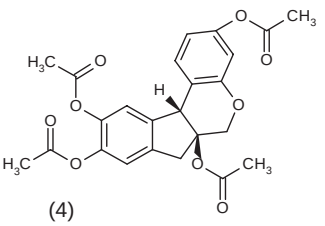
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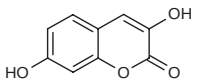
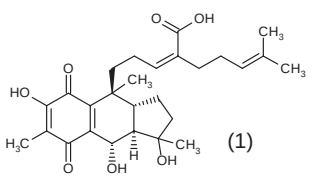

(5)

Quinones

1. Pycnanthuquinone B — *Pycnanthus angolensis*
2. Pycnanthuquinone A — *Pycnanthus angolensis*
3. Emodin — *Rheum undulatum*, *Rheum officinale*
4. Chrysophanol — *Rheum undulatum*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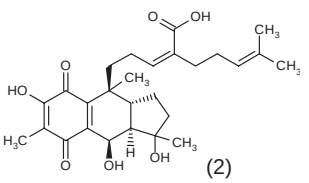
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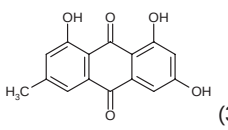
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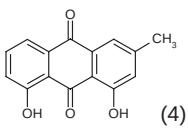
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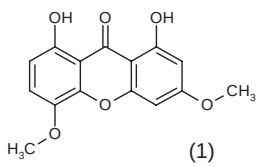
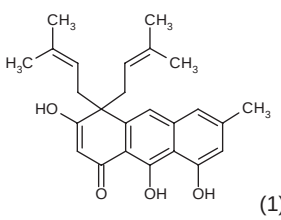
Xanthones

1. Swerchirin — *Swertia chirayita*


(1)

Anthracenes

1. Vismin — *Harungana madagascariensis*
2. Harunganin — *Harungana madagascariensis*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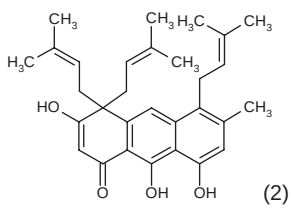
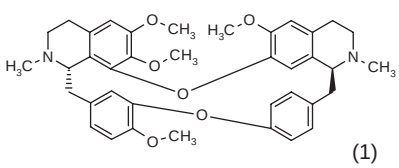

(2)

Alkaloids

1. Tetrandrine — *Stephania tetrandra* S. Moore
2. Fangchinoline — *Stephania tetrandra* S. Moore
3. Berberine iodide — *Coptis chinensis*
4. Cryptolepine chloride — *Cryptolepis sanguinolenta*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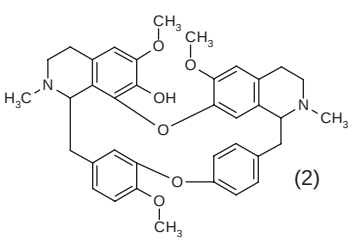
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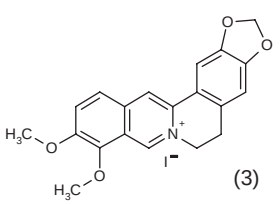
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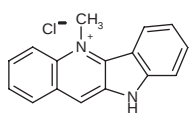
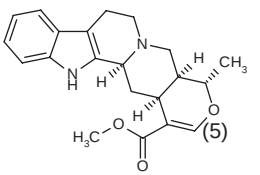

(4)

(Continuation)

Table I: Chemical structures of active antidiabetic constituents from plants (from Prous Science Integrity®).

