UDC 615.322:582.796:616.379-008.64

Anastasiia KULAKIVSKA
Student at the Department of Technology of Biologically Active Substances, Pharmacy and Biotechnology, Lviv Polytechnic National University, Stepan Bandera Street, 12, Lviv, Ukraine, 79013 (anastasiia.kulakivska.mnbtm.2024@lpnu.ua)
ORCID: *0009-0001-8188-7779*
SCOPUS: *58966749100*

Iryna HNATIV
Postgraduate Student at the Department of Technology of Biologically Active Substances, Pharmacy and Biotechnology of Lviv Polytechnic National University, Stepan Bandera Street, 12, Lviv, Ukraine, 79013 (iryna.y.hnativ@lpnu.ua)
ORCID: *0009-0009-0519-5189*

Yulian KONECHNYI
Doctor of Philosophy, General Practitioner, Associate Professor at the Department of Microbiology, Danylo Halytsky Lviv National Medical University, Pekarska Street, 69, Lviv, Ukraine, 79010 (yuliankonechnyi@gmail.com)
ORCID: *0000-0003-4789-1675*
SCOPUS: *57222226566*

Andriy KARKHUT
Candidate of Chemical Sciences, Associate Professor at the Department of Technology of Biologically Active Substances, Pharmacy and Biotechnology, Lviv Polytechnic National University, Stepan Bandera Street, 12, Lviv, Ukraine, 79013 (andrii.i.karkhut@lpnu.ua)
ORCID: *0000-0003-2386-1973*
SCOPUS: *36634306300*

Svyatoslav POLOVKOVYCH
Doctor of Science, Professor at the Department of Technology of Biologically Active Substances, Pharmacy and Biotechnology, Lviv Polytechnic National University, Stepan Bandera Street, 12, Lviv, Ukraine, 79013 (sviatoslav.v.polovkovych@lpnu.ua)
ORCID: *0000-0002-7143-6931*
SCOPUS: *36634574500*

Lesia ZHURAKHIVSKA
Candidate of Chemical Sciences, Associate Professor at the Department of Technology of Biologically Active Substances, Pharmacy and Biotechnology, Lviv Polytechnic National University, Stepan Bandera Street, 12, Lviv, Ukraine, 79013 (lesia.r.zhurakhivska@lpnu.ua)
ORCID: *0000-0002-8217-1414*
SCOPUS: *57201589852*

Roksolana KONECHNA
Candidate of Pharmaceutical Sciences, Associate Professor at the Department of Technology of Biologically Active Substances, Pharmacy and Biotechnology, Lviv Polytechnic National University, Stepan Bandera Street, 12, Lviv, Ukraine, 79013 (roksolana.t.konechna@lpnu.ua)
ORCID: *0000-0001-6420-9063*
SCOPUS: *56038094400*

To cite this article: Kulakivska A., Hnativ I., Konechnyi Yu., Karkhut A., Polovkovych S., Zhurakhivska L., Konechna R. (2025). Kompleksnyy ohlyad antydiabetychnoyi aktyvnosti roslyn rodyny malvovykh [A comprehensive review of antidiabetic activity of *Malvaceae* family plants]. *Fitoterapiia, Chasopys – Phytotherapy. Journal*, 2, 208–217, doi: https://doi.org/10.32782/2522-9680-2025-2-208

A COMPREHENSIVE REVIEW OF ANTIDIABETIC ACTIVITY OF *MALVACEAE* FAMILY PLANTS

Actuality. *Recently, phytoproducts have gained major recognition as effective components in the complex treatment of chronic metabolic diseases, particularly diabetes mellitus. Plants from the Malvaceae family are a potential source of biologically active* *compounds that was traditionally have been used in ethnomedicine in different countries for the correction of hypoglicemic states. A fundamental study of the antidiabetic properties of extracts from Malvaceae suggested their perspective for the pharmaceutical development of latest therapeutic and preventive drugs, including nanopharmaceutical products, which can be applicated into modern medical practice.*

The aim of the study was to analyze the scientific data on the antidiabetic properties of plants of the Malvaceae family and to evaluate their potential as a perspective raw source materials for phytotherapeutic agents in the treatment of diabetes mellitus.

***Material and methods** to review of the scientific literature, including experimental and review articles, highlights the antidiabetic activity of the studied plants of each Malvaceae subfamily with a focus on their pharmacological properties and therapeutical potential for the diabetes mellitus.*

***Research results.** The results of a comprehensive analysis of scientific literature sources indicate that biologically active extracts and nanoparticles obtained from the representives of the Malvaceae family showed noticeable antidiabetic and hypoglycemic activity. The pharmacological action of these compounds is often attributes to the presence of polyphenols, particularly quarcetin, gallic acid, catechins, and other biologically active metabolites. The key mechanism of implementation of the antiglycemic effect is inhibition of the enzymes α-amylase, α-glucosidase, which regulate the modulation of carbohydrate metabolism and also prevent the excessive release of reducing sugars, which ensures stabilization of the glycemic profile.*

***Conclusion.** The relevance of further studies on pharmacokinetic parameters, molecular targets and safety of extracts and nanoformulation of plants of the Malvaceae in the treatment of diabetes mellitus. In particular, a perspective direction is the development of standardized phytocomplexes based on biologically active metabolites that provide prolonged glycemic action with minimal risk of side effects. Thus, the results of the analysis of scientific sources imply the significant therapeutic potential of reperesentative of the Malvaceae in the phytoterapy for the diabetes mellitus, which reveals new opportunities for the creation of effective and safe herbal medicines with proven mechanisms of action.*

***Key words:** malvaceae, herbal medicines, antidiabetic activity, biologically active compounds, nanoparticles.*

Анастасія КУЛАКІВСЬКА
студент, кафедра технології біологічно активних речовин, фармації та біотехнології, Національний університет «Львівська політехніка», вул. С. Бандери, 12, м. Львів, Україна, 79013 (anastasiia.kulakivska.bt.2020@lpnu.ua)
***ORCID:** 0009-0001-8188-7779*
***SCOPUS:** 58966749100*

Ірина ГНАТІВ
аспірант, кафедра технології біологічно активних речовин, фармації та біотехнології, Національний університет «Львівська політехніка», вул. С. Бандери, 12, м. Львів, Україна, 79013 (iryna.y.hnativ@lpnu.ua)
***ORCID:** 0009-0009-0519-5189*

Юліан КОНЕЧНИЙ
доктор філософії, лікар-терапевт, доцент, кафедра мікробіології, Львівський Національний медичний університет імені Данила Галицького, вул. Пекарська, 69, м. Львів, Україна, 79010 (yuliankonechnyi@gmail.com)
***ORCID:** 0000-0003-4789-1675*
***SCOPUS:** 57222226566*

Андрій КАРХУТ
кандидат хімічних наук, доцент кафедри технології біологічно активних речовин, фармації та біотехнології, Національний університет «Львівська політехніка», вул. С. Бандери, 12, м. Львів, Україна, 79013 (andrii.i.karkhut@lpnu.ua)
***ORCID:** 0000-0003-2386-1973*
***SCOPUS:** 36634306300*

Святослав ПОЛОВКОВИЧ
доктор хімічних наук, професор кафедри технології біологічно активних речовин, фармації та біотехнології, Національний університет «Львівська політехніка», вул. С. Бандери, 12, м. Львів, Україна, 79013 (sviatoslav.v.polovkovych@lpnu.ua)
***ORCID:** 0000-0002-7143-6931*
***SCOPUS:** 36634574500*

Леся ЖУРАХІВСЬКА
кандидат хімічних наук, доцент кафедри технології біологічно активних речовин, фармації та біотехнології, Національний університет «Львівська політехніка», вул. С. Бандери, 12, м. Львів, Україна, 79013 (lesia.r.zhurakhivska@lpnu.ua)
***ORCID:** 0000-0002-8217-1414*
***SCOPUS:** 57201589852*

