Stručni skup DKTK

11.07.2024., Koprivnica

DKTK

DRUŠTVO KEMIČARA I TEHNOLOGA KOPRIVNICA

Biljke i biljni pripravci za zdravlje i ljepotu: Znanstveni pogled

Doc. dr. sc. Dunja Šamec

Odjel za prehrambenu tehnologiju, Sveučilište Sjever, Koprivnica

Sveučilište Sjever

Biljke kroz život za zdravlje i ljepotu

Kamilica ili **komorač** protiv grčeva

Čaj od šipka za umirenje želuca

Kozmetički proizvodi s biljnim ektraktima

Alkoholni napici s biljem- za sve

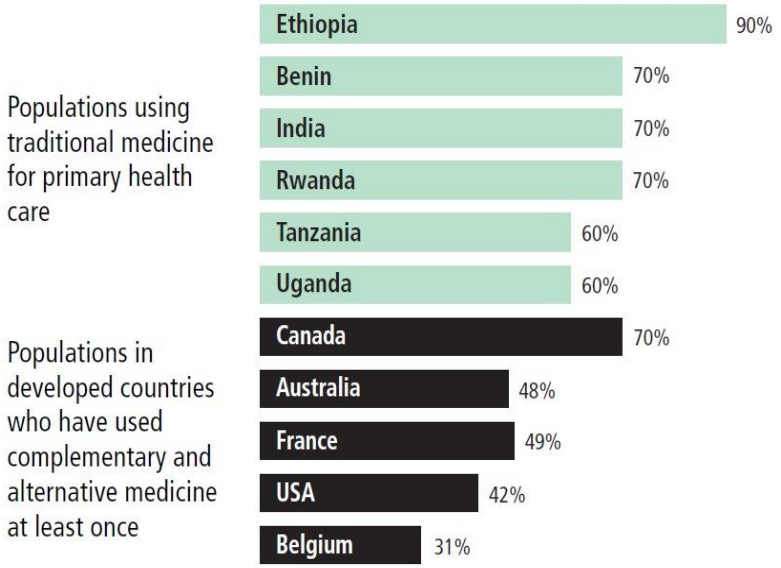
Soja za pomoć kod regulacije hormona

Ginko za kognitivne funkcije

Upotreba biljaka u liječenju poznata od davnina

- Najstariji pisani tragovi o upotrebi biljaka u liječenju stari oko 5000 godina
- Upotreba zabilježena u zapisima gotovo svih poznatih kultura širom svijeta

Figure 1 **Many developing country populations use TM to help meet health care needs, while many populations in developed countries have used CAM at least once**



Sources: Eisenberg DM et al, 1998; Fisher P & Ward A, 1994; Health Canada, 2001; World Health Organization, 1998; and government reports submitted to WHO.

Suvremena upotreba biljaka

Krajem 19. st. i početkom 20. st. s razvojem organske kemije i sintetičkih lijekova biljke padaju u drugi plan

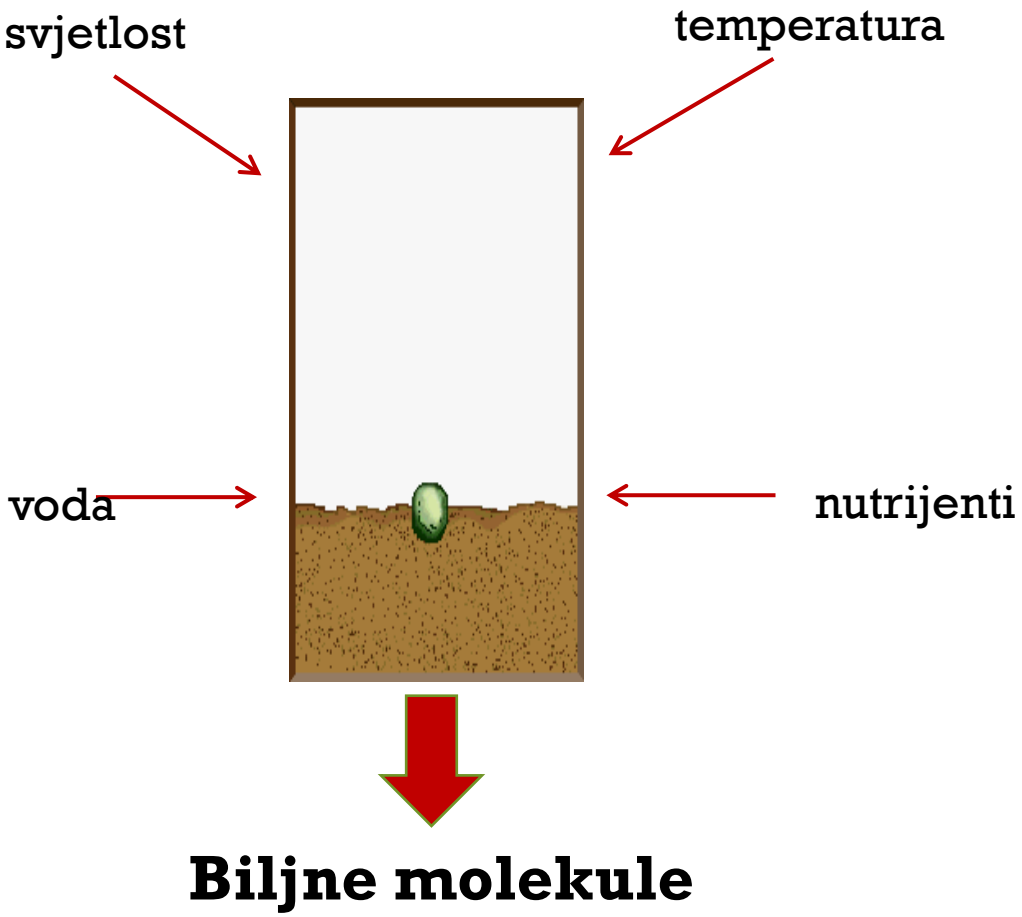
Krajem 20. st. i početkom novog milenija→ trend ´*zdravog*´ načina života→ ponovno okretanje prirodi

- Raste tržište dodataka prehrani i kozmetičkih proizvoda baziranih na biljkama
- Raste tržište funkcionalne hrane
- ´Superhrana´
- ´Super biljke´

Gdje je tu znanost?