Alkaloids

5.	Tetrahydroalstonine	*Catharanthus roseus*
6.	Vindolinine	*Catharanthus roseus*
7.	Vindoline	*Catharanthus roseus*
8.	Lochnerine	*Catharanthus roseus*
9.	Multiflorine	*Lupinus pilosus*
10.	Anisodamine	*Anisodis tanguticus*
11.	Tecomanine	*Tecoma stans*
12.	Fagomine	*Morus alba*
13.	Trigonelline	*Trigonella foenum-graecum*
14.	Lupanine	*Lupinus albus* var. *albus*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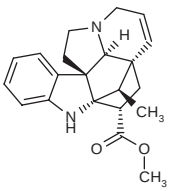
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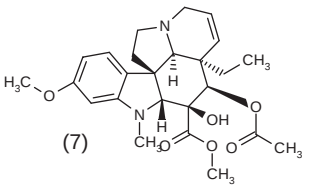
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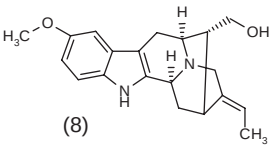
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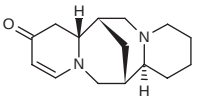
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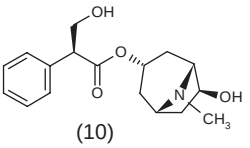
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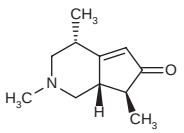
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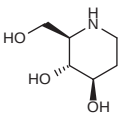
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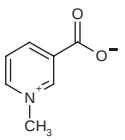
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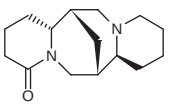
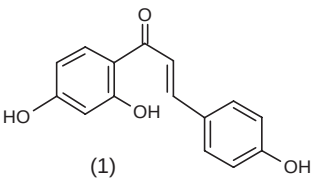

(14)

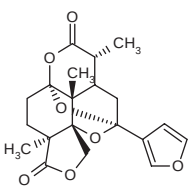
Chalcones

1.	Isoliquiritigenin	*Glycyrrhiza uralensis*


(1)

Polycyclics

1.	Saudin	*Cluytia richardiana*
2.	Grandinin	*Melaleuca quinquenervia*
3.	Lithosperman B	*Lithospermum erythrorhizon*
4.	Lactucain C	*Lactuca indica*
5.	Maprouneacin	*Maprounea africana*
6.	Kaurenoic acid	*Aralia cordata*
		Mikania glomerata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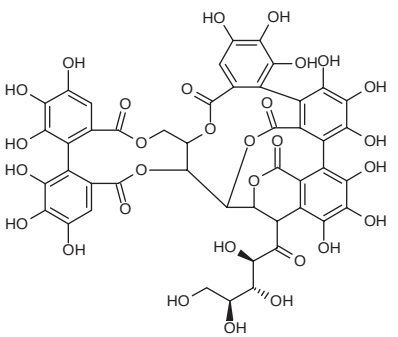
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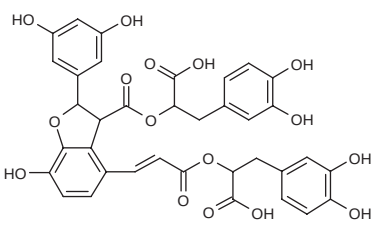
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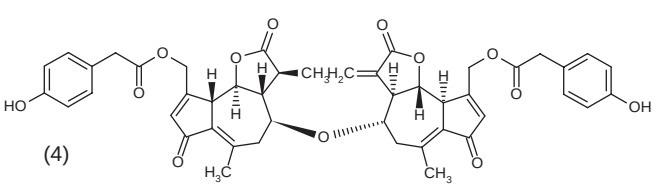
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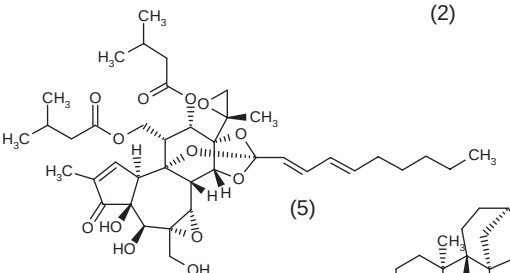
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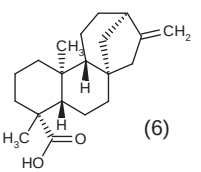
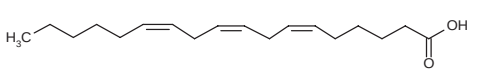

(6)

(Continuation)

Table I: Chemical structures of active antidiabetic constituents from plants (from Prous Science Integrity®).