Роксолана КОНЕЧНА
кандидат фармацевтичних наук, доцент кафедри технології біологічно активних речовин, фармації та біотехнології, Національний університет «Львівська політехніка», вул. С. Бандери, 12, м. Львів, Україна, 79013 (roksolana.t.konechna@lpnu.ua)
***ORCID:** 0000-0001-6420-9063*
***SCOPUS:** 56038094400*

Бібліографічний опис статті: Кулаківська А., Гнатів І., Конечний Ю., Кархут А., Половкович С., Журахівська Л., Конечна Р. (2025). Комплексний огляд антидіабетичної дії рослин родини Malvaceae. *Фітотерапія. Часопис,* 2, 208–217, doi: https://doi.org/10.32782/2522-9680-2025-2-208

КОМПЛЕКСНИЙ ОГЛЯД АНТИДІАБЕТИЧНОЇ ДІЇ РОСЛИН РОДИНИ *MALVACEAE*

Актуальність. *Останнім часом фітотерапевтичні засоби привертають багато уваги як ефективний компонент у комплексному лікуванні хронічних метаболічних захворювань, зокрема цукрового діабету. Рослини родини Malvaceae є перспективним джерелом біологічно активних сполук, які традиційно застосовувалися в етномедицині різних країн для корекції гіперглікемічних станів. Ґрунтовні дослідження антидіабетичних властивостей екстрактів рослин родини Malvaceae свідчать про перспективу їх застосування для розроблення нових лікувально-профілактичних засобів, зокрема й нанофармацевтичних препаратів, які можуть бути застосовані в сучасній медичній практиці.*

Мета дослідження *полягає у проведенні аналізу наукових даних щодо антидіабетичних властивостей рослин родини Malvaceae і оцінюванні їхнього потенціалу як перспективних сировинних джерел для фітотерапевтичних засобів у терапії цукрового діабету.*

Матеріал і методи. *Огляд наукової літератури, зокрема й експериментальних і оглядових статтей, що висвітлюють антидіабетичну активність відомих рослин, які належать до різних субродин родини Malvaceae, з акцентом на їхні фармакологічні властивості та терапевтичний потенціал у лікуванні цукрового діабету.*

Результати дослідження. *Результати комплексного аналізу літературних джерел засвідчують, що біологічно активні екстракти та наночастинки, отримані із представників родини Malvaceae, демонструють виражену протидіабетичну та гіпоглікемічну активність. Фармакологічна дія цих сполук переважно зумовлена наявністю поліфенольних компонентів, зокрема кверцетину, галової кислоти, катехінів та інших біологічно активних метаболітів. Ключовими механізмами реалізації антигіперглікемічного ефекту є інгібування ферментів α-амілази і α-глюкозидази, що сприяє регуляції вуглеводного метаболізму, а також запобігання надмірному вивільненню редукуючих цукрів, що забезпечує стабілізацію глікемічного профілю.*

Висновок. *Актуальними є подальші дослідження фармакокінетичних параметрів, молекулярних мішеней і безпечності застосування екстрактів, нанопрепаратів рослин Malvaceae у терапії цукрового діабету. Зокрема, перспективним напрямом є розроблення стандартизованих фітокомплексів на основі біологічно активних метаболітів, які забезпечуватимуть пролонговану гіпоглікемічну дію, з мінімальним ризиком побічних ефектів. Отже, результати аналізу наукових джерел вказують на значний терапевтичний потенціал представників родини Malvaceae у фітотерапії цукрового діабету, що відкриває нові можливості для створення ефективних і безпечних фітопрепаратів із доведеними механізмами дії.*

Ключові слова: *Malvaceae, фітозасоби, антидіабетична активність, біологічно активні речовини, наночастинки.*

Introduction. Actuality. Diabetes mellitus is one of the fastest-growing diseases in the worldwide. The International diabetes federation estimates 1 286 cases of diabetes were registered in Ukraine in 2000, and this number is projected to increase to 1 196 thousand cases in 2011 and 2 325 cases in 2021 in 1 000s people (Ukrainian Diabetes Report 2000–2045). Globally, 200 million people lived with diabetes in 1990, and this number is expected to increase to 830 million by 2022 (World Health Organization). Diabetes is often linked to cardiovascular diseases and cancer and is associated with infection complications, such as Covid-19, that makes it more lethal (Tomic et al., 2022).

Plants are an abundant and affordable source of bioactive substances with significant potential for use in pharmaceutical products. This is particularly beneficial in developing countries, where access to synthetic medications is limited. (Przeor, 2022). Compared to chemical antidiabetic compounds, such as metformin, sulfonylureas, which have several side effects, plants tend to have fewer side effects. Plants are considered safe, effective, and may offer alternative mechanisms of action, which associated with multiple reaction between phytocompounds and cells proteins, for developing new medicinal products (ДРЛЗ; Ansaria et al., 2022).

Plants of the *Malvaceae* family (Mallows) are known to contain biologically active compounds such as carotenoids, phenolic acids, flavonoids, coumarins, alkaloids, polysaccharides that possess antidiabetic properties (Erukainure et al., 2019; Akhtar et al., 2022). Mallows are a diverse and economically important family, distributed in tropical and temperate climates in both hemispheres. The most well-known plants of this family are *Hibiscus sabdariffa* (roselle), *Malva sylvestris* L. (common mallow), *Althea rosea* (marschmallow), *Theobroma cacao* L. (cocoa tree), *Tilia* sp. (linden), *Gossypium* sp. (cotton), etc (Cvetković et al., 2021).

Some plants of the *Malvaceae* family are recognized as a medicinal plants and are included in pharmacopeias. For example, the Ukrainian pharmacopeia includes 9 monographs for 6 plants of the *Malvaceae* family, while British pharmacopeia – 10 monographs for 7 plants (ДФУ; BP; Samen et al., 2024).

The objective of this study – to conduct a comprehensive review of the literature regarding the antidiabetic properties of plants belonging to the *Malvaceae* family. Additionally, the investigation aimed to highlight the therapeutic benefits and possible application of these compounds in the treatment of this chronic disease.

Materials and methods. The literature analysis was analyzed from various academic sources, such as MDPI, Google Scholar, IntechOpen, Springer databases. The following keywords were used for the search: “Plant with antidiabetic properties”, “*Malvoideae* with antidiabetic properties”, “*Malvaceae* family plants nanoparticles with antidiabetic properties”.

Research results. The *Malvaceae* consist of over 4225 accepted species, and divided at 10 subfamillies: *Grewioideae, Kydia, Byttnerioideae, Helicteroideae, Sterculioideae, Brownlowioideae, Dombeyoideae, Tilioideae, Bombacoideae, Malvoideae* (Cvetković et al., 2021). From each of the *Malvaceae* subfamilies, several plants were selected by deliberate selection to contain all relevant research articles about biological activity and traditional applications in the context of diabetes mellitus and shown in fig 1.

Grewioideae. Grewia lasiodiscus leaves ethanolic extract has been shown to prevent glucose uptake by Saccharomyces cerevisiae. In an initial glucose solution (1 mg/ml), uptake was inhibited by 50%, whereas at 5 mg/ml, uptake reached to 75%. This adsorption is linked with tannins and flavonoids (Eloh et al., 2024).

Similarly, fruit extracts of *Grewia asiatica L.* (phalsa) were tested *in vivo* on rats with induced diabetes: glucose level in the control group averaged 175,0 ml/dl, while animals with diabetes had 395,15 ml/dl. The glucose level in the group that was treated with extract decreased to 115,0 ml/dl (Akram et al., 2021).

The 80% ethanolic leaf extract of *Corchorus olitorius* L. (nalta jute) was studied *in vivo* in rats. The extract was found to lowered the level of glucose in the blood and regenerate β-cells (Olysanya et al., 2018).