- Od ukupnog broja biljaka (300 000) većina znanstvenika se bavi modelnim biljkama (manje od 100)
- Fitokemikalije se određene u oko 15-20% biljaka
- Biosintetski putovi i biološka uloga fitokemikalija najčešće nepoznata

Fitokemikalije (biljne molekule)



Bioaktivne molekule- pokazuju biološku aktivnost- štite biljku, prenose signale, privlače životinje za oprašivanje i sl.

Zbog svoje specifične kemijske strukture imaju:

Antioksidativni učinak-> štite od slobodnih radikala

Antibakterijski učinak -> uništavaju bakterije

Antiviralni učinak -> uništavaju viruse

Odgovorni za upotrebu biljaka, od pradavnih vremena, u liječenju, ublažavanju bolesti, u kozmetici, održavanje higijene i sl.

Karotenoidi
- U crvenom, žutom, naranđastu voću, povrću, cvijeću…
- Antioksidativna aktivnost, preveniraju nastanak karcinoma, oboljenja krvožilnog sustava te pomažu imunosustavu

Fitosteroli
- U sjemenkama suncokreta, sezamu, koštunjičavom voću, soji…
- Zaštita od karcinoma debelog crijeva, smanjuju kolesterol→ slične kolesterolu te sprečavaju apsorpciju kolesterola

Saponini
- U leguminozama, špinatu
- Pomažu imunosustavu, smanjuju razinu kolesterola te štite od nastanka krvožilnih oboljenja

Glukozinolati
- U biljkama iz porodice krstašica- zelje, cvijetaća, brokula…
- Pomažu kod upalnih oboljenja te smanjuju rizik od nastanka nekih vrsta hormonalno uvjetovanih karcinoma

Polifenoli
- U različitom voću i povrću -- > posebno obojenom
- Antioksidativna, antibakterijska, antiviralna svojstva, štite od nastanka karcinoma, krvožilnih oboljenja i sl.

Alkaloidi

Nađeni u velikom broju biljaka, oko 10-25% biljaka ih sadrži

Mnogi lijekovi su alkaloidi ali i većina droga- morfin, THC…

Terpeni

- U raznovrsnom bilju, ulaze u sastav eteričnih ulja
- Neki imaju antitumorska svojstva
- Upotreba u aromaterapiji

Fitoestrogeni

- Žitu, leguminozama te proizvodima od žita
- Slični spolnim hormonima te imaju ulogu u zaštiti od tumora uzrokovanih hormonima- karcinom dojke, maternice, prostate ali također pozitivno utječu na kardiovaskularne bolesti, bolesti mozga, osteoporozu…

Sulfidi

Komponente koje sadrže sumpor, prisutne u biljkama iz porodici ljiljana- luk, poriluk, šparoge, češnjak…

Antibakterijska, antioksidativna svojstva, smanjuju kolesterol, štite od nekih vrsta karcinoma…

Kumarini

- Nađeni u različitim biljkama
- Neki mogu imati ulogu u zaštiti od virusa HIV-a, antitumorska svojstva, antiseptička, za tretman astme…

Send Orders for Reprints to reprints@benthamscience.ae

Current Medicinal Chemistry, **2018**, *25*, 1-11

REVIEW ARTICLE

Rutin as Neuroprotective Agent: From Bench to Bedside

Barbara Budzynska[1], Caterina Faggio[2], Marta Kruk-Slomka[1], Dunja Samec[3], Seyed Fazel Nabavi[4], Antoni Sureda[5,6], Kasi Pandima Devi[7] and Seyed Mohammad Nabavi[4,*]

[1]*Department of Pharmacology and Pharmacodynamics, Medical University of Lublin, Chodzki 4a Street, 20-093 Lublin, Poland;* [2]*Department of Biological and Environmental Sciences, University of Messina Viale Ferdinando Stagno d'Alcontres, 31 98166, S.Agata, Messina, Italy;* [3]*Department of Molecular Biology, Institute Ruđer Bošković, Bijenička c. 54, 10000 Zagreb, Croatia;* [4]*Applied Biotechnology Research Center, Baqiyatallah University of Medical Sciences, Tehran, Iran;* [5]*Research Group on Community Nutrition and Oxidative Stress (NUCOX), University of Balearic Islands, E-07122 Palma de Mallorca, Balearic Islands, Spain;* [6]*CIBEROBN (Physiopathology of Obesity and Nutrition), E-07122 Palma de Mallorca, Balearic Islands, Spain;* [7]*Department of Biotechnology, Alagappa University, Karaikudi 630 004, Tamil Nadu, India*

ARTICLE HISTORY

Received: December 16, 2016
Revised: September 20, 2017
Accepted: September 22, 2017

DOI: 10.2174/0929867324666171003114154

Abstract: Flavonoids are major dietary constituents of plant-based food found ubiquitously in plant kingdom where they are usually present in substantial amounts. Rutin is a flavonol-type polyphenol which consists of the flavonol quercetin and the disaccharide rutinose. Rutin has been reported to exert diverse biological effects such as antitumor and antimicrobial mainly associated to its antioxidant and anti-inflammatory activities. Mental, neurological, and behavioural disorders are an important and growing cause of morbidity. Most of these disorders combine a high prevalence, early onset, progressive clinical course, and impairment of critical brain functions making them a major contributor to the global disease burden. In the present work, the biological *in vitro* and *in vivo* effects and the potential therapeutic applications of rutin in neurodegenerative processes are reviewed, as well as their bioavailability and pharmacokinetics, which are essential for a better understanding of its biological effectiveness. Moreover, the present review also provides an overview of the molecular mechanisms through which rutin proposed to exert its neuroprotective effects.

