Review

Research progress of different kinds of traditional Chinese medicine in the treatment of type 2 diabetes

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Abstract

In recent years, diabetes has posed a serious threat to human health. Traditional Chinese medicine for lowering blood sugar has attracted much attention due to its unique advantages in the treatment of diabetes. This paper summarizes the research results on common traditional Chinese medicines for lowering blood sugar in recent years. These results lay a theoretical foundation for the future clinical development and use of hypoglycemic Chinese medicine, the improvement of the quality standards of hypoglycemic Chinese medicine, and the in-depth research on the mechanisms.

Keywords: type 2 diabetes; traditional Chinese medicine; research progress

1 Introduction

Type 2 diabetes mellitus (T2DM) is induced by factors such as diet, environment, drugs and genetics. These factors lead to absolute or relative insufficient insulin secretion in the body, thereby preventing the decrease of blood sugar concentration. Long-term chronic hyperglycemia can lead to dry mouth, polydipsia, polyuria and weight loss. There are mainly two treatments, Western medicine and Traditional Chinese Medicine (TCM). Although Western medicine takes effect quickly, it is characterized by unstable efficacy, the need for long-term medication, and various complications and adverse reactions. TCM has mild treatment process, small side effects, and moderate price. More importantly, most people are afraid of the treatment involving antihypertensive drugs or insulin injections, so they are more likely to accept the mild treatment of TCM. The mechanism of action, expression mode, compositional diversity and multi-target characteristics of Traditional Chinese medicine in the treatment of diabetes show greater advantages than chemical synthetic drugs. In the treatment of diabetes and its complications, the active substances

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of TCM have irreplaceable advantages, broad research prospects and excellent economic benefits, which are worthy of our further in-depth study.

Through comprehensive retrieval in the ScienceDirect and Web of Science databases, a total of 1642 articles were obtained, among which 147 articles were related to the hypoglycemic efficacy and mechanism of single traditional Chinese medicine. In recent years, molecular identification technology has increasingly become the main method for the identification of traditional Chinese medicine. The commonly used molecular identification methods include SSCP, DDGE, 16SrRNA and DDTE. SSCP, single strand conformation polymorphism, is an analysis technique that uses the polymorphism characteristics of DNA or RNA single strand conformation combined with PCR technology, also called PCR-SSCP technology, to analyze the genetic characteristics and gene mutations of microorganisms. DDGE is denatured gradient gel electrophoresis, in which denaturants (urea and formamide) are added to the usual polyacrylamide gel to distinguish DNA fragments with the same length but different sequences. A specific DNA fragment has a unique sequence composition, which determines its melting domain and melting behavior. In this paper, the emerging molecular identification techniques in recent years are analyzed and summarized. Compared with traditional methods, molecular identification method can avoid subjective judgment and human error, and the results are more accurate and the experimental process is more efficient. On the basis of the literature review, we classified traditional Chinese medicine for lowering blood sugar into eight families, and studied and elaborated their hypoglycemic mechanism.

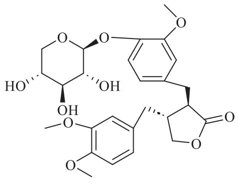
2 Common TCM for treating T2DM

2.1 Asteraceae

The plants of *Asteraceae*, such as *Arctium lappa* and *Atractylodes Rhizoma* possess antioxidant, hepatoprotective, vasodilatory and wound-healing effects, which can prevent the occurrence of diabetes and lower human blood sugar [1].

2.1.1 Arctium lappa

According to contemporary pharmacological research, the principal pharmacological active constituents of burdock are arctiin (**1**) and arctigenin (**2**). These two active substances maintain blood glucose equilibrium and possess anti-tumor activity. The compounds were isolated and purified through modern approaches. The chemical structures of arctiin and arctigenin were analyzed and identified by spectroscopic techniques. The effective sites of hypoglycemic compounds were isolated, namely matairesinol (**3**), arctiin and arctigenin. These hypoglycemic substance bases are closely associated with the total lignans contained. The primary active ingredient of lignans is arctigenin, which constitutes the largest proportion of the compounds present in burdock seeds. Arctigenin functions as an α-glucosidase inhibitor, delaying the absorption of glucose and reducing postprandial blood sugar. The structures are shown in Fig. 1[2].