The methanol-macerated and freeze-dried fruit extract of *Desplatsia deweurei* exhibited antiglycemic activity on days 7, and 14 that was higher than glibenclamide (Idu et al., 2024).

Kydia. The powdered bark of Kydia calycina combined with other herbs, for example, Bombax ceiba (also belonging to the Malvaceae), has been shown to decrease blood glucose levels. However, it is mechanism of action remains unidentified (Goyal et al., 2020).

Byttnerioideae. Theobroma cacao L. (cocoa), *Theobroma grandiflorum* (cupuassu) liquors have been shown to increase the body and liver weights of diabetic rats and lower glucose levels. Over 40 days, the effect of the herbs on triacylglycerol levels in rat blood plasma was measured: the control group (received only water) had 513 ± 139 ml/dl; group cup1 (the animal was feed with 3,6 g/kg water solution of cupuassu liquor) – 286 ± 105 ml/dl; cup 2 (7,2 g/kg of cupuassu liquor) – 267 ± 112 ml/dl; coc 1 (3,6 g/kg water solution of cocoa liquor) – 328 ± 144 ml/dl; coc 2 (7,2 g/kg water solution of cocoa liquor) – 263 ± 122 ml/dl (De Oliveira et al., 2013). The aqueous extract of *Theobroma cacao* husk, considered agricultural waste, has also confirmed *in vitro* antidiabetic properties, which were investigated by an assay with a dialysis membrane and yeast (Cura et al., 2021).

A methanolic extract of the entire plant *Waltheria indica* L., obtained by the Soxhlet method, decreased the sugar level in the blood, cholesterol and triglyceride content, and had antioxidant activity proven by *in vivo* studies on rats (Kannan et al., 2016).

Helicteroideae. The bioactive compounds of Durio zibethinus L. (durian) fruit rinds of the plant chloroform fraction (concentration 1 000 μg/ml) inhibited α-amylase

Fig. 1. Subfamilies of *Malvaceae* and plants, which was reviewed in this work

Antidiabetic plants of the Malvaceae family and α-glucosidase enzymes by 83,06, 81,14% respectively, which were lower than acarbose. The studied fraction contained higher levels of flavonoids and quercetin, which help regulate hyperglycemia and prevent oxidant-mediated liver damage by reducing lipid peroxidation (Tran et al., 2023).

The ethanolic extract of roots and explants grown from the leaves of *Helicteres angustifolia* L. exhibits antiglycemic, antiradical, and immunomodulatory effects (Hu et al., 2016).

Sterculioideae. Sterculia villosa showed concentration-dependent activity against α-amylase and α-glucosidase. The IC_{50} of the methanolic leaf extract inhibits amylase at 87,73 ± 1,9 μg/ml, as opposed to 27,77 ± 1,4 μg/ml for the standard medication acarbose. The extract was active even at the lowest concentration. An in silico study identified stigmasterols as the most active antidiabetic structure compared to γ-sitosterol, lupeol, stigmata-3,5-dien (Hajra et al., 2024). Therefore, bith Sterculia foetida and Sterculia setigera have proven antidiabetic effects (Swarnalatha et al., 2019; Abba et al., 2022).

Cola nitida, *Cola acuminata* have been experimentally shown to exhibit hypoglycemic activity in rats. This activity is linked to the contents of caffeine, theobromine, phenols, tannins, saponins, flavonoids, and carotenoids (Erukainure et al., 2019; Victoria et al., 2023).

Abroma augusta, extracted with ethanol, which is rich in abromine (betaine), triterpenoids, alkaloids, triterpenes, flavonoids, megastigmenes, glycosides, has shown antiglycemic activity in clinical trials. The clinical trials were conducted at the Homeopathic medical college – Viniyaka mission hospital (Venkatesan et al., 2020).

Brownlowioideae. The ethanolic extract of Brownlowia tersa leaves reduced the catalytic activity of enzymes associated with diabetes (α-amylase and α-glucosidase), which is attributed to the following biologically active substances: quarcetine, myrecetine and catechol derivatives (Chakrabarty et al., 2020).

Dombeyoideae. The extracts of three species of Pterospermum xylocarpum leaves prevented glucose accumulation by the yeast model, with IC_{50} value for methanolic extract – 45,36 μg/ml and 81,9 μg/ml for water extracts. These results were further confirmed by in vivo studies using on a rat model (Jaber et al., 2018).

Tilioideae. The coumarins and tannins in the ethanolic extract of Tilia americana var. mexicana (linden) exhibited significant hypoglycemic activity for 4 hours after the rats received the 500 mg/kg extract compared to the control. The antioxidant activity of the extract, estimated by DPPH (EC_{50}), was 8,84 ± 1,05 mg/ml (Rodríguez-Magaña et al., 2019).

Bombacoideae. Polyphenolic compounds of Adansonia digitata (baobab) extracts inhibit the activity of digestive enzymes in vitro at various concentrations. The IC_{50} 4,5 μg gallic acid equivalent/ml modulates starch digestion by decreasing the activities of alpha-amylase and alpha-glucosidase. Additionally, baobab has a high content of fiber, which can also suppress the release of reducing sugar. Adansonia digitata L. fruits increase the number and size of Langerhans islets, regenerating pancreatic cells, which are destroyed by diabetic necrosis and fibrosis. The potential use of baobab for glycemic control has been investigated in various animal models, indicating it is antidiabetic effect in vivo (Silva et al., 2023).

Bombax ceiba is traditionally used to treat diabetes mellitus. The water and water-ethanolic solution (50, 95%) extracts of the plant had high levels of flavonoids and phenols, which inhibited α-amylase, α-glucosidase. The most important active compound identified in this study was determined to be mangiferin, which belong to phenolic compounds, xanthonoid (Katisart et al., 2020).

Malvoideae. The gallic and protocatechuic phenolic acids of Hibiscus sabdariffa (roselle) calyxes extracted with ethanol, demonstrated a higher inhibition rate of glycosidase compared to the extract prepared with n-hexane, ethyl acetate, n-butanol in both in vitro and in situ trials. In vivo experiments indicated that the level of rats blood sugar was reduced from 443,64 to 134,65 ml/dl after 15 days of oral administration 400 mg/kg of the ethanolic extract (Alegbe et al., 2019).

Similar results were obtained for the ethanolic fraction of *Hibiscus articulatus* leaves, which also lowered blood sugar levels in Wistar rats when administered at doses of 250 and 500 mg/kg (Yakubu et al., 2022).

The ethanol extracts of *Malva sylvestris*, *Malva pseudolavatera* leaves decreased levels of glucose in experimental animals (rats): the positive control had 119,67 mg/dl, the group treated with 1 000 mg/kg of *M. sylvestris* – 146,5 mg/dl, 1 000 mg/kg of *M. pseudolavatera* – 129,40 mg/dl. *Malva pseudolavatera* has a greater antiglycemic effect than *Malva sylvestris* (Sarmiento-Tomalá et al., 2020).

Malva neglecta, contains kaempferol, cinnamic acid, and other phenolic compounds, has scavenging potential, reduces insulin resistance and α-amylase activity, which was observed in *in vitro* and *in vivo* studies on Wistar rats (Akhtar et al., 2022).

Mucilage extracted from *Althea rosea* alleviates the action of hydrolytic enzymes that break down polysaccharides. It has been identified that mucilage contains glycosides, tannins, saponins, steroids. At higher concentration of mucilage (200 μg/ml) reduces α-amylase metabolic function to 75 ± 1,4% and α-glucosidase to 81 ± 1,2%. However, at the lowest concentration (40 μg/ml) it inhibits amylase, glucosidase to 35 ± 1,2, 44 ±

1,5%, respectively. Mucilage helps to control the level of glucose in the blood by water-holding capacity and swelling that intensifies the viscosity of small intestines and blocks glucose diffusion, also by glucose-binding between mucilage and polyphenols (Hassan et al., 2022).