Keywords: Alzheimer's disease, Antioxidant, Flavonoid, Neurodegenerative diseases, Polyphenols, Rutin.

Pharmacological Research 128 (2018) 359–365

Contents lists available at ScienceDirect

Pharmacological Research

journal homepage: www.elsevier.com/locate/yphrs

Invited review

Apigenin as neuroprotective agent: Of mice and men

Seyed Fazel Nabavi[a], Haroon Khan[b,*], Grazia D'onofrio[c], Dunja Šamec[d], Samira Shirooie[e], Ahmad Reza Dehpour[e,f], Sandro Argüelles[g], Solomon Habtemariam[h], Eduardo Sobarzo-Sanchez[i,j]

[a] *Applied Biotechnology Research Center, Baqiyatallah University of Medical Sciences, Tehran 14359-16471, Iran*
[b] *Depatment of Pharmacy, Abdul Wali Khan University, Mardan 23200, Pakistan*
[c] *Gerontology-Geriatric Research Laboratory, Department of Medical Sciences, I.R.C.C.S. "Casa Sollievo della Sofferenza", Foggia, Italy*
[d] *Department of Molecular Biology, Institute 'Ruđer Bošković', Zagreb, Croatia*
[e] *Department of Pharmacology, Faculty of Medicine, Tehran University of Medical Sciences, Tehran, Iran*
[f] *Experimental Medicine Research Center, Tehran University of Medical Sciences, Tehran, Iran*
[g] *Department of Physiology, Faculty of Pharmacy, University of Seville, Seville, Spain*
[h] *Pharmacognosy Research Laboratories & Herbal Analysis Services UK, University of Greenwich, Chatham-Maritime, Kent ME4 4TB, UK*
[i] *Laboratory of Pharmaceutical Chemistry, Faculty of Pharmacy, University of Santiago de Compostela 15782, Spain*
[j] *Instituto de Investigación en Innovación en Salud, Facultad de Ciencias de la Salud, Universidad Central de Chile, Santiago, Chile*

ARTICLE INFO

Article history:
Received 29 September 2017
Received in revised form 13 October 2017
Accepted 16 October 2017
Available online 18 October 2017

Keywords:
Neuroprotection
Alzheimer's disease
Parkinson's disease
Apigenin
Flavonoids

ABSTRACT

Neurodegenerative disorders (NDDs) such as Alzheimer's and Parkinson's diseases are the most common age-related pathologies that affect millions of people all over the world. To date, effective therapy for NDDs is not available and current approaches to disease management include neuroprotection strategy with a hope of maintaining and enhancing the function of surviving neurons. Of course, such an approach by its own will not offer a cure but is likely to delay the disease progression by ameliorating the increase of neurotoxic agents such reactive oxygen species (ROS) as well as the associated inflammatory cascades. In this regard, natural products including flavonods that offer neuroprotection through multiple mechanisms have gained a lot of interest in recent years. In this communication, evidences from the various experimental models and clinical trials on the therapeutic potential of one promising flavonod, apigenin, is presented. Its chemistry, mechanism of action and potential benefits in the various examples of NDDs are discussed in the light of drug discovery aspects.

Mol Neurobiol
DOI 10.1007/s12035-016-9839-9

Resveratrol and Alzheimer's Disease: Mechanistic Insights

Touqeer Ahmed[1] · Sehrish Javed[1] · Sana Javed[1] · Ameema Tariq[1] · Dunja Šamec[2] · Silvia Tejada[3] · Seyed Fazel Nabavi[4] · Nady Braidy[5] · Seyed Mohammad Nabavi[4]

Received: 28 January 2016 / Accepted: 4 March 2016

Abstract Alzheimer's disease (AD) is the leading cause of dementia in the elderly and is characterized by progressive cognitive and memory deficits. The pathological hallmarks of AD include extracellular senile plaques and intracellular neurofibrillary tangles. Although several mechanisms have been used to explain the underlying pathogenesis of AD, current treatment regimens remain inadequate. The neuroprotective effects of the polyphenolic stilbene resveratrol (3,5,4′-trihydroxy-*trans*-stilbene) have been investigated in several *in vitro* and *in vivo* models of AD. The current review discusses the multiple potential mechanisms of action of resveratrol on the pathobiology of AD. Moreover, due to the limited pharmacokinetic parameters of resveratrol, multiple strategies aimed at increasing the bioavailability of resveratrol have also been addressed.

Keywords Alzheimer's disease · Resveratrol · Amyloid · Neurodegeneration · Neuroinflammation

Introduction

Despite advances in medicine and drug therapies, treatment of neuronal injury and mental diseases is still not well developed. Some strategies are used; however, there is a need to develop new management techniques and procedures. At present, natural products have become very important as a potential target for the possible treatment of human diseases. Polyphenols are secondary metabolites of plants, mainly synthesized in response to a major stress. Since animals are unable to synthesize these compounds, they need to be ingested through their diet. The beneficial effects of several polyphenols in human

life

MDPI

Review

Neuroprotective Potential of Biflavone Ginkgetin: A Review

İ. İrem Tatlı Çankaya [1], Hari Prasad Devkota [2], Gokhan Zengin [3] and Dunja Šamec [4,*]

1 Department of Pharmaceutical Botany, Faculty of Pharmacy, Hacettepe University, 06100 Ankara, Turkey
2 Graduate School of Pharmaceutical Sciences, Kumamoto University, Chuo-ku, Kumamoto 862-0973, Japan
3 Department of Biology, Science Faculty, Selcuk University, 42130 Konya, Turkey
4 Department of Food Technology, University Center Koprivnica, University North, 48000 Koprivnica, Croatia
* Correspondence: dsamec@unin.hr