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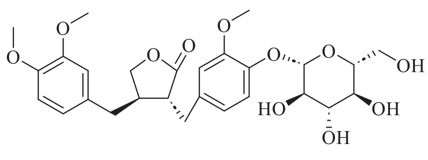

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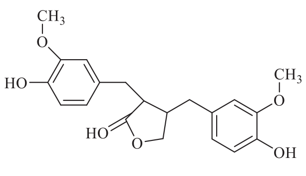

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Fig. 1 The structures of the pharmacological active constituents in *Arctium lappa*

2.1.2 Atractylodes macrocephala

The study of the hypoglycemic effect and mechanism of the extract of *A.macrocephala* in db/db mice at the Affiliated Hospital of Zhejiang University revealed that *A.macrocephala* possessesed the functions of protecting the gastrointestinal tract, anti-inflammation, anti-oxidation, lowering blood glucose, and inhibiting the growth of tumor cells. The main components of *A.macrocephala* are atractylenolide (**4**), polysaccharide and volatile oil. The extract of *A.macrocephala* can ameliorate disorders of glucose and lipid metabolism, enhance insulin sensitivity, improve the inflammatory level, and alleviate liver damage and lipid deposition in db/db mice. It exhibits the hypoglycemic effect by upregulating the protein expression of Glucagon-like peptide-1 receptor agonist (GLP-1RA) in liver tissue and promoting the phosphorylation of Phosphoinositide 3-kinase (PI3K). Studies have proved that GLP-1R can repress FOXO1 in B cells and the expression of B cells in hepatocytes, thereby suppressing hepatic gluconeogenesis. Forkhead box O1(FOXO1) is a downstream target of the PI3K/AKT and pancreatic and duodenal homeobox 1(PDX-1) pathways, and it can partially bind to the PDX-1 promoter to prevent PDX-1 translocation from the nucleus to the cytoplasm of pancreatic B cells and inhibit B cell proliferation. It was discovered that pancreases lacked organization in Pdx-1 knockout mice and in humans with Pdx-1 mutations. Further investigations were conducted on the effects of *A.macrocephala* on the GLP-1R and PI3K/AKT signaling pathways. The results indicated that the protein expressions of GLP-1R, p-PI3K and PDX-1 were significantly upregulated, while the protein expression of FOXO1 was significantly downregulated. This suggests that the extract of *A.macrocephala* can modify and enhance islet B cell function, improve insulin sensitivity, reduce insulin resistance, decrease hepatic gluconeogenesis, and increase the body's uptake and utilization of glucose, which might be one of the mechanisms of action of *A.macrocephala* in regulating blood glucose. The structures are shown in Fig. 2 [3].

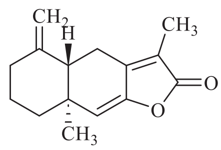

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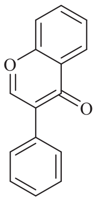
Fig. 2 The structures of atractylenolide

2.2 Leguminosae

Numerous studies have demonstrated that legumes can lower the risk of mortality among patients with cardiovascular and cerebrovascular diseases, and can effectively regulate blood sugar in the body, as well as complications related to type 2 diabetes. The hypoglycemic mechanism of pueraria and astragalus is reviewed below.

2.2.1 Pueraria lobata

Pueraria is the dried root of the leguminous herb. The results of the study on the hypoglycemic effect of *pueraria* microemulsion extract on streptozotocin-induced type 2 diabetic mice showed that the injection of pueraria microemulsion extract significantly reduced blood sugar in mice. Puerarin microemulsion of extract was mostly polysaccharides (**5**) and flavonoids (**6**). Modern pharmacological studies have revealed that the isoflavones are the main active ingredients of *pueraria* in the treatment of diabetes. This active substances increase the sensitivity of the insulin receptor, reduce the aggregation of inflammatory factors and the degree of oxidation reaction within the body, weaken IR, eliminate free radicals, adjust glucose and lipid metabolism, and subsequently improve blood microcirculation, thereby controlling blood sugar, slowing the progression of diabetes, and reducing complications .The structures are shown in Fig. 3 [4].