The extract of *Thesperia garckeana,* contains a higher level of luteolin, which recognized for it is potential to inhibits α-amylase, α-glucosidase. This has been demonstrated throught *in vitro* results, and in experiments conducted on rats and by molecular docking studies (Alozieuwa et al., 2022).

Ethyl ether and ethanol were used to prepare extracts of *Gossypium herbaceum* (cotton), which has hypoglycemic action toward blood sugar in rats. After 14 days, the ethyl ether extract decreased glucose to 145,56 mg/dl, while the ethanol extract lowered to 133,75 mg/dl. In compassion, the control group of rats with diabetes has 489,16 mg/dl level and those treated with oral drug glibelclamide had level of 130,0 mg/dl. The mechanism of action is linked with increasing secretion from β-sell or accelerating the release of bounded insulin (Velmurugan et al., 2014).

The fruit and seeds of *Abelmoschus esculentus* L. (okra) have been investigated for their antidiabetic investigation. The OMA (okra mucilage extract), OSE (okra seed extract) significantly reduced blood sugar level from 392,66 to 284,83 and 338,16 mg/dl, respectively. Polyphenolic compounds of *Abelmoschus esculentus,* particularly quarcetine, can enhance insulin release from pancreatic beta cells. Quercetin has also antioxidant and vasodilator properties. The flavonoids generally regulate glucose homeostasis and insulin activity at the cellular level (Aleissa et al., 2022).

Pavonia odorata Willd. roots have a high level of essential oils, which have antiglycemic effects and toxicity. Chloroform, ethanol extract at 100 and 200 mg/kg concentration exhibited a maximal effect on lowering blood glucose levels after 10 days (Rayar et al., 2015).

The dosages of 200, 400 mg/kg of aqueous and ethanol extract of whole *Sida cordifolia* plant reduced hyperglycemia in rats with alloxan-induced diabetes, as level of serum triglyceride, cholesterol, etc (Rao et al., 2020).

Plant-based antidiabetic formulation. However, herbal mixtures often have low solubility in water, inadequate absorption, limited permeability. Additionally, the bioactive compounds of plants have rapid degradation and became instable in varying gastrointestinal tracts or under different environmental conditions. Moreover, managing chronic condition such as diabetes mellitus requires to use of large quantities of phytocompounds; however, the toxicity of these products is not yet fully discovered. Another concerns are the potential interaction between compounds within herbal mixtures (Kambale et al., 2022).

To solve the issue of bioavailability for the herbal extract, various types of nanoparticles have been developed. Therefore, we will describe some examples of nanoparticles with antidiabetic properties, that have been biosynthesized using water extract of the *Malvaceae* family plants, and summarize them in the able. This data specifies the importance of exploring plants from the *Malvaceae* family, for medicine to deal with diabetes mellitus and other diseases.

Conclusions. *Malvaceae* is a family of various plant species, that have antidiabetic activity. Leaves, fruit and herb extract possess antidiabetic activity by blocking of the enzymes (α-amylase, α-glucosidase) or by minimizing the adsorption of sugar by the digestive system. Several groups of bioactive compounds with hypoglycemic action have been identified: flavonoids, phenols, essential oils, tannins, etc. Nanoparticles synthesized with Mallows plant extract have antidiabetic activity, are made from various materials, such as metals and polymers, and were tested in *in vitro and in vivo* essays.

Table

Nanoparticles with antidiabetic activity that synthesized with aim of *Malvaceae* family plant extract

Plant	Part of plant	Nanocarrier	Size of nanoparticles	Antidiabetic activity essay that was used	
				Inhibition of α-amylase	Influence on glucose levels in rats
Sida cordifolia (Alam et al., 2023)	Aerial part	Chitosan	10–30	+	
Malva parfilova (Mohammed et al., 2022)	Leaves	Emulsion	7–20		+
Brachychiton populneus (Naveed et al., 2022)	Leaves	Silver	15		
Hibiscus sabdariffa (Bala et al., 2014)	Leaves	Zinc oxide	12–46		+
Abutilon indicum (Eswari et al., 2022)	Leaves	Zinc oxide	22	+	
Hibiscus rosa sinensis (Kainat et al., 2021)	Leaves	Cobalt oxide	19.98	+	
		Magnesium oxide	22,72	+	

BIBLIOGRAPHY

Державна Фармакопея України : у 3 т. ДП «Український науковий фармакопейний центр якості лікарських засобів». 2-е вид. Т. 3. Харків : ДП «Український науковий фармакопейний центр якості лікарських препаратів», 2014. 732 с.

ДРЛЗ. *Державний реєстр лікарських засобів України :* вебсайт. URL: http://www.drlz.com.ua/ (дата звернення: 15.01.2025).

Akhtar, M. F., Farooq, U., Saleem, A., Saleem, Md. H., Asraf, G. Md. Ameliorating Effect of *Malva neglecta* Wallr on obesity and diabetes in Wistar Rats: a mechanistic Study. *BioMed Research International*. 2022. Vol. 2022. 1. P. 1–15. Doi 10.1155/2022/2614599

Akram, Z., Noreen, A., Hussain, M., Inayat, M., Akhter, M., Farooqi, U. G., Akram, A., Sabzoi, W. A. *In-vivo* hypoglycemic activity of *Grewia asiatica* fruit extract in streptozotocin mediated diabetic rats. *Journal of Pharmaceutical Research International*. 2021. Vol. 33. 1. P. 68–75. Doi 10.9734/jpri/2021/v33i131140.

Alam, P., Imran, M., Ahmed, S., Majid, H., Akhtar, A. Chitosan nanoparticles for enhanced delivery of *Sida cordifolia* extract: formulation, optimization and bioactivity assessment. *Pharmaceuticals*. 2023. Vol. 16. 11. P. 1561. Doi 10.3390/ph16111561.

Alegbe, E. O., Terali, K., Olofinsan, K. A., Surgun, S., Ogbada, C. C., Ajiboye, T. O. Antidiabetic activity-guided isolation of gallic and protocatechuic acids from *Hibiscus sabdariffa* calyxes. *Journal of Food Biochemistry*. 2022. Vol. 43. 7. Doi 10.1111/jfbc.12927.

Aleissa, M. S., Al-Zharani, M., Alneghery, L. M., Hasnain, Md. S., Almutairi, B., Ali, D., Alarifi S., Alkahtani S. Comparative study of the anti-diabetic effect of mucilage and seed extract of *Abelmoschus esculentus* against streptozotocin-induced diabetes in rat model. *Journal of King Saud University – Science*. 2022. Vol. 34. 8. P. 102297. Doi 10.1016/j.jksus.2022.102297.

Alozieuwa, U. B., Lawal, B., Sani, S., Onikanni, A. S., Osuji, O., Ibrahim, Y. O., Babalola, S., B., Mostafa-Hedeab, G., Alsayegh, A. A., Conte-Junior, C. A. Luteolin-rich extract of *Thespesia garckeana* F. Hoffm. (Snot Apple) contains potential drug-like candidates and modulates glycemic and oxidoinflammatory aberrations in experimental animals. *Oxidative Medicine and Cellular Longevity*. 2022. P. 1–20. Doi 10.1155/2022/1215097.

Ansari, P., Akther, S., Hannan, J. M. A., Seidel, V., Nujat, N. J., Abdel-Wahab, Y. H. A. Pharmacologically active phytomolecules isolated from traditional antidiabetic plants and their therapeutic role for the management of diabetes mellitus. *Molecules*. 2022. Vol. 27. 13. P. 4278. Doi 10.3390/molecules27134278.

Bala, N., Saha, S., Chakraborty, M. Maiti, M., Das, S., Basu, R., Nandy, P. Green synthesis of zinc oxide nanoparticles using *Hibiscus subdariffa* leaf extract: effect of temperature on synthesis, anti-bacterial activity and anti-diabetic activity. *RSC Advances*. 2014. Vol. 5. 7. P. 4993–5003. Doi 10.1039/c4ra12784f.