Abstract: Neurological disorders are becoming more common, and there is an intense search for molecules that can help treat them. Several natural components, especially those from the flavonoid group, have shown promising results. Ginkgetin is the first known biflavonoid, a flavonoid dimer isolated from ginkgo (*Ginkgo biloba* L.). Later, its occurrence was discovered in more than 20 different plant species, most of which are known for their use in traditional medicine. Herein we have summarized the data on the neuroprotective potential of ginkgetin. There is evidence of protection against neuronal damage caused by ischemic strokes, neurotumors, Alzheimer's disease (AD), and Parkinson's disease (PD). Beneficial effects in ischemic strokes have been demonstrated in animal studies in which injection of ginkgetin before or after onset of the stoke showed protection from neuronal damage. AD protection has been the most studied to date. Possible mechanisms include inhibition of reactive oxygen species, inhibition of β-secretase, inhibition of Aβ fibril formation, amelioration of inflammation, and antimicrobial activity. Ginkgetin has also shown positive effects on the relief of PD symptoms in animal studies. Most of the available data are from in vitro or in vivo animal studies, where ginkgetin showed promising results, and further clinical studies should be conducted.

Keywords: Alzheimer's disease; biflavonoids; ginkgetin; neuroprotection; ginkgo

viruses

MDPI

Review

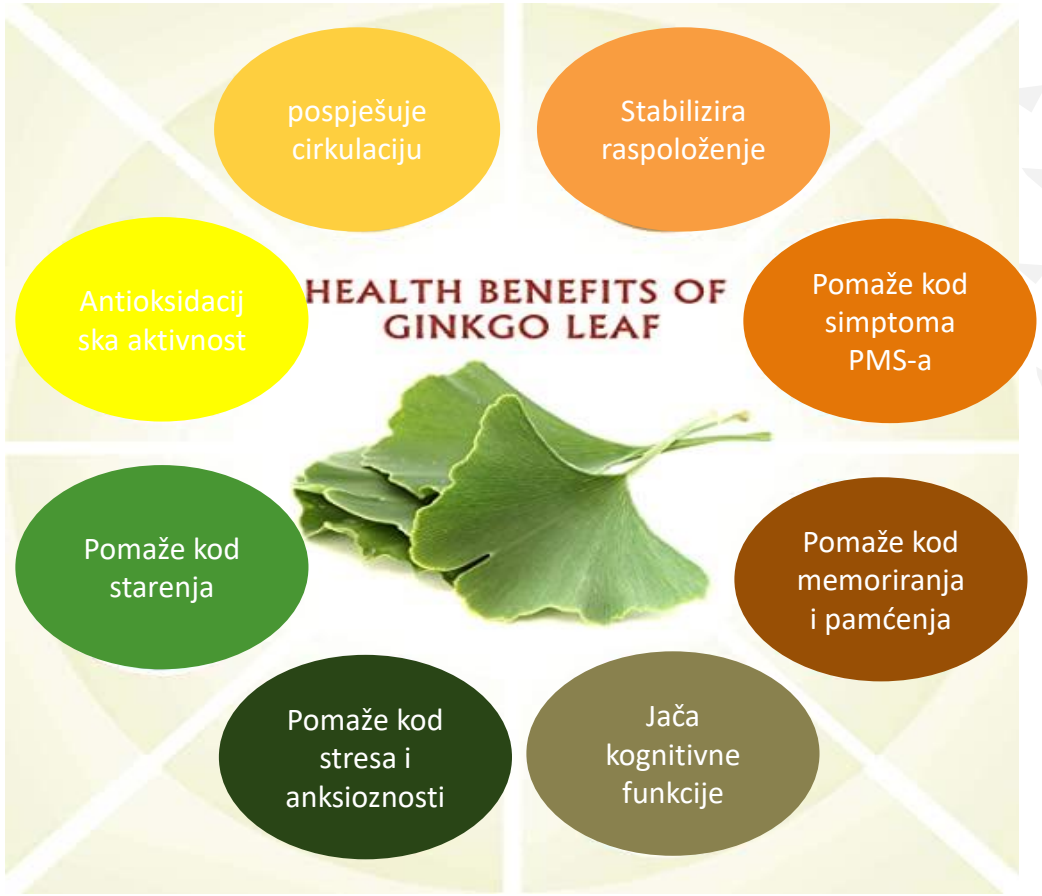
Flavonoids Target Human Herpesviruses That Infect the Nervous System: Mechanisms of Action and Therapeutic Insights

Miroslava Šudomová [1], Kateřina Berchová-Bímová [2], Alena Mazurakova [3], Dunja Šamec [4], Peter Kubatka [5] and Sherif T. S. Hassan [2,*]

1 Museum of Literature in Moravia, Klášter 1, 664 61 Rajhrad, Czech Republic; sudomova@post.cz
2 Department of Applied Ecology, Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Kamýcká 129, 16500 Prague, Czech Republic; berchova@fzp.czu.cz
3 Department of Obstetrics and Gynecology, Jessenius Faculty of Medicine, Comenius University in Bratislava, 03601 Martin, Slovakia; alenka.liskova@gmail.com
4 Department of Food Technology, University Center Koprivnica, University North, Trga Dr. Žarka Dolinara 1, 48 000 Koprivnica, Croatia; dsamec@unin.hr
5 Department of Medical Biology, Jessenius Faculty of Medicine, Comenius University in Bratislava, 03601 Martin, Slovakia; kubatkap@gmail.com
* Correspondence: sherif.hassan@seznam.cz; Tel.: +420-774-630-604

Ginko (*Ginkgo biloba* L.)