Miscellaneous

1. Gamolenic acid	*Borago officinalis*
2. Bakuchiol	*Cullen corylifolium*
	Otholobium pubescenses
	Otholobium glandulosum
3. Capsaicin	*Capsicum frutescens*
4. Pinitol	*Bougainvillea spectabilis*
	Pinus halepensis Mill.
	Pinus lambertiana Douglas
	Pinus sylvestris
5. Salacinol	*Salacia oblonga* Wall
	Salacia reticulata Wight
6. Isoferulic acid	*Actaea dahurica*
	Actaea heracleifolia
	Actaea racemosa L.
7. 4-HBA	*Pandanus amaryllifolius*
8. Cinnamaldehyde	*Cinnamomum aromaticum* Nees
9. Pterostilbene	*Pterocarpus marsupium* Roxb.
10. Meglutol	*Tillandsia usneoides*
11. ID-1101	*Trigonella foenum-graecum*
12. MCPG	*Litchi chinensis*
13. Alliin	*Allium sativum*
14. Allicin	*Allium sativum*
15. Deoxyrhapontigenin	*Rheum undulatum*
16. Apocynin	*Paeonia suffruticosa*
17. APDS	*Allium sativum*
	Allium cepa
18. 3,4,5-Tricaffeoylquinic acid	*Ipomoea batatas*
19. Reticulanol	*Salacia reticulata* Wight
20. *p*-Methoxycinnamic acid	*Oryza sativa* L.
	Scrophularia buergeriana
21. Bilobol dimethyl ether	*Ginkgo biloba*
22. Gallic acid	*Paeonia lactiflora*
	Euphorbia lunulata
	Rubus suavissimus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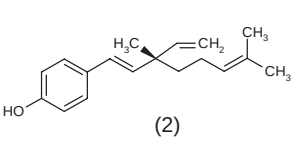
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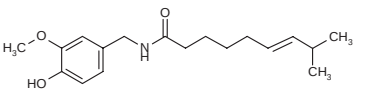
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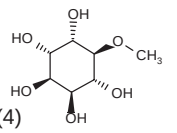
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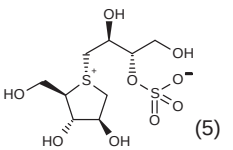
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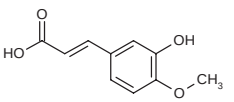
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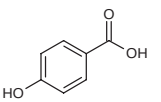
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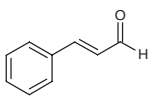
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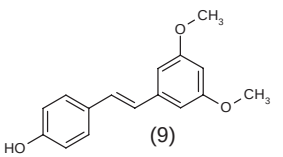
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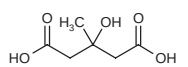
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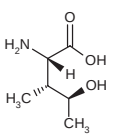
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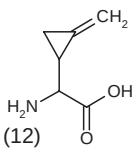
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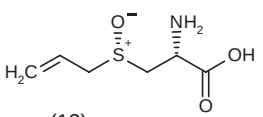
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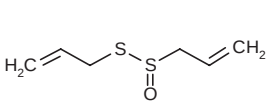
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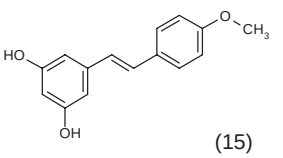
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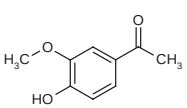
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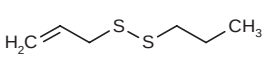
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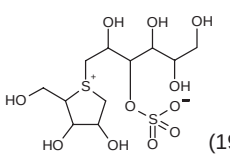
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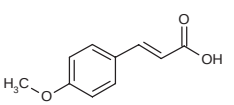
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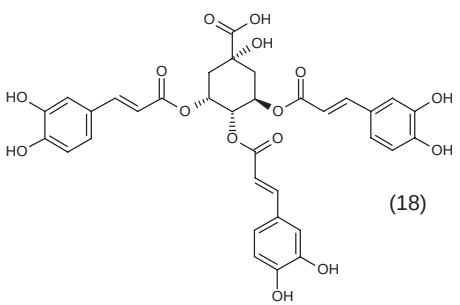
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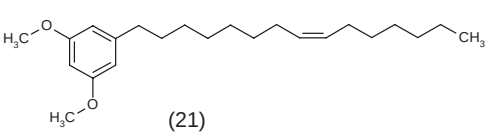
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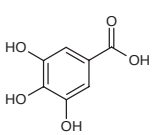
(22)