British Pharmacopoeia: in 3 v. Medicine and Healthcare products Regulatory Agency. 2024th ed. V. 4 : Medicine and Healthcare products Regulatory Agency, 2024. 576 p.

Chakrabarty, B., Achryya, R. N., Kundu, N., Mahmud, I., Hossain, H., Biswas, N. N., Uddin, S. J., Dev, S., Das, A. K. Evaluation of Anti-Diabetic and Anti-Allergic Activities of *Brownlowia tersa* (L.) Kosterm Leaves Extract and Determination of its Phenolic Compounds by HPLC-DAD. *Tropical journal of natural product research.* 2020. Vol. 4. № 8.

Cura, J. K., Basilio, A., Llagas, Ma. C. Antidiabetic, anti-inflammatory and cytotoxic potential of *Theobroma cacao* Linn. husk aqueous extracts. *Clinical Phytoscience*. 2021. Vol. 7. № 1. Doi 10.1186/s40816-021-00320-1.

Cvetković, T., Fabiola, A.-B., Hinsinger, D. D. Thomas, D. C., Wieringa J. J., Ganesan, S. K., Strjk, J. S. Phylogenomics resolves deep subfamilial relationships in *Malvaceae* s.l. *G3 Genes Genomes Genetics*. 2021. Vol. 11. № 7. Doi 10.1093/g3journal/jkab136.

De Oliveira, T. B., Genovese, M. I. (2013). Chemical composition of cupuassu (*Theobroma grandiflorum*) and cocoa (*Theobroma cacao*) liquors and their effects on streptozotocin-induced diabetic rats. *Food Research International*. 2013. Vol. 51. 2. P. 929–935. Doi 10.1016/j.foodres.2013.02.019.

Diabetes. World Health Organization. URL: https://www.who.int/news-room/fact-sheets/detail/diabetes (дата звернення: 15.01.2025).

Eloh, K., Koza, B., Samalou, O., Sanvee, S. C. J., Bakai, M. F. Phytochemical analysis, antioxidant potential, and *in vitro* antidiabetic activity of *Grewia lasiodiscus* (K Schum) leaves extract. *Journal of Herbmed Pharmacology*. 2024. Vol. 13. 1. P. 129–136. Doi 10.34172/jhp.2024.48164.

Erukainure O. L., Sanni O., Ijomone O. M., Ibeji C. U., Chkwuma C. I., Islam Md S. The antidiabetic properties of the hot water extract of kola nut (*Cola nitida* (Vent.) Schott & Endl.) in type 2 diabetic rats. *Journal of Ethnopharmacology*. 2019. Vol. 242. P. 112033. Doi 10.1016/j.jep.2019.112033.

Eswari, K. M., Asaithambi, S., Karuppaiah, M., Sakthivel, P., Balaji, V., Ponelakkia, D. K., Yuvakkumar, R., Kumar, P., Vijayaprabhu, N., Ravi, G. Green synthesis of ZnO nanoparticles using *Abutilon indicum* and *Tectona grandis* leaf extracts for evaluation of anti-diabetic, anti-inflammatory and in-vitro cytotoxicity activities. *Ceramics International*. 2022. Vol. 48. 22. P. 33624–33634. Doi 10.1016/j.ceramint.2022.07.308.

Goyal, P. K., Jeyabalan, G. A comprehensive review on pharmacological properties of *Kydia calycina*. *International Journal of Pharmacognosy*. 2020. Vol. 11. 10.

Hajra, D., Chouni, A., Paul, A. Phytochemistry, antioxidant and anti-diabetic activities of Sterculia villosa *in-vitro*. *Pharmacological Research – Modern Chinese Medicine*. 2024. Doi 10.1016/j.prmcm.2024.100530.

Hassan, I., Ahmad, M., Banday, J. Extraction of polysaccharide from *Althea rosea* and its physicochemical, anti-diabetic, anti-hypertensive and antioxidant properties. *Scientific Reports*. 2022.Vol. 12. 1. Doi10.1038/s41598-022-20134-6.

Hu, X., Cheng, D., Zhang, Z. Antidiabetic activity of *Helicteres angustifolia* root. *Pharmaceutical Biology*. 2016. Vol. 54. 6. P. 938–944. Doi 10.3109/13880209.2015.1077871.

Idu, M., Gabriel, B. O., Osunde, M. O., Godwin, O. O. Anti-hyperglycemic potential of *Desplatsia dewevrei* (De Wild. & Th. Dur) Burret methanol seed extract in diabetic wistar rats. *Al-Qadisiyah Journal of Pure Science*. 2024. Vol. 29. 1. Doi 10.29350/2411-3514.1227.

Jaber, H. H., Kunchala, R., Babu, M. K. *In vitro* and *in vivo* anti-Diabetic activity of a nearly threatened woody tree species *Pterospermum xylocarpum*. *International Journal of Science and Research (IJSR).* 2018. Vol. 8. 11. Doi 10.21275/ART20202235.

Kainat, N., Khan, M. A., Ali, F., Faisal, S., Rizwan, M., Hussain, Z., Afsheen, Zaman N., Uddin, M. N., Bibi, N. Exploring the therapeutic potential of *Hibiscus rosa sinensis* synthesized cobalt oxide (Co3O4-NPs) and magnesium oxide nanoparticles (MgO-NPs). *Saudi Journal of Biological Sciences*. 2021. Vol. 28. 9. P. 5157–5167. Doi 10.1016/j.sjbs.2021.05.035.

Kambale, E. K., Leclercq, J. Q., Memvanga, P. B., Beloqui, A. An Overview of Herbal-Based Antidiabetic drug delivery Systems: Focus on Lipid- and Inorganic-Based nanoformulations. *Pharmaceutics*. 2022. Vol. 14. 10. Doi 10.3390/pharmaceutics14102135.

Kannan, M., Kumar, T. S., Rao, M. V. Antidiabetic and Antioxidant Properties of *Waltheria indica* L., an Ethnomedicinal Plant. *International Journal of Pharma Research and Health Sciences*. 2016. Vol. 4. 5. P. 1376–1384. Doi 10.21276/ijprhs.2016.05.07.

Katisart, T., Kriintong, N. *In vitro* antioxidant and antidiabetic activities of leaf and flower extracts from *Bombax ceiba*. *Pharmacognosy Research*. 2020. Vol. 12. 2. Doi 10.4103/pr.pr_116_19.

Mohammed, D. M., Elsayed, N., Baker, D. H. A., Ahmed, K., A., Sabry, B. A. Bioactivity and antidiabetic properties of *Malva parviflora* L. leaves extract and its nano-formulation in streptozotocin-induced diabetic rats. *Heliyon.* 2022. Vol. 8. 12. Doi 10.1016/j.heliyon.2022.e12027.

Naveed, M., Batool, H., Rehman, S., Javed, A., Makhdoom, A. I., Aziz, T., Mohamed, A. A., Sameeh, M. Y., Alruways, M. W., Dablool, A. S., Almalki, A. A., Alamri, A. S., Alhomrani, M. Characterization and evaluation of the antioxidant, antidiabetic, anti-inflammatory, and cytotoxic activities of silver nanoparticles synthesized using *Brachychiton populneus* leaf extract. *Processes*. 2022. Vol. 10. 8. Doi 10.3390/pr10081521.

Olusanya, A. R., Ifeoluwa, B. S., Jumoke, A. A., Khadijat, B. Antidiabetic and safety properties of ethanolic leaf extract of *Corchorus olitorius* in alloxan-induced diabetic rats. *InTech eBooks*. 2018. Doi 10.5772/intechopen.71529.