- U tradicionalnoj kineskoj medicini lišće i plodovi koriste se već nekoliko stoljeća s dokumentiranom upotrebom koja datira od 1280. do 1368. godine.
- Više od 500 godina ajemenci se pripisuju različita ljekovita svojstva za tretiranje astme, kašalja i infekcije mjehura, dok se lišće uglavnom koristi za liječenje kožnih infekcija i plućne disfunkcije.
- Najpoznatija svojstva ginkga su njegova blagotvorna djelovanja na **kognitivne tegobe** → Standardizirani ekstrakt formula- EGb761 koristi se diljem svijeta (24% flavonoida, 6% terpenskih trilaktona (TTL) manje od 5 ppm ginkgolične kiseline).
- <u>No zna li se točno koja je aktivna komponenta?</u>



Ginko (*Ginkgo biloba* L.)

Ekstrakt koji se ože koristiti za pripravu dodataka prehrani po standardu sadrži : **24% flavonoida, 6% terpenskih trilaktona (TTL) manje od 5 ppm ginkgolične kiseline**

FLAVONOIDI- velika skupina biljnih metabolita- uključuje oko 8000 različitih spojeva s različitim kemijskim strukturama- **različito biološko djelovanje**

U ginku prema literaturi je prisutno **110 različitih flavonoida** čiji sadržaj ovisi o dijelu biljke, starosti lišća, starosti samog stabla i sl.

Jedna od skupina flavonoida u ginku – **biflavonoidi- dimerne strukture flavonoida**

ISTRAŽIVANJA NA SVEUČILIŠTU SJEVER:

Projekt financiran sredstvima Hrvatske zaklade za znanost: „Uloga biflavonoida u biljkama: Gingko biloba L. kao modelnu sustav" HRZZ-UIP-2019-04-1018 (voditelj D. Šamec)

Biflavonoidi kao ključni faktori u zdravstvenim benefitima ginka?

plants

Highly Cited Paper

MDPI

Review

Biflavonoids: Important Contributions to the Health Benefits of Ginkgo (*Ginkgo biloba* L.)

Dunja Šamec [1,*], Erna Karalija [2], Sabina Dahija [2] and Sherif T. S. Hassan [3]

1 Department of Food Technology, University North, Trga Dr. Žarka Dolinara 1, 48000 Koprivnica, Croatia
2 Department for Biology, Faculty of Science, University of Sarajevo, Zmaja od Bosne 33-35, 71000 Sarajevo, Bosnia and Herzegovina; erna.k@pmf.unsa.ba (E.K.); sabina_dudevic@yahoo.com (S.D.)
3 Department of Applied Ecology, Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Kamýcká 129, 165 00 Prague, Czech Republic; sherif.hassan@seznam.cz
* Correspondence: dsamec@unin.hr

Abstract: Ginkgo (*Ginkgo biloba* L.) is one of the most distinctive plants, characterized by excellent resistance to various environmental conditions. It is used as an ornamental plant and is recognized as a medicinal plant in both traditional and Western medicine. Its bioactive potential is associated with the presence of flavonoids and terpene trilactones, but many other compounds may also have synergistic effects. Flavonoid dimers—biflavonoids—are important constituents of ginkgophytopharmaceuticals. Currently, the presence of 13 biflavonoids has been reported in ginkgo, of which amentoflavone, bilobetin, sciadopitysin, ginkgetin and isoginkgetin are the most common. Their role in plants remains unknown, but their bioactivity and potential role in the management of human health are better investigated. In this review, we have provided an overview of the chemistry, diversity and biological factors that influence the presence of biflavonoids in ginkgo, as well as their bioactive and health-related properties. We have focused on their antioxidant, anticancer, antiviral, antibacterial, antifungal and anti-inflammatory activities as well as their potential role in the treatment of cardiovascular, metabolic and neurodegenerative diseases. We also highlighted their potential toxicity and pointed out further research directions.

Keywords: *Ginkgo biloba* L.; biflavonoids; ginkgetin; isoginkgetin; bilobetin; sciadopitysin; amentoflavone; bioactive compounds

check for updates

Citation: Šamec, D.; Karalija, E.; Dahija, S.; Hassan, S.T.S. Biflavonoids: Important Contributions to the Health Benefits

life

MDPI

Review

Neuroprotective Potential of Biflavone Ginkgetin: A Review

İ. İrem Tatlı Çankaya [1], Hari Prasad Devkota [2], Gokhan Zengin [3] and Dunja Šamec [4,*]

1 Department of Pharmaceutical Botany, Faculty of Pharmacy, Hacettepe University, 06100 Ankara, Turkey
2 Graduate School of Pharmaceutical Sciences, Kumamoto University, Chuo-ku, Kumamoto 862-0973, Japan
3 Department of Biology, Science Faculty, Selcuk University, 42130 Konya, Turkey
4 Department of Food Technology, University Center Koprivnica, University North, 48000 Koprivnica, Croatia
* Correspondence: dsamec@unin.hr

Abstract: Neurological disorders are becoming more common, and there is an intense search for molecules that can help treat them. Several natural components, especially those from the flavonoid group, have shown promising results. Ginkgetin is the first known biflavonoid, a flavonoid dimer isolated from ginkgo (*Ginkgo biloba* L.). Later, its occurrence was discovered in more than 20 different plant species, most of which are known for their use in traditional medicine. Herein we have summarized the data on the neuroprotective potential of ginkgetin. There is evidence of protection against neuronal damage caused by ischemic strokes, neurotumors, Alzheimer's disease (AD), and Parkinson's disease (PD). Beneficial effects in ischemic strokes have been demonstrated in animal studies in which injection of ginkgetin before or after onset of the stoke showed protection from neuronal damage. AD protection has been the most studied to date. Possible mechanisms include inhibition of reactive oxygen species, inhibition of β-secretase, inhibition of Aβ fibril formation, amelioration of inflammation, and antimicrobial activity. Ginkgetin has also shown positive effects on the relief of PD symptoms in animal studies. Most of the available data are from in vitro or in vivo animal studies, where ginkgetin showed promising results, and further clinical studies should be conducted.