(Continuation)

Table I: Chemical structures of active antidiabetic constituents from plants (from Prous Science Integrity®).

Structure not yet determined:

Polysaccharides

1. Moran A	*Morus alba*
2. Aconitan A	*Aconitum carmichaelii*
3. Aconitan B	*Aconitum carmichaelii*
4. Aconitan C	*Aconitum carmichaelii*
5. Coixan A	*Coix lacryma-jobi* L.
6. Ganoderan A	*Ganoderma lucidum*
7. Ganoderan B	*Ganoderma lucidum*
8. Atractan A	*Atractylodes japonica*
9. Atractan B	*Atractylodes japonica*
10. Atractan C	*Atractylodes japonica*
11. Dioscoran A	*Dioscorea japonica*
12. Dioscoran B	*Dioscorea japonica*
13. Dioscoran C	*Dioscorea japonica*
14. Dioscoran D	*Dioscorea japonica*
15. Dioscoran E	*Dioscorea japonica*
16. Dioscoran F	*Dioscorea japonica*
17. Lithosperman A	*Lithospermum erythrorhizon*
18. Lithosperman C	*Lithospermum erythrorhizon*
19. Quinquefolan A	*Panax quinquefolius* L.
20. Trichosan A	*Trichosanthes kirilowii* Maxim.
21. Panaxan A	*Panax ginseng* C.A. Meyer
22. Panaxan B	*Panax ginseng* C.A. Meyer
23. Ephedran A	*Ephedra distachya* L.
24. Ephedran B	*Ephedra distachya* L.
25. Ephedran C	*Ephedra distachya* L.
26. Ephedran D	*Ephedra distachya* L.
27. Ephedran E	*Ephedra distachya* L.
28. Eleutheran A	*Eleutherococcus senticosus*
29. Eleutheran B	*Eleutherococcus senticosus*
30. Eleutheran C	*Eleutherococcus senticosus*
31. Eleutheran D	*Eleutherococcus senticosus*
32. Eleutheran E	*Eleutherococcus senticosus*
33. Eleutheran F	*Eleutherococcus senticosus*
34. Eleutheran G	*Eleutherococcus senticosus*
35. Oryzabran A	*Oryza sativa* L.
36. Oryzabran B	*Oryza sativa* L.
37. Oryzabran C	*Oryza sativa* L.
38. Oryzabran D	*Oryza sativa* L.
39. Oryzaran A	*Oryza sativa* L.
40. Oryzaran B	*Oryza sativa* L.
41. Oryzaran C	*Oryza sativa* L.
42. Oryzaran D	*Oryza sativa* L.
43. Glucomannan	*Aloe vera* *Amorphophallus konjac*

Peptides

1. Charantin	*Momordica charantia*
2. Polypeptide-P	*Momordica charantia*

Glycoside-terpenoids

1. Gymnemic acids	*Gymnema sylvestre*

Table II: Natural sources of antidiabetic constituents (from Prous Science Integrity®).