Przeor, M. Some Common Medicinal Plants with Antidiabetic Activity, Known and Available in Europe (A Mini-Review). *Pharmaceuticals*. 2022. Vol. 15. 1. Doi 10.3390/ph15010065.

Rao, Y. N., Babu, N. K., Srikanth, M. Anti-diabetic activity of *Sida cordifolia*. *Journal of Integral Sciences*. 2020. Vol. 3. 1. P. 1–7.

Rayar, A., Manivannan, R. Evaluation of antidiabetic activity from the root extracts of *Pavonia odorata* wild in alloxan induced diabetic rates. *International Journal of Pharmaceutical Science Invention*. 2015. Vol. 4. 5. P. 46–52. Doi 10.6084/m9.figshare.1473073.v1.

Rodríguez-Magaña, M. P., Cordero-Perez, P., Rivas-Morales, C., Oranday-Cardenas, A. O., Moreno-Pena, D. G., Garcia-Hernandez, D. G., Leos-Rivas, C. Hypoglycemic Activity of *Tilia americana, Borago officinalis, Chenopodium nuttalliae*, and *Piper sanctumon* Wistar Rats. *Journal of Diabetes Research*. 2019. Vol. 2019. 1–6. Doi 10.1155/2019/7836820.

Sameh, S., Elissawy, A. M., Al-Sayed, E., Labib, R. M., Chang, H.-W., Yu, S.-Y., Chang, F.-R., Yang, S.-C., Saingab, A. N. B. Family *Malvaceae*: a potential source of secondary metabolites with chemopreventive and anticancer activities supported with *in silico* pharmacokinetic and pharmacodynamic profiles. *Frontiers in Pharmacology*. 2024. Vol. 15. Doi 10.3389/fphar.2024.1465055.

Sarmiento-Tomalá, G. M., Miranda-Martinez, M., Gutierrez-Gaiten, Y. I., Delgado-Hernandez, R. Chemical Study, antioxidant capacity, and hypoglycemic activity of *Malva pseudolavatera* Webb & Berthel and *Malva sylvestris* L. (*Malvaceae*), grown in Ecuador. *Tropical Journal of Natural Product Research*. 2022. Vol. 4. 20. Doi 10.26538/tjnpr/v1i4.5.

Silva, M. L., Rita, K., Bernardo, M. A., Mesquita, M. F., Pintao, A. M., Moncada, M. *Adansonia digitata* L. (Baobab) bioactive compounds, biological activities, and the potential effect on glycemia: a narrative review. *Nutrients*. 2023. Vol. 15. 9. Doi 10.3390/nu15092170.

Swarnalatha, K., Babu, Ch. V. K., Babu, B. H. Phytochemical screening, anti-diabetic and antioxidant activities of *Kigelia africana* (LAM.) and *Sterculia foetida* L. *RASAYAN Journal of Chemistry*. 2019. Vol. 12. 2. P. 907–914. Doi 10.31788/rjc.2019.1225168.

Tomic, D., Shaw, J. E., Magliano, D. J. The burden and risks of emerging complications of diabetes mellitus. *Nature Reviews Endocrinology*. 2022. Vol. 18. 9. P. 525–539. Doi 10.1038/s41574-022-00690-7.

Tran, H. K., Nguyen, N. P. N, Nguyen, T. T. T., Nguyen, K. N., Do, B. D., Nguyen, T. V. A., Tran, A. K., Nguyen, T. K. C., Ho, Q. T., Truong, D.-H., Barrow, C. J., Nguyen, H. C. Extraction of flavonoids from durian (*Durio zibethinus*) fruit rinds and evaluation of their antioxidant, antidiabetic and anticancer properties. *International Journal of Food Science & Technology*. 2023. Vol. 59. 3. P. 1409–1420. Doi 10.1111/ijfs.16886.

Ukraine diabetes report 2000–2045. *International Diabetes Federation*. URL: https://diabetesatlas.org/data/en/country/207/ua.html (дата звернення: 15.01.2025).

Ukwnani-Kwaja, A. N., Nwaogu, J., Abba, A. Antidiabetic, antioxidant and hypolipidemic potentials of *Sterculia setigera* methanol stem bark extract in alloxan-induced diabetic rats. *International Journal of Advanced Biological and Biomedical Research*. 2022. Vol. 10. 1. P. 84–97. Doi 10.22034/ijabbr.2022.546271.1375.

Velmurugan, C., Bhargava, A. anti-diabetic activity of *Gossypium herbaceum* by Alloxan Induced Model in Rats. *PharmaTutor*. 2014. Vol. 2. 4. P. 126–132.

Venkatesan, H., Karthi, S. Hypoglycaemic effect of alcoholic extracts of the leaves of *Abroma Augusta & Gymnema Sylvestre* Plants in Type II Diabetes Mellitus Patients. *Indian Journal of Public Health Research & Development*. 2020. Doi 10.37506/ijphrd.v11i7.10096.

Victoria, O. O., Stephen, S. O., Ruth, O. O., Rufina, A. S. Y. Antidiabetic and antioxidative potentials of aqueous extract of *Cola acuminata* leaves in Alloxan-Induced diabetes mellitus in male albino rats. *Advances in Animal and Veterinary Sciences*. 2023. Vol. 11. 2. Doi 10.17582/journal.aavs/2023/11.2.305.309.

Yakubu, M. A., Anafi, S. B., Zezi, A. U., Mohammed, B. Chemical constituents and effect of ethanol leaf extract of *Hibiscus articulatus* Hochst. ex A. Rich. (*Malvaceae*) on glucose- and streptozotocin-induced hyperglycaemia using Wistar Rats. *Journal of Current Biomedical Research*. 2022. Vol. 2. P. 503–532. Doi 10.54117/jcbr.v2i5.8.

REFERENCES

Akhtar, M.F., Farooq, U., Saleem, A., Saleem, M., Rahman, Md.H., & Asraf, G.Md (2022). Ameliorating effect of *Malva neglecta* wallr on obesity and diabetes in wistar rats: A Mechanistic Study. *BioMed Research International*, *2022*, 1–15. https://doi.org/10.1155/2022/2614599.

Akram, Z., Noreen, A., Hussain, M., Inayat, M., Akhter, M., Farooqi, U.G., Akram, A., & Sabzoi, W.A. (2021). In-vivo hypoglycemic activity of *Grewia asiatica* fruit extract in streptozotocin mediated diabetic rats. *Journal of Pharmaceutical Research International*, 68–75. https://doi.org/10.9734/jpri/2021/v33i131140.

Alam, P., Imran, M., Ahmed, S., Majid, H., & Akhtar, A. (2023). Chitosan nanoparticles for enhanced delivery of *Sida cordifolia* extract: formulation, optimization and bioactivity assessment. *Pharmaceuticals*, *16* (11), 1561. https://doi.org/10.3390/ph16111561.

Alegbe, E.O., Terali, K., Olofinsan, K.A., Surgun, S., Ogbada, C.C., & Ajiboye, T.O. (2019). Antidiabetic activity-guided isolation of gallic and protocatechuic acids from *Hibiscus sabdariffa* calyxes. *Journal of Food Biochemistry*, *43* (7). https://doi.org/10.1111/jfbc.12927.

Aleissa, M.S., Al-Zharani, M., Alneghery, L.M., Hasnain, Md.S., Almutairi, B., Ali, D., Alarifi, S., & Alkahtani, S. (2022). Comparative study of the anti-diabetic effect of mucilage and seed extract of *Abelmoschus esculentus* against streptozotocin-induced diabetes in rat model. *Journal of King Saud University – Science*, *34* (8), 102297. https://doi.org/10.1016/j.jksus.2022.102297.