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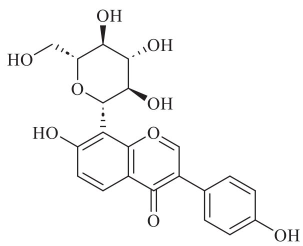

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Fig. 3 The structures of Puerarin microemulsion

2.2.2 Astragalus membranaceus

Astragalus belongs to the leguminous family. A research project of the School of Medicine of Wuhan University indicates that *astragalus* can enhance insulin sensitivity and lower blood sugar in diabetic patients. By increasing the activity of glycogen synthetase and insulin receptor substrate, *astragalus* can raise the content of glucose transporter in the body, increase the activity of glycogen synthetase and enhance insulin sensitivity, thereby reducing blood sugar. In addition, the experimental results of the affiliated hospital of Sun Yat-sen University on the hypoglycemic function of astragaloside has shown that astragaloside (**7**) is the main effective component. The experimental results of the root of *A.membranaceus* indicated that methyl glucoside of the root of *A.membranaceus* had no hypoglycemic effect in normal mice, but could inhibit the increase in blood sugar in mice induced by alloxan and adrenaline. This study provides an experimental basis for the development and utilization of astragaloside. The structures are shown in Fig. 4 [5,6].

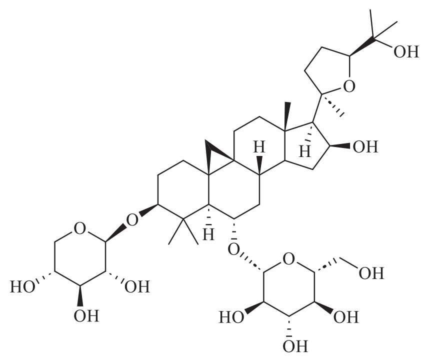

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Fig. 4 The structures of astragaloside

2.3 Liliaceae

Liliaceae are monocotyledonous plants, mainly distributed in temperate and subtropical regions with a long history. Liliaceous plants have high medicinal value, and can be ornamental or edible, and also make a great contribution to greening. The hypoglycemic mechanism of anemarrhena asphodeloides and polygonatum polygonatum is introduced as follows.

2.3.1 Anemarrhena asphodeloides

Anemarrhena's primary chemical components include polysaccharides, phenols, and saponins. Pharmacological experiments showed that the polysaccharide exhibited excellent antioxidant activity and could enhance glucose consumption and glycogen synthesis in insulin-resistant human hepatocellular carcinomas(HepG2) cells. The total phenol and saponin of *A.asphodeloides* can significantly inhibit the activity of α-glucosidase, reduce the fasting blood glucose value, and subsequently improve the blood glucose concentration in diabetic patients. Based on the research findings regarding the hypoglycemic effect of *A.asphodeloides* extract at China Pharmaceutical University, mangiferin (**8**), Neomangiferin (**9**) and Sarsasapogenin (**10**) were isolated from the aqueous extract. Through the modeling analysis of 55 diabetic rats, it was revealed that the main hypoglycemic mechanism is that the total saponin of *A.asphodeloides* (TSAA) and the total polyphenol of *A.asphodeloides* (TPAA) inhibit the activity of α-glucosidase. Further experiments showed that mangiferin could inhibit the activity of α-glucosidase, but neomangiferin could not. In pharmacological experiments, it was discovered that the polysaccharide exhibited excellent antioxidant activity and could enhance glucose consumption and glycogen synthesis in insulin-resistant HepG2 cells. The total phenol and saponin of *A.asphodeloides* can significantly inhibit the activity of α-glucosidase, reduce the fasting blood glucose value, and subsequently improve the blood glucose concentration in diabetic patients. The maternal polysaccharide could potentially regulate key proteins such as PI3K, p-Akt and GS within the PI3K/Akt(phosphatidyl-inositol 3-kinase/serine-threonine kinase) signaling pathway. It also suppressed the expression of GSK-3β(Glycogen synthase kinase3β) and exerted a hypoglycemic effect. The structures are shown in Fig. 5 [6,7,8-10].

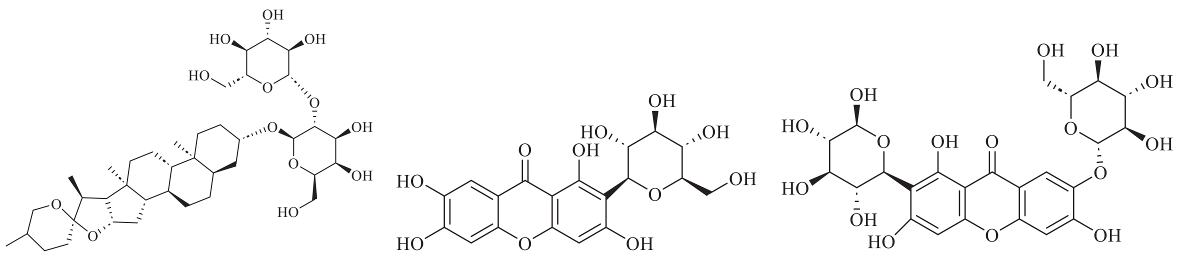

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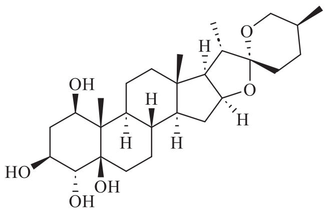
Fig. 5 The structures of *A.asphodeloides* extract