Keywords: Alzheimer's disease; biflavonoids; ginkgetin; neuroprotection; ginkgo

check for updates

Biološka aktivnost biflavonoida

antioxidants

MDPI

Article

A Comparative Analysis of Radical Scavenging, Antifungal and Enzyme Inhibition Activity of 3′-8″-Biflavones and Their Monomeric Subunits

Iva Jurčević Šangut [1], Bojan Šarkanj [1], Erna Karalija [2] and Dunja Šamec [1,*]

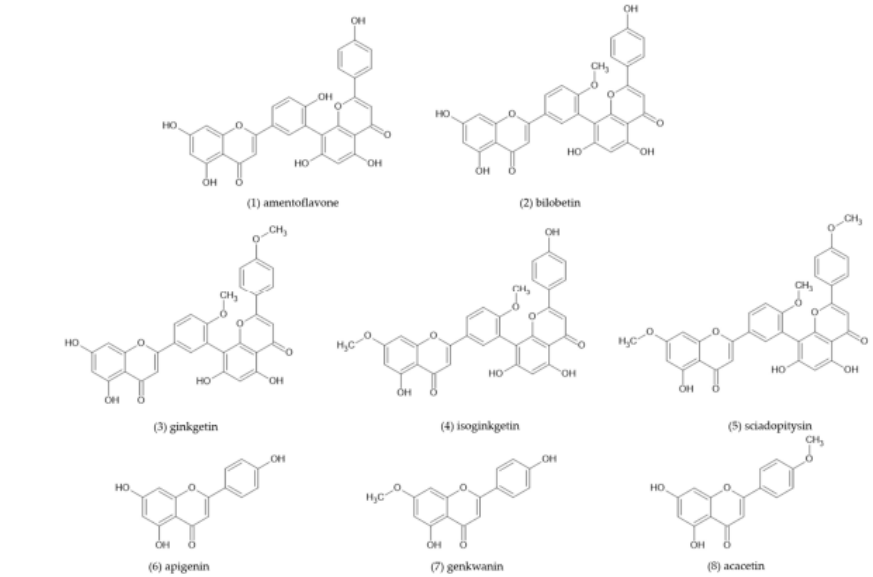
[1] Department of Food Technology, University North, 48000 Koprivnica, Croatia; ijurcevic@unin.hr (I.J.Š.); bsarkanj@unin.hr (B.Š.)
[2] Department for Biology, Faculty of Science, University of Sarajevo, 71000 Sarajevo, Bosnia and Herzegovina; erna.k@pmf.unsa.ba
* Correspondence: dsamec@unin.hr

Abstract: Biflavonoids are dimeric forms of flavonoids that have recently gained importance as an effective new scaffold for drug discovery. In particular, 3′-8″-biflavones exhibit antiviral and antimicrobial activity and are promising molecules for the treatment of neurodegenerative and metabolic diseases as well as cancer therapies. In the present study, we directly compared 3′-8″-biflavones (amentoflavone, bilobetin, ginkgetin, isoginkgetin, and sciadopitysin) and their monomeric subunits (apigenin, genkwanin, and acacetin) and evaluated their radical scavenging activity (with DPPH), antifungal activity against mycotoxigenic fungi (*Alternaria alternata*, *Aspergillus flavus*, *Aspergillus ochraceus*, *Fusarium graminearum*, and *Fusarium verticillioides*), and inhibitory activity on enzymes (acetylcholinesterase, tyrosinase, α-amylase, and α-glucosidase). All the tested compounds showed weak radical scavenging activity, while antifungal activity strongly depended on the tested concentration and fungal species. Biflavonoids, especially ginkgetin and isoginkgetin, proved to be potent acetylcholinesterase inhibitors, whereas monomeric flavonoids showed higher tyrosinase inhibitory activity than the tested 3′-8″-biflavones. Amentoflavone proved to be a potent α-amylase and α-glucosidase inhibitor, and in general, 3′-8″-biflavones showed a stronger inhibitory potential on these enzymes than their monomeric subunits. Thus, we can conclude that 3′-8″-dimerization enhanced acetylcholinesterase, α-amylase, and α-glucosidase activities, but the activity also depends on the number of hydroxyl and methoxy groups in the structure of the compound.

Keywords: 3′-8″-biflavones; amentoflavone; bilobetin; ginkgetin; isoginkgetin; sciadopitysin; apigenin; genkwanin; acacetin

check for updates

Citation: Jurčević Šangut, I.; Šarkanj, B.; Karalija, E.; Šamec, D. A Comparative Analysis of Radical Scavenging, Antifungal and Enzyme Inhibition Activity of 3′-8″-Biflavones and Their Monomeric Subunits. *Antioxidants* **2023**, *12*, 1854. https://