Alozieuwa, U.B., Lawal, B., Sani, S., Onikanni, A.S., Osuji, O., Ibrahim, Y.O., Babalola, S.B., Mostafa-Hedeab, G., Alsayegh, A.A., & Conte-Junior, C.A. (2022). Luteolin-rich extract of *Thespesia garckeana* F. Hoffm. (Snot Apple) contains potential drug-like candidates and modulates glycemic and oxidoinflammatory aberrations in experimental animals. *Oxidative Medicine and Cellular Longevity*, 1–20. https://doi.org/10.1155/2022/1215097.

Ansari, P., Akther, S., Hannan, J.M.A., Seidel, V., Nujat, N.J., & Abdel-Wahab, Y.H.A. (2022). Pharmacologically active phytomolecules isolated from traditional antidiabetic plants and their therapeutic role for the management of diabetes mellitus. *Molecules*, *27* (13), 4278. https://doi.org/10.3390/molecules27134278.

Bala, N., Saha, S., Chakraborty, M. Maiti, M., Das, S., Basu, R., & Nandy, P. (2014). Green synthesis of zinc oxide nanoparticles using *Hibiscus sabdariffa* leaf extract: effect of temperature on synthesis, anti-bacterial activity and anti-diabetic activity. *RSC Advances*, *5* (7), 4993–5003. https://doi.org/10.1039/c4ra12784f.

Chakrabarty, B., Achryya, R.N., Kundu, N., Mahmud, I., Hossain, H., Biswas, N.N., Uddin, S.J., Dev, S., & Das, A.K. (2020). Evaluation of Anti-Diabetic and Anti-Allergic Activities of *Brownlowia tersa* (L.) Kosterm Leaves Extract and Determination of its Phenolic Compounds by HPLC-DAD. *Tropical journal of natural product research, 4* (8).

Cura, J.K., Basilio, A., & Llagas, Ma.C. (2021). Antidiabetic, anti-inflammatory and cytotoxic potential of *Theobroma cacao* Linn. husk aqueous extracts. *Clinical Phytoscience*, 7 (1). https://doi.org/10.1186/s40816-021-00320-1.

Cvetković, T., Fabiola, A.-B., Hinsinger, D.D., Thomas, D.C., Wieringa, J.J., Ganesan, S.K., & Strjk, J.S. (2021). Phylogenomics resolves deep subfamilial relationships in *Malvaceae* s.l. *G3 Genes Genomes Genetics*, *11* (7). https://doi.org/10.1093/g3journal/jkab136.

De Oliveira, T.B., & Genovese, M.I. (2013). Chemical composition of cupuassu (*Theobroma grandiflorum*) and cocoa (*Theobroma cacao*) liquors and their effects on streptozotocin-induced diabetic rats. *Food Research International*, *51* (2), 929–935. https://doi.org/10.1016/j.foodres.2013.02.019.

Derzhavnyy reyestr likars'kykh zasobiv Ukrayiny [The national register of medicines of Ukraine]. Retrived from http://www.drlz.com.ua/ [in Ukrainian].

Eloh, K., Koza, B., Samalou, O., Sanvee, S.C.J., & Bakai, M.F. (2024). Phytochemical analysis, antioxidant potential, and in vitro antidiabetic activity of *Grewia lasiodiscus* (K Schum) leaves extract. *Journal of Herbmed Pharmacology*, *13* (1), 129–136.
https://doi.org/10.34172/jhp.2024.48164.

Erukainure, O.L., Sanni, O., Ijomone, O.M., Ibeji, C.U., Chkwuma, C.I., & Islam, Md.S. (2019). The antidiabetic properties of the hot water extract of kola nut (*Cola nitida* (Vent.) Schott & Endl.) in type 2 diabetic rats. *Journal of Ethnopharmacology*, *242*, 112033. https://doi.org/10.1016/j.jep.2019.112033.

Eswari, K.M., Asaithambi, S., Karuppaiah, M., Sakthivel, P., Balaji, V., Ponelakkia, D.K., Yuvakkumar, R., Kumar, P., Vijayaprabhu, N., & Ravi, G. (2022). Green synthesis of ZnO nanoparticles using *Abutilon indicum* and *Tectona grandis* leaf extracts for evaluation of anti-diabetic, anti-inflammatory and in-vitro cytotoxicity activities. *Ceramics International*, *48* (22), 33624–33634. https://doi.org/10.1016/j.ceramint.2022.07.308.

Goyal, P.K., & Jeyabalan, G. (2020). A comprehensive review on pharmacological properties of *Kydia calycina*. *International Journal of Pharmacognosy*, 11 (10).

Hajra, D., Chouni, A., & Paul, A. (2024). Phytochemistry, antioxidant and anti-diabetic activities of *Sterculia villosa* in-vitro. *Pharmacological Research – Modern Chinese Medicine*, 100530. https://doi.org/10.1016/j.prmcm.2024.100530.

Hassan, I., Ahmad, M., & Banday, J (2022). Extraction of polysaccharide from *Althea rosea* and its physicochemical, anti-diabetic, anti-hypertensive and antioxidant properties. *Scientific Reports*, *12* (1). https://doi.org/10.1038/s41598-022-20134-6.

Hu, X., Cheng, D., & Zhang, Z. (2016). Antidiabetic activity of *Helicteres angustifolia* root. *Pharmaceutical Biology*, *54* (6), 938–944. https://doi.org/10.3109/13880209.2015.1077871.

Idu, M., Gabriel, B.O., Osunde, M.O., & Godwin O.O. (2024). Anti-hyperglycemic Potential of *Desplatsia dewevrei* (De Wild. & Th. Dur) Burret Methanol Seed Extract in Diabetic Wistar Rats. *Al-Qadisiyah Journal of Pure Science*, *29* (1). https://doi.org/10.29350/2411-3514.1227.

Jaber, H.H., Kunchala, R., & Babu, M.K. (2018). *In vitro* and *in vivo* anti-diabetic activity of a nearly threatened woody tree species *Pterospermum xylocarpum. International Journal of Science and Research (IJSR)*. http://dx.doi.org/10.21275/ART20202235.

Kainat, N., Khan, M.A., Ali, F., Faisal, S., Rizwan, M., Hussain, Z., Afsheen, Zaman N., Uddin, M.N., & Bibi, N. (2021). Exploring the therapeutic potential of Hibiscus rosa sinensis synthesized cobalt oxide (Co3O4-NPs) and magnesium oxide nanoparticles (MgO-NPs). *Saudi Journal of Biological Sciences*, *28* (9), 5157–5167. https://doi.org/10.1016/j.sjbs.2021.05.035.

Kambale, E.K., Leclercq, J.Q., Memvanga, P.B., & Beloqui, A. (2022). An Overview of Herbal-Based Antidiabetic drug delivery Systems: Focus on Lipid- and Inorganic-Based nanoformulations. *Pharmaceutics*, *14* (10), 2135. https://doi.org/10.3390/pharmaceutics14102135.

Kannan, M., Kumar, T.S., & Rao, M.V. (2016). Antidiabetic and Antioxidant Properties of *Waltheria indica* L., an Ethnomedicinal Plant. *International Journal of Pharma Research and Health Sciences*, *4* (5), 1376–1384. https://doi.org/10.21276/ijprhs.2016.05.07.

Katisart, T., & Kriintong, N. (2020). *In vitro* antioxidant and antidiabetic activities of leaf and flower extracts from *Bombax ceiba*. *Pharmacognosy Research*, *12* (2), 194. https://doi.org/10.4103/pr.pr_116_19.

Medicine and Healthcare products Regulatory Agency. British Pharmacopoeia: in 3 v. (Vol. 4) London.

Mohammed, D.M., Elsayed, N., Baker, D.H.A., Ahmed, K.A., & Sabry, B.A. (2022). Bioactivity and antidiabetic properties of *Malva parviflora* L. leaves extract and its nano-formulation in streptozotocin-induced diabetic rats. *Heliyon*, *8* (12), 12027. https://doi.org/10.1016/j.heliyon.2022.e12027.

