Macedonian Pharmaceutical Bulletin, 72 (Suppl 1) 419 - 420 (2026)
Online ISSN: 1857-8969
DOI: 10.33320/maced.pharm.bull.2026.72.03.202
Short communication

Pharmacological perspectives of *Centaurium erythraea*, *Salvia officinalis* and *Morus alba* in metabolic disorders: opportunities for evaluation using advanced 3D pancreatic cell models

Lina Boshnakoska*, Veronika Stoilkovska Gjorgievska, Ana Trajkovska Matevska, Iskra Davkova, Filip Todorov, Marija Karapandzova, Gjoshe Stefkov, Ivana Cvetkovikj Karanfilova

Institute of Pharmacognosy, Faculty of Pharmacy, Ss. Cyril and Methodius University in Skopje, Majka Tereza 47, 1000 Skopje, Republic of North Macedonia

Introduction

Diabetes mellitus (DM) and associated metabolic disorders remain major global health challenges characterized by impaired glucose homeostasis, oxidative stress, chronic inflammation and progressive pancreatic *β*-cell dysfunction. Despite advances in pharmacotherapy, the increasing prevalence of diabetes highlights the need for novel preventive and therapeutic approaches. Medicinal plants continue to attract considerable interest as sources of bioactive compounds with antihyperglycemic, antioxidant and cytoprotective activities. Among them, *Centaurium erythraea* (CE), *Salvia officinalis* (SO) and *Morus alba* (MA) were selected for their complementary relevance as a traditional Balkan medicinal plant, a globally recognized medicinal species and a nutraceutical with documented antidiabetic potential, respectively. Recent advances in physiologically relevant 3D cell cultures, bioreactor systems and fluorescence microscopy offer new opportunities for investigating the antidiabetic activity and mechanisms of action of natural products.

Centaurium erythraea, Balkan medicinal plant with β-cell protective potential

Centaurium erythraea Rafn. from Gentianaceae is a well-known medicinal plant traditionally used throughout the Balkan region for digestive and metabolic disorders. Its phytochemical profile is characterized by secoiridoids, particularly gentiopicroside, swertiamarin and sweroside, together with xanthones, flavonoids and phenolic acids. Recent studies demonstrated that hydromethanolic extracts of CE improve insulin secretion, reduce oxidative stress and protect pancreatic *β*-cells from oxidative and nitrosative damage. Furthermore, restoration of glutathione homeostasis and modulation of antioxidant enzymes suggest a significant cytoprotective potential. These findings position CE as a candidate for validation in 3D pancreatic spheroid cultures and bioreactor systems, where multicellular architecture allows for more accurate monitoring of *β*-cell viability and insulin secretory dynamics under simulated diabetic stress (Đorđević et al., 2020).

*Lboshnakoska@yahoo.com

Salvia officinalis, multitarget metabolic modulator

Salvia officinalis L. (Lamiaceae) is among the most extensively investigated medicinal and aromatic plants worldwide. Sage contains rosmarinic acid, carnosic acid, flavonoids and volatile terpenoids (Cvetkovikj et al., 2013). Experimental and clinical studies have demonstrated antihyperglycemic, antioxidant and anti-inflammatory effects through modulation of insulin sensitivity, enhancement of glucose uptake, inhibition of carbohydrate-digesting enzymes and regulation of lipid metabolism (Abd Rashed and Rathi, 2021).

The complex pharmacological profile of SO suggests that advanced 3D cell culture systems could provide valuable insights into the interconnected cellular responses and molecular mechanisms underlying its antidiabetic activity.

Morus alba (MA): nutraceutical plant with capacity for glucose regulation

Morus alba L. (Moraceae) is widely recognized as a medicinal and nutraceutical plant with significant potential in metabolic disease management. The leaves are rich in flavonoids, chlorogenic acid derivatives and the iminosugar 1-deoxynojirimycin (DNJ), a potent α-glucosidase inhibitor. Experimental and clinical studies have demonstrated beneficial effects on glycemic control, insulin sensitivity, oxidative stress and pancreatic islet cell protection. The growing incorporation of MA into nutraceutical products highlights its translational potential and supports its further investigation using advanced cellular models (Chan et al., 2016).

Advanced 3D screening paradigms for phytochemical candidates

Recent advances in analytical and cellular technologies have expanded the possibilities for investigating the antidiabetic activity and mechanisms of action of CE, SO and MA. Characterization of their diverse secondary metabolites, ranging from secoiridoids and phenolics to volatile terpenoids and iminosugars, is achieved using modern HPLC-DAD, GC-MS and LC-MS/MS platforms.

Furthermore, 3D pancreatic cell models and bioreactor systems provide physiologically relevant platforms that bridge the gap between conventional *in vitro* studies and *in vivo* conditions. Combined with fluorescence microscopy, these systems enable assessment of *β*-cell viability, oxidative stress, apoptosis and intracellular signaling pathways, contributing to a better understanding of the mechanisms underlying pancreatic *β*-cell protection.

Conclusion

Centaurium erythraea, Salvia officinalis and *Morus alba* possess well-documented pharmacological potential in managing metabolic disorders acting through overlapping antioxidant, anti-inflammatory, and antihyperglycemic pathways. Beyond traditional ethnomedical data, evaluation of these species using modern 3D pancreatic cell models and fluorescence imaging approaches may contribute to a deeper understanding of their mechanisms of action. Merging phytochemical profiling with physiologically relevant 3D bio-assays provides a robust framework for discovering complex mechanisms of action as well as synergistic natural product combinations for diabetes management.

References

Abd Rashed, A. and Rathi, D.-N.G., 2021. Bioactive Components of Salvia and Their Potential Antidiabetic Properties: A Review. Molecules 26(10), 3042. https://doi.org/10.3390/molecules26103042

Chan, E.W.-C. et al., 2016. Phytochemistry, pharmacology, and clinical trials of Morus alba. Chinese Journal of Natural Medicines 14(1), 17–30. https://doi.org/10.3724/SP.J.1009.2016.00017

Cvetkovikj, I. et al., 2013. Polyphenolic characterization and chromatographic methods for fast assessment of culinary Salvia species from South East Europe. Journal of Chromatography A 1282, 38–45. https://doi.org/10.1016/j.chroma.2012.12.068.

Đorđević, M. et al., 2020. Centaurium erythraea extract reduces redox imbalance and improves insulin expression and secretion in pancreatic β-cells exposed to oxidative and nitrosative stress. Archives of Biological Sciences 72(1), 117–128.