2.3.2 Polygonatum polygonatum

P.polygonatum's main active substances include saponins, flavonoids, amino acids and polysaccharides. According to the research report on the hypoglycemic effect of *P.polygonatum* published in Chinese Pharmacist, *P.polygonatum* demonstrates a remarkable hypoglycemic effect on experimental hyperglycemia animal models such as rabbits and mice induced by adrenaline. Spirosterane

(**11**), the principal hypoglycemic active component of *P.polygonatum*, exerted a hypoglycemic effect by inhibiting glycogen degradation in the liver. The methanol (**12**) extract of *P.polygonatum* can significantly inhibit the manifestation of glucose transporter genes, thereby suppressing the decomposition of liver glycogen to achieve the hypoglycemic effect. *P.polygonatum* polysaccharide has no impact on the blood sugar levels of normal mice but can notably reduce the blood sugar of the adrenaline-induced hyperglycemia mice model. The reason is that it functions as a second messenger in the neuroendocrine regulation, controlling one of the key factors for hepatic glycogen synthesis and decomposition to maintain constant blood sugar. Low doses of rhizoma polygonati saponins showed no significant difference in lowering blood glucose in mice, indicating that yellow liquor saponins can enhance the utilization of blood glucose in diabetes and have an obvious hypoglycemic effect.The structures are shown in Fig. 6 [11,12].



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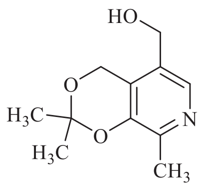

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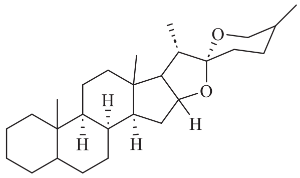
Fig. 6 The structures of *P.polygonatum*'s main active substances

2.3.3 Ophiopogon japonicus

O.japonicus is the dried root of a perennial plant belonging to the genus ophiopogon of the liliaceae family. Its main components encompass steroidal saponins (**13**), diverse types of polysaccharides, high isoflavone compounds (**14**), reducing chromogenone (**15**), and so forth. According to the research report from Jianghan University regarding the hypoglycemic activity of *O.japonicus* polysaccharide, the concentration of *O.japonicus* polysaccharide was inversely proportional to the activity of *α*-glucosidase. The inhibitory effect of *O.japonicus* polysaccharide on *α*-glucosidase was intensified with the rise in the concentration of *O.japonicus* polysaccharide. The inhibitory capacity of acarbose in its experimental control group was essentially saturated at concentrations greater than or equal to 100 μg/mL. When the concentration of *O.japonicus* polysaccharide reached 200 μg/mL, its inhibitory ability against *α*-glucosidase was nearly equivalent to that of acarbose. The results indicated that *O.japonicus* polysaccharide possessed a favorable ability to inhibit the activity of *α*-glucosidase and could be utilized as a potential hypoglycemic agent. The structures are shown in Fig. 7 [13,14].



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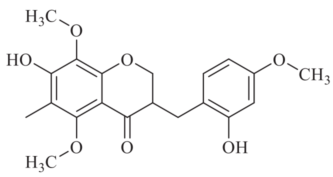

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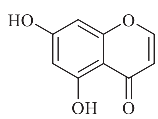

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Fig. 7 The structures of *O.japonicus*

2.3.4 Polygonatum odoratum

Literature review shows that the main active ingredients of *Polygonatum odoratum* are *P.odoratum* sugar, flavonoids, saponins and other components, among which *P.odoratum* polysaccharide has a definite hypoglycemic effect, which is the focus of research on *P.odoratum*. Modern pharmacological experiments showed that the blood glucose of mice in each dose group was significantly decreased, while the insulin level was significantly increased. The results also showed that the *P.odoratum* polysaccharide had a certain inhibitory effect on the destruction of islet B cells induced by alloxan. Besides, *P.odoratum* polysaccharide had a certain improvement on the disorder of lipid levels induced by alloxan, especially on the level of glyceripid. It is suggested that the polysaccharide of *P.odoratum* may have some therapeutic effect on various complications of diabetes caused by elevated blood lipids. The experiment also showed that the *P.odoratum* polysaccharide had little effect on blood glucose levels in normal mice as indicated by the above results. *P.odoratum* polysaccharide can reduce blood glucose and blood lipid levels in diabetic mice. The specific influencing factors still need to be further studied [15,16].