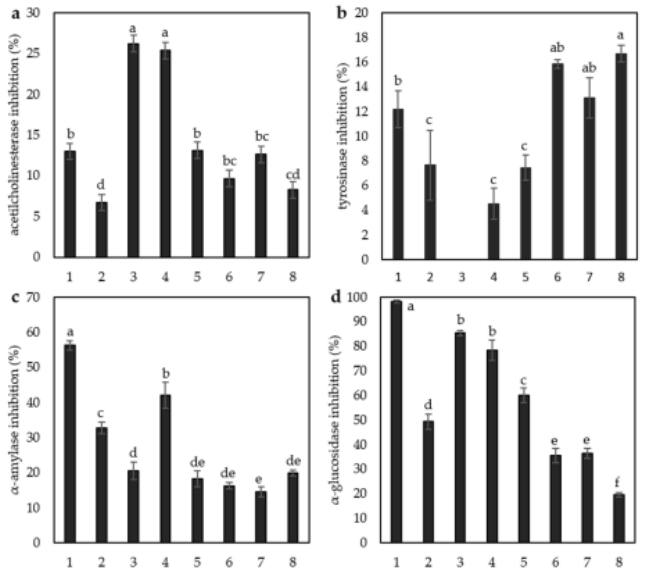
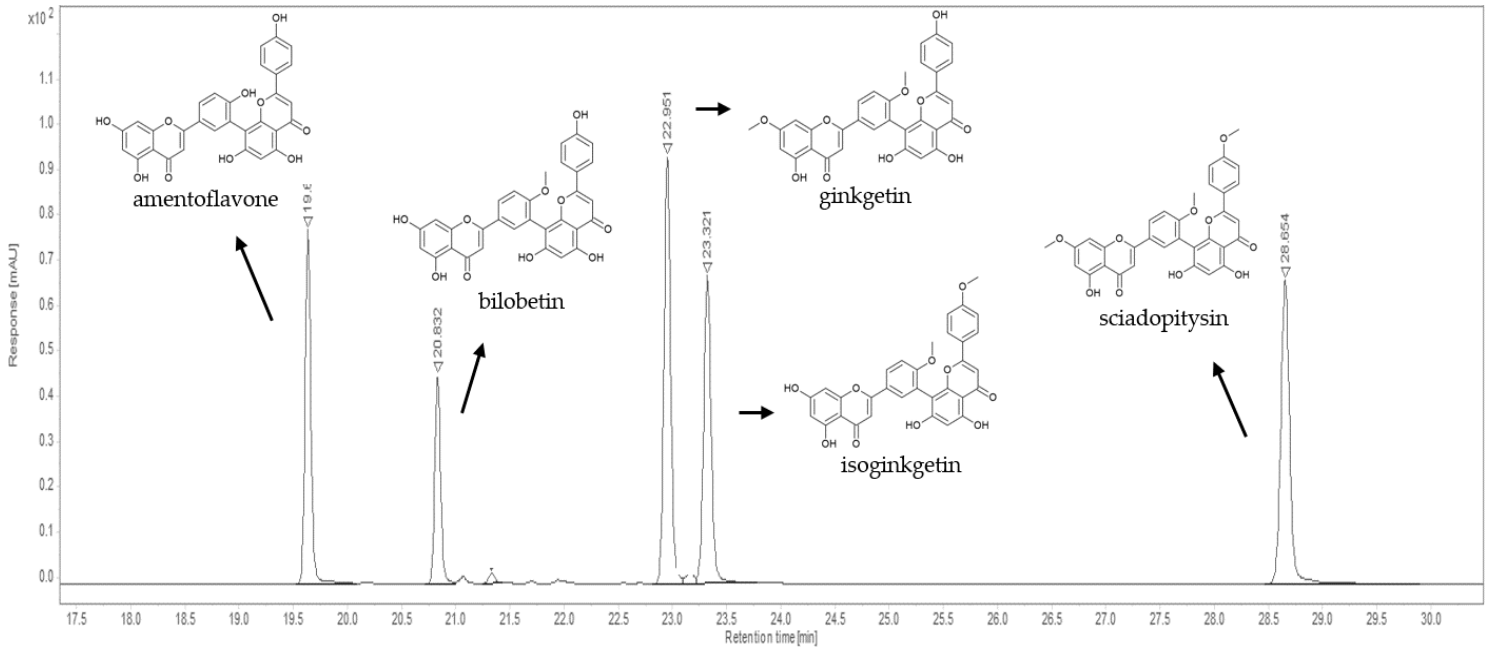
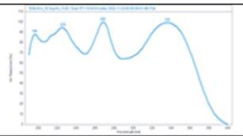
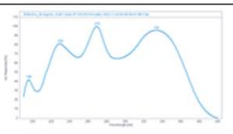
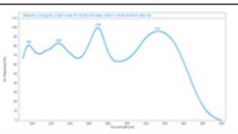
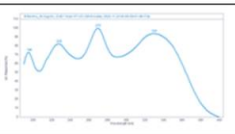
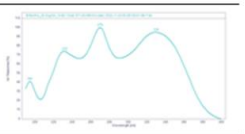


Figure 4. Enzyme inhibition activity of (1) amentoflavone, (2) bilobetin, (3) ginkgetin, (4) isoginkgetin, (5) sciadopitysin, (6) apigenin, (7) genkwanin, and (8) acacetin against (**a**) acetylcholinesterase, (**b**) tyrosinase, (**c**) α-amylase, and (**d**) α-glucosidase at a concentration of 100 µM. Values with different letters differ significantly at $p < 0.05$.

Razvijena HPLC-DAD metoda za profiliranje biflavonoids



	amentoflavone	bilobetin	ginkgetin	isoginkgetin	sciadopitysin
retention time (min)	19.634	20.832	22.951	23.321	28.654
characteristic UV spectrum					
maximum UV apsorption (nm)	196, 226, 268, 336	196, 230, 270, 334	196, 228, 270, 332	196, 228, 270, 332	194, 232, 270, 330

plants

MDPI

Communication

Tissue-Specific Profiling of Biflavonoids in Ginkgo (*Ginkgo biloba* L.)

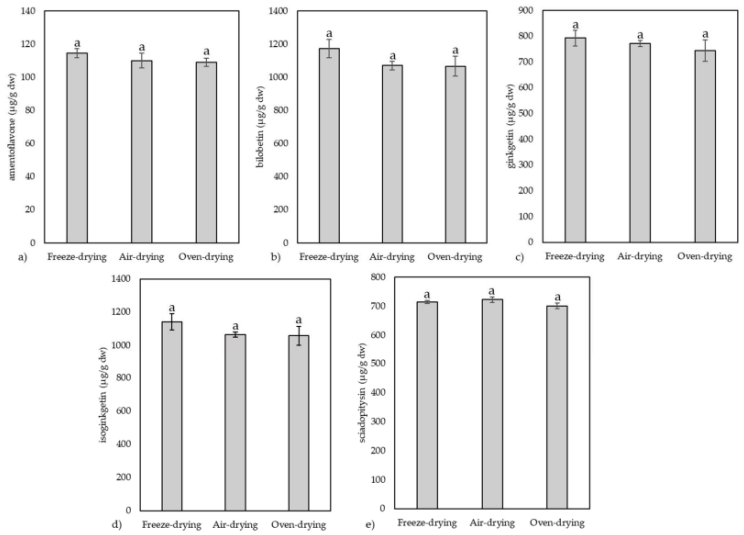
Marija Kovač Tomas, Iva Jurčević and Dunja Šamec *