Plant	Product	Ref.
Acer pseudoplatanus L.	MCPG	75,76
Achyrocline satureioides	Achyrofuran	77
Aconitum carmichaelii	Aconitan A	55,78-81
Actaea dahurica (Cimicifuga dahurica)	Isoferulic acid	82-85
Actaea heracleifolia (Cimicifuga heracleifolia)	Isoferulic acid	82-85
Actaea racemosa L. *(Cimicifuga racemosa)*	Isoferulic acid	82-85
Aesculus assamica Griff	Assamicin I	86
	Assamicin II	86
Allium cepa	APDS	9,75,87,88
Allium sativum	APDS	9,75,87,88
	Alliin	10,89
Aloe vera	*Aloe vera* gel	11,13,14,90-92,94,95,97
	Glucomannan	93,96,98,103,104
Amorphophallus konjac	Glucomannan	93,96,98,103,104
Andrographis paniculata	Andrographolide	105,106
Anemarrhena asphodeloides	Mangiferin	107-111
	Neomangiferin	107,109,111
Angelica keiskei koizumi	Cynaroside	112,113,422
Anisodus tanguticus	Anisodamine	75
Aralia cordata	Kaurenoic acid	114
Aralia elata Seem.	Momordin Ib	115,116,119,123,124
	Elatoside E	115,119,120,123,124
	Oleanolic acid 3-*O*-glucuronide	120
Artemisia capillaris	4-Monohydroxycoumarin	125,126
	Capillarisin	125,126
	Scoparone	126
Artemisia dracunculus	*Artemisia dracunculus* extract	127,128
Atractylodes japonica	Atractan A	75,129
	Atractan B	75,129
	Atractan C	75,129
Avena sativa	Oat beta-glucan	50,130-135
Bassia scoparia (Kochia scoparia)	Momordin Ic	117,119,120,137
	Oleanolic acid	136
Bauhinia forficata	Kaempferitrin	138,139
Belamcanda chinensis	Tectorigenin	140
Berberis aristata	Berberine iodide	55,141-144
Beta vulgaris L.	Betavulgaroside II	145,146
	Betavulgaroside III	145-147
	Betavulgaroside IV	145-147
Bombax ceiba	Mangiferin	107-111
Borago officinalis	Gamolenic acid	58,148-166,423,424
Bougainvillea spectabilis	Pinitol	167-171,425
Brassica oleracea var. *italica*	Luteolin	172
Brickellia veronicifolia	Centaureidin	173
Caesalpinia bonduc (C. bonducella)	BM-169	174
Caesalpinia ferrea	2-(2,3,6-Trihydroxy-4-carboxyphenyl)ellagic acid	426,427
	BM-170B	174
Caesalpinia sappan L.	Tetraacetylbrazilin	175
	Brazilin	75,176-180
Camellia sinensis	Myricetin	181,183,184,443
	Oolong tea	182,185
	Epicatechin	186-189
Cannabis sativa	*Cannabis sativa* L. extract	190
Capsicum frutescens	Capsaicin	191-198
Carthamus tinctorius	Cynaroside	112,113,422
Catharanthus roseus (Vinca rosea)	Oleanolic acid	136
	Vindolinine	5,199
	Vindoline	5,199
	Lochnerine	5,199

(Continuation)

Table II: Natural sources of antidiabetic constituents (from Prous Science Integrity®).