2.4 Scrophulariaceae

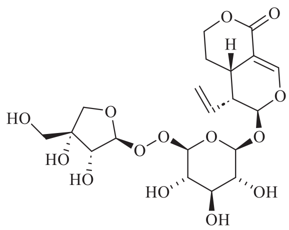
Scrophulariaceae is a family of angiosperms, dicotyledons, chrysanthemum and tubular flowers. The principal chemical constituents of medicinal plants within this family include iridoids, flavonoids, cardiac glycosides, alkaloids, phenols and sugars. The hypoglycemic mechanisms of rehmanniae and scrophularia are primarily described below.

2.4.1 Rehmannia glutinosa

The research of Tianjin Pharmaceutical Research Institute regarding the mechanism of *R.glutinosa* in treating type II diabetes showed that the hypoglycemic and active ingredients of *R.glutinosa* mainly consisted of iridoids (**16**), ionones (**17**), phenylethanols (**18**) and sugars. Modern pharmacological studies have demonstrated that catalpol (**19**), oligosaccharide and polysaccharide are the representative components of iridoid glycosides in *R.glutinosa*. Catalpol might inhibit the expression of c-Jun N-terminal kinase (JNK) in adipose tissue and the expression of JNK in the pancreas and kidney, as well as the nuclear factor-κB (NF-κB) signaling pathway in the liver, thereby reducing the inflammatory response and improving T2DM.

Additionally, it has been found that catalpol can inhibit advanced glycation end product-mediated inflammation by suppressing the production of reactive oxygen species (ROS) and the activity of NF-κB, thereby influencing the progression of T2DM. Furthermore, a considerable number of experiments have indicated that rehmannia oligosaccharides possess the effects of protecting neurons, improving hyperlipidemia and safeguarding liver tissue. Moreover, the activity and gene expression of glucokinase (GK) were increased, while the fasting blood glucose value and the activity and gene expression of glucose-6-phosphatase (G6-pase) were decreased. GK is capable of mediating the amplitude of the insulin release response induced by glucose and controlling the uptake and utilization of glucose by hepatocytes. G-6-pase is the key enzyme that catalyzes the hydrolysis of glucose-6-phosphate to glucose.

These results suggest that the mechanism by which rehmannia oligosaccharides improve T2DM might be that they enhance the activity and gene expression of GK, decrease the activity and gene expression of G-6-pase, and subsequently exert insulin resistance (IR) in T2DM rats. Studies have demonstrated that raw rehmannia and its chemical components possess hypoglycemic effects. Zeng et al. indicated that intragastric administration of rehmannia oligosaccharides reduced the blood glucose of rats and also mitigated the adrenergic hyperglycemia in rats. The traditional Chinese medicine compound of raw Dihuang Zhibai Dihuang Pills also exhibits hypoglycemic effects. Zhang et al. utilized neural internal points to study the pharmacological effect and mechanism of Rehmannia oligosaccharides in lowering blood glucose by the secret-immune regulatory network theory for the first time, providing a new theoretical basis for the treatment of diabetes.The structures are shown in Fig. 8 [17-19].



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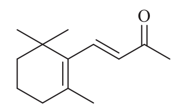

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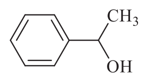

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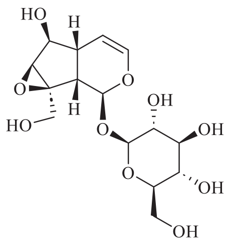

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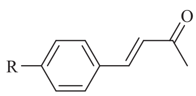
Fig. 8 The structures of *R.glutinosa*