Naveed, M., Batool, H., Rehman, S., Javed, A., Makhdoom, A.I., Aziz, T., Mohamed, A.A., Sameeh, M.Y., Alruways, M.W., Dablool, A.S., Almalki, A.A., Alamri, A.S., & Alhomrani, M. (2022). Characterization and evaluation of the antioxidant, antidiabetic, anti-inflammatory, and cytotoxic activities of silver nanoparticles synthesized using *Brachychiton populneus* leaf extract. *Processes*, *10* (8), 1521. https://doi.org/10.3390/pr10081521.

Olusanya, A.R., Ifeoluwa, B.S., Jumoke, A.A., & Khadijat, B. (2018). Antidiabetic and safety properties of ethanolic leaf extract of *Corchorus olitorius* in Alloxan-Induced Diabetic Rats. In *InTech eBooks*. https://doi.org/10.5772/intechopen.71529.

Przeor, M. (2022). Some Common Medicinal Plants with Antidiabetic Activity, Known and Available in Europe (A Mini-Review). *Pharmaceuticals*, *15* (1), 65. https://doi.org/10.3390/ph15010065.

Rao, Y.N., Babu, N.K., & Srikanth, M. (2020). Anti-diabetic activity of Sida *Cordifolia*. *Journal of Integral Sciences*, *3* (1), 1–7.

Rayar, A., & Manivannan, R. (2015). Evaluation of antidiabetic activity from the root extracts of *Pavonia odorata* wild in alloxan induced diabetic rates. *International Journal of Pharmaceutical Science Invention*, *4* (5), 46–52. https://doi.org/10.6084/m9.figshare.1473073.v1.

Rodríguez-Magaña, M.P., Cordero-Perez, P., Rivas-Morales, C., Oranday-Cardenas, A.O., Moreno-Pena, D.G., Garcia-Hernandez, D.G., & Leos-Rivas, C. (2019). Hypoglycemic Activity of *Tilia americana,Borago officinalis,Chenopodium nuttalliae, and Piper sanctumon* Wistar Rats. *Journal of Diabetes Research*, *2019*, 1–6. https://doi.org/10.1155/2019/7836820.

Sameh, S., Elissawy, A.M., Al-Sayed, E., Labib, R.M., Chang, H.-W., Yu, S.-Y., Chang, F.-R., Yang, S.-C., & Saingab, A.N.B. (2024). Family *Malvaceae*: a potential source of secondary metabolites with chemopreventive and anticancer activities supported with in silico pharmacokinetic and pharmacodynamic profiles. *Frontiers in Pharmacology*, *15*. https://doi.org/10.3389/fphar.2024.1465055.

Sarmiento-Tomalá, G.M., Miranda-Martinez, M., Gutierrez-Gaiten, Y.I., & Delgado-Hernandez, R. (2020) Chemical study, antioxidant capacity, and hypoglycemic activity of *Malva pseudolavatera* Webb & Berthel and *Malva sylvestris* L. (*Malvaceae*), grown in Ecuador. *Tropical Journal of Natural Product Research*, 4 (20). http://www.doi.org/10.26538/tjnpr/v1i4.5.

Silva, M.L., Rita, K., Bernardo, M.A., Mesquita, M.F., Pintao, A.M., & Moncada, M. (2023). *Adansonia digitata* L. (Baobab) bioactive compounds, biological activities, and the potential effect on glycemia: a narrative review. *Nutrients*, *15* (9), 2170. https://doi.org/10.3390/nu15092170.

Swarnalatha, K., Babu, Ch.V.K., & Babu, B.H. (2019). Phytochemical screening, anti-diabetic and antioxidant activities of *Kigelia africana* (LAM.) and *Sterculia foetida* L. *RASAYAN Journal of Chemistry*, *12* (02), 907–914. https://doi.org/10.31788/rjc.2019.1225168.

Tomic, D., Shaw, J.E., & Magliano, D.J. (2022). The burden and risks of emerging complications of diabetes mellitus. *Nature Reviews Endocrinology*, *18* (9), 525–539. https://doi.org/10.1038/s41574-022-00690-7.

Tran, H.K., Nguyen, N.P.N, Nguyen, T.T.T., Nguyen, K.N., Do, B.D., Nguyen, T.V.A., Tran, A.K., Nguyen, T.K.C., Ho, Q.T., Truong, D.-H., Barrow, C.J., & Nguyen, H.C. (2023). Extraction of flavonoids from durian (*Durio zibethinus*) fruit rinds and evaluation of their antioxidant, antidiabetic and anticancer properties. *International Journal of Food Science & Technology*, *59* (3), 1409–1420. https://doi.org/10.1111/ijfs.16886.

Ukraine diabetes report 2000–2045. International Diabetes Federation. Retrived from https://diabetesatlas.org/data/en/country/207/ua.html.

Ukrainskyi Naukovyi Farmakopeinyi Tsenter Yakosti Likarskykh Zasobiv (2014). Derzhavna farmakopeya Ukrayiny u 3 t [The State Pharmacopoeia of Ukraine]. (Vol. 3) Kharkiv (in Ukrainian).

Ukwnani-Kwaja, A.N., Nwaogu, J., & Abba, A. (2022). Antidiabetic, antioxidant and hypolipidemic potentials of *Sterculia setigera* methanol stem bark extract in alloxan-induced diabetic rats. *International Journal of Advanced Biological and Biomedical Research*, 10 (1), 13–18. https://doi.org/10.22034/ijabbr.2022.546271.1375.

Velmurugan, C., & Bhargava, A. (2014) Anti-Diabetic activity of *Gossypium Herbaceum* by Alloxan Induced Model in Rats. *PharmaTutor*, 2 (4), 126–132.

Venkatesan, H., & Karthi, S. (2020). Hypoglycaemic effect of alcoholic extracts of the leaves of *Abroma Augusta* & *Gymnema Sylvestre* Plants in Type II diabetes mellitus patients. *Indian Journal of Public Health Research & Development*. https://doi.org/10.37506/ijphrd.v11i7.10096.

Victoria, O.O., Stephen, S.O., Ruth, O.O., & Rufina, A.S.Y. (2023). Antidiabetic and antioxidative potentials of aqueous extract of *Cola acuminata* leaves in alloxan-induced diabetes mellitus in male albino rats. *Advances in Animal and Veterinary Sciences*, *11* (2). https://doi.org/10.17582/journal.aavs /2023/ 11.2.305.309.

World Health Organization. Diabetes. Retrived from https://www.who.int/news-room/fact-sheets/detail/diabetes.

Yakubu, M.A., Anafi, S.B., Zezi, A.U., & Mohammed, B. (2022). Chemical Constituents and Effect of Ethanol Leaf Extract of *Hibiscus articulatus* Hochst. ex A. Rich. (*Malvaceae*) on Glucose- and Streptozotocin-Induced Hyperglycaemia using Wistar Rats. *Journal of Current Biomedical Research*, *2* (5), 503–532. https://doi.org/10.54117/jcbr.v2i5.8.

Стаття надійшла до редакції 15.11.2024
Стаття прийнята до друку 24.03.2025

The authors declare no conflict of interest.

Funding: The study was funded by the Ministry of Health of Ukraine [grant number: 0123U100153]; grants of the National Research Foundation of Ukraine 2023.03/0104; 2023.05/0021.

Contribution of the authors:
Kulakivska A. – data collection and analysis, article writing;
Hnativ I. – collection of data, annotations;
Konechnyi Yu. – analysis of data, literature review;
Karkhut A. – analysis of data, annotations, text editing;
Polovkovych S. – collection and analysis of data, annotations;
Zhurakhivska L. – collection of data, conclusions;
Konechna R. – final approval of the article, correction of the article.

Acknowledgments: The authors express their gratitude to the Armed Forces of Ukraine.

Email address for correspondence with authors: ***anastasiia.kulakivska.mnbtm.2024@lpnu.ua***