Plant	Product	Ref.
Catharanthus roseus (Vinca rosea)	Tetrahydroalstonine	200
	Ursolic acid	75,201
Centella asiatica	Ursolic acid	75,201
	Total triterpenic fraction of *Centella asiatica*	202,203
	Corosolic acid	204,205,428,429
Cinnamomum aromaticum Nees (*Cinnamomun cassia*)	Cinnamon extract	206,207
Cinnamomum osmophloeum	Kaempferitrin	138,139
Cistus laurifolius	Quercetin-3-*O*-methyl ether	431
Cluytia richardiana	Saudin	432
Coccinia grandis (C. indica)	*Coccinia indica* extract	208-213
Coix lacryma-jobi L.	Coixan A	214
Coptis chinensis	Berberine iodide	55,141-144
Coridothymus capitatus	Ursolic acid	75,201
Crassocephalum crepidioides	Isoquercitrin	215
	Astragalin	433
Cryptolepis sanguinolenta	Cryptolepine chloride	216-219,434,435
Cucurbita ficifolia	*Cucurbita ficifolia* extract	220
Cullen corylifolium (Psoralea corylifolia)	Bakuchiol	221
Curcuma longa	Turmeric extract	222,223
	Curcumin	223
Cynara scolymus L.	Cynaroside	112,113,422
	Luteolin	172
Descurainia sophia	Isorhamnetin-3-*O*-β-D-glucopyranoside	224
Dioscorea japonica	Dioscoran A	225
	Dioscoran B	225
	Dioscoran C	225
	Dioscoran D	225
	Dioscoran E	225
	Dioscoran F	225
Diospyros cathayensis	Isoquercitrin	215
	Astragalin	433
Diospyros kaki	Isoquercitrin	215
Dipteryx odorata	Isoliquiritigenin	226,227
Dracocephalum kotschyi	Ursolic acid	75,201
	Corosolic acid	204,205,428,429
	Oleanolic acid	136
Eleutherococcus senticosus (Acanthopanax senticosus)	Eleutheran A	228
	Eleutheran B	228
	Eleutheran C	228
	Eleutheran D	228
	Eleutheran E	228
	Eleutheran F	228
	Eleutheran G	228
Enicostemma littorale	*Enicostemma littorale* extract	229,232
Ephedra distachya L.	Ephedran A	75,233
	Ephedran B	75,233
	Ephedran C	75,233
	Ephedran D	75,233
	Ephedran E	75,233
Equisetum myriochaetum	*Equisetum myriochaetum* extract	235,236
Eriobotrya japonica	Corosolic acid	204,205,428,429
Eucommia ulmoides	Astragalin	433
Euphorbia lunulata	Quercetin	181,237-240,242,244,422,436
	Gallic acid	241,243
	Quercetin 3-*O*-(2",3"-digalloyl)-β-D-galactopyranoside	437
	Quercetin 3-*O*-(2"-galloyl)-β-D-galactopyranoside	437
Euphorbia terracina	3,7-Dihydroxycoumarin	438,439

(Continuation)

Table II: Natural sources of antidiabetic constituents (from Prous Science Integrity®).

Plant	Product	Ref.
Ficus racemosa L.	Quercetin	181,237-240,242,244,422,436
Firmiana simplex	Quercitrin	113,422,443
Fumaria parviflora	*Fumaria parviflora* extract	245
Ganoderma lucidum	Ganoderan B	79,246-248
Ginkgo biloba	*Ginkgo biloba* extract	249-262
	Bilobol dimethyl ether	440
Glycine max	Touchi extract	263,264
	Myrtillin	265
Glycyrrhiza glabra	Glycyrrhizin	266-270
Glycyrrhiza uralensis	Isoliquiritigenin	226,227
	Glycyrin	271,272
Gmelina asiatica	*Gmelina asiatica* extract	273
Gymnema sylvestre	*Gymnema sylvestre* extract	11,75,274-281,411
	Gymnemoside B	75,278,279,281
	Gymnemasaponin V	75,278,279
	Gymnemic acids	17,276,279-281,412
Gynostemma pentaphyllum	Phanoside	282,283
Harungana madagascariensis	Vismin	441
	Harunganin	441,442
Hibiscus sabdariffa	Myrtillin	265
Hordeum vulgare	Young barley leaf extract	265
Hyacinthus orientalis	MDL-25637	285-289
Hydrastis canadensis	Berberine iodide	55,141-144
Hypericum perforatum	Quercitrin	113,422,443
	Quercetin	181,237-240,242,244,422,436
Ipomoea batatas	*Ipomoea batatas* extract	70,71,290-292,413
	3,4,5-Tricaffeoylquinic acid	293
Lactuca indica	Cynaroside	112,113,422
	Luteolin	172
	Lactucain C	172
	Lactucaside	172
Lagerstroemia speciosa (L.) Pers.	Corosolic acid	204,205,428,429
Lepidium didymum (Coronopus didymus)	*Coronopus didymus* water extract	294
Litchi chinensis	MCPG	75,76
Lithospermum erythrorhizon	Lithosperman A	75,79,234
	Lithosperman B	75,79,234
	Lithosperman C	75,79,234
Lobelia sessilifolia	MDL-25637	285-289
Lupinus albus var. *albus (Lupinus termis)*	Lupanine	295
Lupinus pilosus (Lupinus hirsutus)	Multiflorine	75,296
Mahonia aquifolium	Berberine iodide	55,141-144
Mangifera indica L.	Mangiferin	107-111
Maprounea africana	Maprouneacin	297
Melaleuca quinquenervia	Grandinin	444
Mikania glomerata	Kaurenoic acid	114
Momordica charantia	Polypeptide-P	15,75,90,298,300
	Vicine	11,75,90
	Momordica charantia water extract	11,21,33,90,299,301-312,418
	Charantin	11,15,75,90,298
Morella rubra (Myrica rubra)	Myricetin	181,183,184,443
	Myricetin	445,446
Morus alba	Fagomine	313,314
	Moran A	315
Mucuna pruriens	*Mucuna pruriens* extract	306
Muntingia calabura	Isoliquiritigenin	226,227
Myrcia multiflora DC	Myrciacitrin I	118,121,443
	Myrciacitrin II	118,121
	Myrciaphenone B	118
	Mearncitrin	118
	Myrciacetin	118