2.4.2 Scrophularia ningpoensis

The study conducted by the China Academy of Chinese Medical Sciences on the hypoglycemic effect of *S.ningpoensis* and its separated components in type 2 diabetic rats has revealed that the main active substances responsible for its hypoglycemic effect are iridoids and polysaccharides. It was discovered that in this model, the C-peptide level of diabetic rats in the iridoid group rose, the total insulin level increased, and the levels of triglyceride, total cholesterol and low-density lipoprotein cholesterol decreased, exerting a preventive effect on diabetic complications. Compared with the model group, the body weight of mice in the iridoid group increased significantly, and the glycosylated hemoglobin level also decreased effectively. These results demonstrated that the iridoid glycosides of *S.ningpoensis* exerted a hypoglycemic effect on type 2 diabetes mellitus. Further pharmacological experiments indicated that harpagoside (**20**), aucubin (**21**) and harpagide (**22**) exhibited hypoglycemic activity on human hepatocellular carcinomas HepG2 cells, among which harbazoside presented the best hypoglycemic activity. 6-*O*-*α*-D-Galactopyranosylharpagoside (**23**), 8-*O*-Feruloylharpagide (**24**) and ningpogenin (**25**) were capable of inhibiting the activity of *α*-glucosidase. It was also found that aucubin could reduce the blood glucose concentration, increase the number of islet *β* cells, and safeguard the pancreas of streptozotocin (STZ)-induced diabetic rats. The structures are shown in Fig. 9 [20,21].



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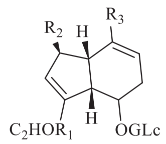

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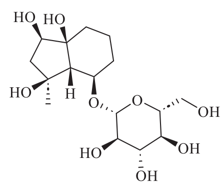

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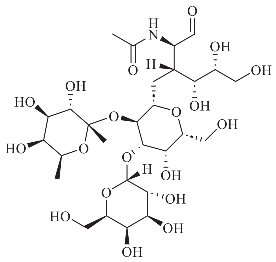

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Fig. 9 The structures of *S.ningpoensis*

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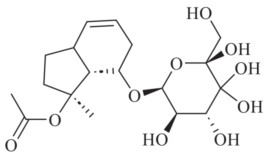

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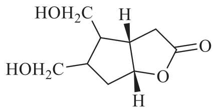

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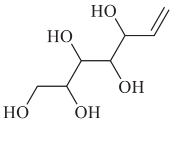
Continued Fig. 9

2.5 Solanaceae

Solanaceae is a family of plants under the tube flower. The main chemical constituents include alkaloids, flavonoids and their glycosides, steroids, triterpenoids and their glycosides, organic acids and their derivatives. Next, we will discuss the hypoglycemic mechanism of Lycium barbarum. Based on the literature review, the principal hypoglycemic constituent of *L.barbarum* is *L.barbarum* polysaccharide (LBP). The main components include mannose (**26**), and its potential target metabolite, inositol (**27**), which can enhance the expression level of glucose transporter 4 and the uptake of glucose in peripheral cells. Inositol can also upregulate the expression level of glucokinase, enhance insulin sensitivity, and ameliorate glucose metabolism. LBP suppresses certain pro-inflammatory factors in MDF 88 KO mice with type 2 diabetes by attenuating the phosphorylation of macrophage NF-κB inhibitory protein and inhibiting the nuclear translocation of nuclear factor Nf-κb. The total flavonoids (**28**) of *L.barbarum* (TFLB) can defer the escalation of blood glucose, regulate lipid metabolism disorders, safeguard islet function in diabetic rats, and alleviate insulin resistance in diabetic rats. TFLB can mitigate the damage of vascular endothelial cells induced by hyperglycemia, regulate the content of vascular injury-related factors, and retard the advancement of diabetes and its complications. The ethyl acetate extract of *L.barbarum* can significantly reduce the oxidative stress and inflammatory response of low obesity rats, increase the activities of SuperoxideDismutase (SOD), catalase, and glutathione peroxidase, and markedly lower body weight, blood lipid levels, serum insulin, and glucose levels, thereby exerting an anti-obesity effect. *L.barbarum* polysaccharide reduces blood glucose and restores insulin level in diabetic rats by down-regulating the expression of iNOS mRNA in pancreatic islets and exerting strong anti-oxidative stress. The hypoglycemic effect of the extract might be related to its antioxidant effect.The structures are shown in Fig. 10 [22-24].



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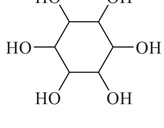

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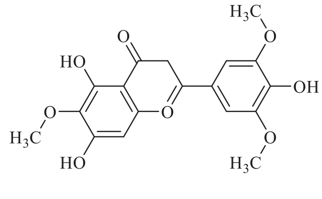

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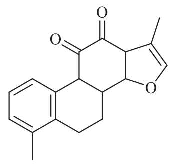
Fig. 10 The structures of *Lycium barbarum*

2.6 Lamiaceae

Lamiaceae is a family in the dicotyledonous plants, famous for the rich aromatic oils. The hypoglycemic mechanism of Salvia miltiorrhiza is introduced below.