(Continuation)

Table II: Natural sources of antidiabetic constituents (from Prous Science Integrity®).

Plant	Product	Ref.
Myrcia multiflora DC	Quercitrin	113,422,443
	Guaijaverin	113,118,443
	Desmanthin-1	113,118,443
	Myricitrin	445,446
Nigella sativa	*Nigella sativa* extract	316
Not determined	Kotalagenin 16-acetate	122
Not determined	α-Lipoic acid	149,155,317
Not determined	Oxylupanine	295
Not determined	17-Oxolupanine	295
Not determined	(+)-2-Thionosparteine	295
Oenothera biennis	Gamolenic acid	58,148-166
Oenothera grandiflora (O. lamarckiana)	Gamolenic acid	58,148-166
Olea europaea	Luteolin	172
	Cynaroside	112,113,422
	Oleanolic acid	136
Opuntia ficus-indica	Quercetin	181,237-240,242,244,422,436
	Quercetin-3-*O*-methyl ether	431
Oryza sativa L.	Quercetin	181,237-240,242,244,422,436
	Oryzabran A	318
	Oryzabran B	318
	Oryzabran C	318
	Oryzabran D	318
	Oryzaran A	414
	Oryzaran B	414
	Oryzaran C	414
	Oryzaran D	414
	p-Methoxycinnamic acid	319
Otholobium glandulosum (Psoralea glandulosa)	Bakuchiol	221
Otholobium pubescenses	Bakuchiol	221
Paeonia lactiflora	Gallic acid	241,243
	Paeoniflorin	320,321
Paeonia suffruticosa (P. moutan)	Apocynin	322,323
Panax ginseng C. A. Meyer	Ginseng radix extract	324,415
	Ginsenoside Re	325
	Panaxan A	5,75,326-330
	Panaxan B	5,75,326-330
	Ginsenoside Rb2	447,448
Panax quinquefolius L.	North American ginseng extract	11,99-102,331
	Quinquefolan A	332
Pandanus amaryllifolius (Pandanus odorus)	4-HBA	333,334
Pelargonium inquinans	Pentagalloyl glucose	449-451
Phellodendron japonicum	Scoparone	126
	Quercetin	181,237-240,242,244,422,436
Phyllanthus amarus (Phyllanthus niruri)	*Phyllanthus amarus* whole plant	416
Phyllanthus urinaria	Ellagic acid	427
Pinus halepensis Mill.	Pinitol	167-171,425
Pinus lambertiana Douglas	Pinitol	167-171,425
Pinus pinaster	Pycnogenol	317,335-338
Pinus sylvestris	Pinitol	167-171,425
Plantago afra	Plantago Psyllium mucilage	339
Plantago ovata	Psyllium	340-343
Prunus cerasus	Antirrhinin	344
Psacalium decompositum	Cacalol	345,346
	245951	441,442,452
Pseudocydonia sinensis (Chaenomeles sinensis)	Corosolic acid	204,205,428,429
	Tormentic acid	347
Pterocarpus marsupium Roxb.	Epicatechin	186-189
	Pterostilbene	5,350,352
	Marsupsin	5,350,352
	Pterocarpus marsupium extract	348,349,351

(Continuation)

Table II: Natural sources of antidiabetic constituents (from Prous Science Integrity®).

Plant	Product	Ref.
Pterocarpus santalinus	*Pterocarpus santalinus* water extract	419
Pueraria montana (Pueraria thunbergiana)	Tectorigenin	140
	Puerarin	69,353-356
	Tectoridin	445
Punica granatum	Gallic acid	241,243
Pycnanthus angolensis	Pycnanthuquinone A	197,357
	Pycnanthuquinone B	197,357,453
Rehmannia glutinosa	Rehmanniae Radix extract	358
Rheum officinale	Emodin	359,360
Rheum undulatum	Emodin	359,360
	Deoxyrhapontigenin	359
	Chrysophanol	359
Ribes nigrum	Antirrhinin	344
Rosa rugosa	Tormentic acid	347
Rubus idaeus	Antirrhinin	344
Rubus suavissimus	Gallic acid	241,243
Salacia chinensis (Salacia prinoides)	Mangiferin	107-111
	3β,29-Dihydroxylup-20(30)-en-2-one	454
Salacia oblonga Wall	Salacinol	113,122,362
	Kotalanol	113,122,361,362
Salacia reticulata Wight	Salacinol	113,122,362
	Kotalanol	113,122,361,362
	Mangiferin	107-111
	Reticulanol	455
Salvia amplexicaulis Lam.	4-Stigmasten-3-one	363,364
Salvia lavandulifolia Vahl	Luteolin-5-*O*-β-rutinoside	365
Salvia miltiorrhiza	Magnesium lithospermate B	366
Sanguisorba ancistroides (Poterium ancistroides)	Tormentic acid	347,429
Scrophularia buergeriana	p-Methoxycinnamic acid	319
Scrophularia deserti	Harpagoside B	367
	Scropolioside D	367
Sedum sarmentosum	Isoquercitrin	215
Silvetia siliquosa (Pelvetia siliquosa)	Fucosterol	456,457
Silybum marianum (Carduus marianus)	Silymarin	368,370,372
	Silibinin	369,371,417
Stephania tetrandra S. Moore	Tetrandrine	373-376
	Fangchinoline	458
Stevia rebaudiana Bertoni	Rebaudioside A	377,383
	Stevioside	378-383
Swertia chirayita	Swerchirin	75,384,385
	Mangiferin	107-111
Syzygium cumini (Eugenia jambolana)	*Eugenia jambolana* extract	386,387
	Gallic acid	241,243
Tanacetum parthenium	Centaureidin	173
Tecoma stans	Tecomanine	388-390
	Tecostanine	389
Tillandsia usneoides	Meglutol	391-393
Toxicodendron vernicifluum (Rhus verniciflua)	Fisetin	113,445
Trichosanthes kirilowii Maxim.	Tricosan A	394
Trigonella foenum-graecum	Fenugreek seed powder	90,351,395-400
	Trigonelline	75,402
	ID-1101	73,401,403-408,459,460
Vaccinium myrtillus	Myrtillin	265
	Vaccinium myrtillus anthocyanosides	409
Vicia monantha (V. calcarata)	Isoquercitrin	215
	Rutin	445
	Ellagic acid	427
Vitis vinifera L.	Oleanolic acid	136
Waltheria indica	Quercetin	181,237-240,242,244,422,436
	Epicatechin	186-189
Xanthocercis zambesiaca	Fagomine	313,314
Zea mays L.	*Zea mays* extract	410

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