Based on the comprehensive search of the VIP data network, there were 34 articles concerning *S.miltiorrhiza*, among which 6 articles were about the hypoglycemic effect of *S.miltiorrhiza*. According to the literature review, the main chemical active components of *Salvia miltiorrhiza* are furans and phenolic acids. Furans mainly include tanshinone I (**29**), cryptotanshinone (**30**), isotanshinone I (**31**) and isotanshinone II (**32**). Tanshinone can elevate the level of stromal cell-derived factor-1 (SDF-1) in peripheral blood, upregulate the expression of chemokine receptor (CXCR4), induce endothelial progenitor cells (EPCs) to enter peripheral blood from bone marrow, and enhance endothelial function in patients with type 2 diabetes. The water extract of *Salvia miltiorrhiza* can increase the activities of SOD, glutathione peroxidase (GSH-Px), and catalase (CAT) in the serum of diabetic rats induced by streptozotocin, reduce the content of malondialdehyde (MDA), increase the clearance rate of endogenous creatinine, lower the excretion rate of blood urea nitrogen, cholesterol and urinary albumin, and regulate the expression of vascular endothelial growth factor in renal tissue. Pharmacological studies demonstrated that salvianolic acid A (**33**) could significantly decrease the levels of SOD and MDA in the DM model group, suggesting that salvianolic acid A could reduce oxygen free radical damage and improve the body's anti-lipid peroxidation effect, thereby lowering blood glucose. The structures are shown in Fig. 11 [25-27].



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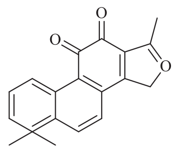

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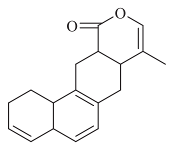

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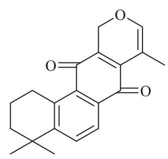

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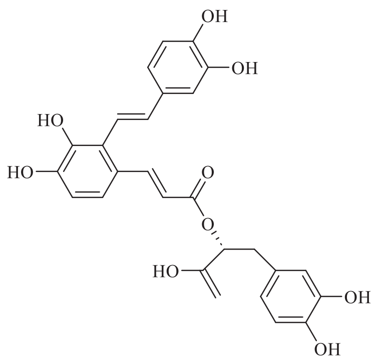

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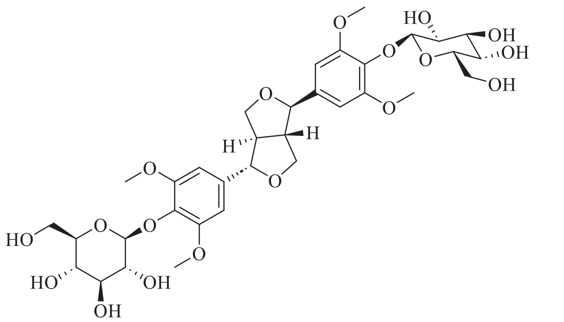
Fig. 11 The structures of *Salvia miltiorrhiza*

2.7 Araliaceae

Araliaceae is a family of dicot plants. The main chemical active ingredients are saponins and polysaccharides, which have anti-inflammatory and anti-aging effects, and can regulate cholesterol by inhibiting or inducing the expression of target cell genes in rats. The hypoglycemic mechanisms of acanthopanax senticosus and panax ginseng are described below.

2.7.1 Acanthopanax senticosus

According to the experimental studies on eleutheroside leaf purification published in China Medical Innovation, eleutheroside eleutheroside E (**34**), syringoside (**35**) and its polysaccharide have hypoglycemic effect on type II diabetic rats. The leaves of *A.senticosus* contain a lot of saponins, flavonoids and phenolic acids. Eleutheroside can significantly improve hemorheology by reducing whole blood viscosity, plasma viscosity, whole blood reduced viscosity, and erythrocyte aggregation index, increase the deformability of red blood cells, and accelerate blood flow. It can reduce fasting blood glucose, serum cholesterol, triglyceride and lipid peroxide in alloxan-induced diabetic rats, increase the activity of superoxide dismutase in whole blood, improve the symptoms of diabetic free radical metabolism disorder, reduce the damage of islet *β* cells or improve the damaged *β* cells. In addition, *A.senticosus* could promote mRNA repair and 6-phosphate synthesis, as well as regulate protein, fat and sugar metabolism.The structures are shown in Fig. 12 [27-29].



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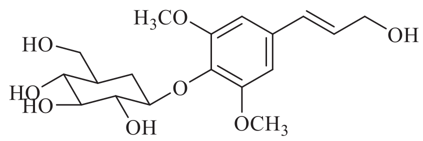

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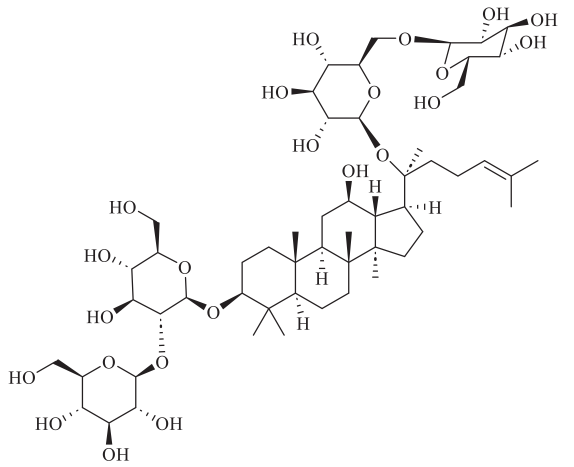
Fig. 12 Eleutheroside E and syringoside

2.7.2 Panax ginseng

We conducted a comprehensive search of Cnki and found 43 related articles, 5 of which were related to the hypoglycemic effect of ginseng active substances. According to the literature, the principal chemical substances of *Panax ginseng* include polysaccharides, saponins, peptides, amino acids, fatty acids and polyethynyl alcohol. Among them, ginsenosides, polysaccharides and peptides have a favorable hypoglycemic effect. Further pharmacological experiments demonstrated that Ginsenoside Rb (specifically Ginsenoside Rb_1, Ginsenoside Rb_2 and Ginsenoside Rb_3) could, to a certain extent, facilitate the differentiation of adipocytes. Further analysis indicated that Ginsenoside Rb could effectively stimulate the expression of peroxisome proliferator-activated receptor γ_2, enhancer binding protein *α* and glucose transporter-4, thereby promoting the enhancement of fatty acid and glucose transport. Ginsenoside Rb_1 (**36**) is an isomer of Rb_3. Studies have also discovered that serum total cholesterol and triglyceride levels were significantly reduced in diabetic mice after 28 d of treatment. Hence, Ginsenoside Rb_3 (**37**) might possess a similar regulatory mechanism as Ginsenoside Rb_1 during the process of lowering blood glucose and blood lipids. Ginsenoside Rb_3 has a remarkable effect on enhancing the activity of SOD in the serum of diabetic mice and can effectively lower the level of MDA *in vivo*. In conclusion, Ginsenoside Rb3 can enhance SOD activity and reduce MDA, thus alleviating oxidative stress and micro-organ complications in diabetic patients. Human polysaccharides and peptides can spontaneously combine with α-glucosidase and inhibit its activity, thereby reducing glucose absorption and treating diabetes. The structures are shown in Fig. 13 [30-32].



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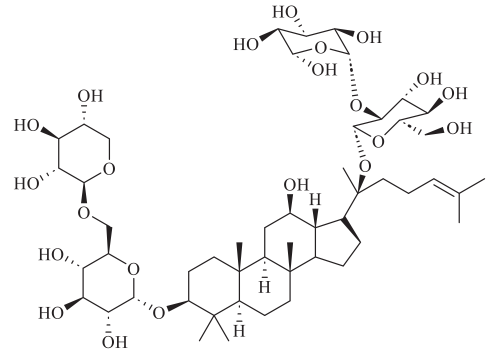

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Fig. 13 Ginsenoside Rb1 and Ginsenoside Rb3

3 Conclusion

Based on the existing research, the chemical components and pharmacological mechanisms of the aforementioned **14** traditional Chinese herbs related to blood glucose reduction were reviewed. These herbs were classified into **7** different families. The pharmacological activities of Chinese herbs include antibacterial and antiviral effects. The hypoglycemic effect of traditional Chinese medicine has also been widely acknowledged by the medical community. However, the specific mechanism of its action still requires more in-depth and systematic research. In the future, if the safety, effectiveness and efficacy of traditional Chinese medicine can be further investigated and discussed, the application of traditional Chinese medicine for blood glucose reduction will be more widely recognized worldwide.

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