Department of Food Technology, University North, Trg Dr. Žarka Dolinara 1, 48000 Koprivnica, Croatia
* Correspondence: dsamec@unin.hr

Abstract: Biflavonoids are flavonoid dimers that are much less studied than monomeric flavonoids. Their precise distribution among plants and their role in plants is still unknown. Here, we have developed a HPLC-DAD method that allows us to separate and simultaneously determine the five major biflavonoids (amentoflavone, bilobetin, ginkgetin, isoginkgetin, and sciadopitysin) in ginkgo (*Ginkgo biloba* L.). We performed tissue-specific profiling of biflavonoids in ten different plant parts: tree bark, twigs bark, twigs without bark, buds, leaf petioles, leaf blades, seed stalks, sarcotesta, nutshells, and kernels. We did not detect biflavonoids in plant parts not in direct contact with the environment (twigs without bark, nutshells, and kernels). We found the highest total biflavonoids content in leaves, where sciadopitysin was predominant. In contrast, in the bark, amentoflavone was the predominant biflavonoid, suggesting that more methylated biflavonoids accumulate in leaves and seeds. This is probably related to their biological function, which remains to be determined.

Keywords: amentoflavone; bilobetin; ginkgetin; isoginkgetin; sciadopitysin; ginkgo; tissue-specific profiling; HPLC-DAD

Optimizacija ekstrakcije – utjecaj načina sušenja



applied sciences

MDPI

Article

Influence of Air Drying, Freeze Drying and Oven Drying on the Biflavone Content in Yellow Ginkgo (*Ginkgo biloba* L.) Leaves

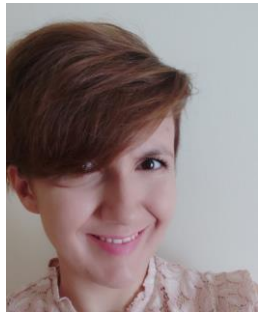
Iva Jurčević Šangut, Lana Pavličević and Dunja Šamec *

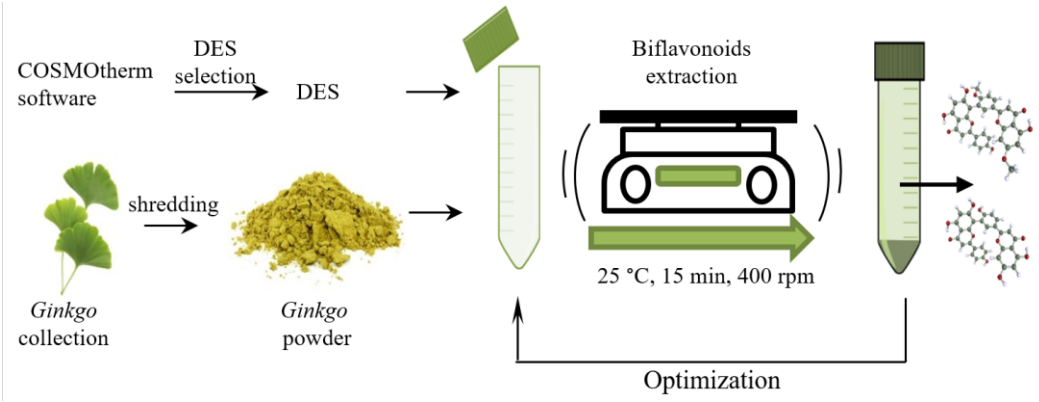
Department of Food Technology, University North, Trg dr. Žarka Dolinara 1, 48000 Koprivnica, Croatia; ijurcevic@unin.hr (I.J.Š.)
* Correspondence: dsamec@unin.hr

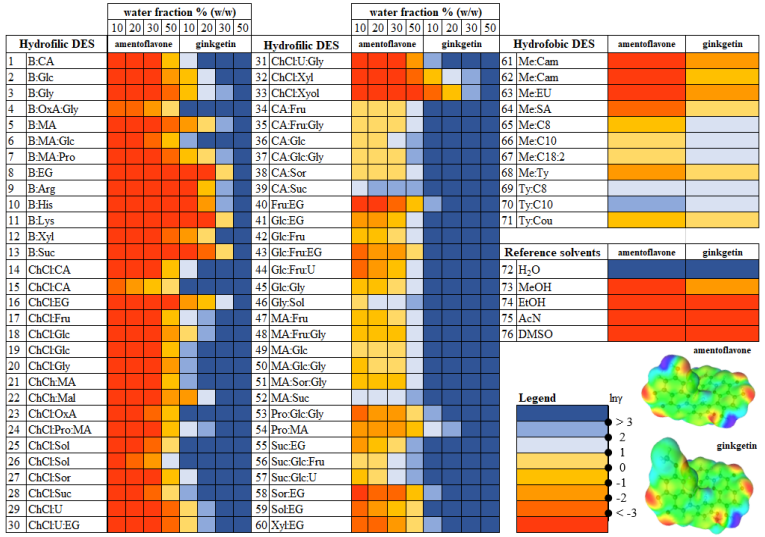
Abstract: Drying herbs is a crucial method for stabilizing and preserving their essential properties and bioactive compounds. Although freeze drying is the preferred method for most herbs, it is expensive due to high energy consumption and operating costs. Biflavonoids are dimeric flavonoids that have recently been recognized as potential molecules possessing biological activities, such as antiviral and antimicrobial activity, and as effective molecules for the treatment of neurodegenerative and metabolic diseases and for cancer therapies. In this study, we performed a comparative analysis of freeze drying, air drying and oven drying to evaluate their effects on biflavonoid content in yellow ginkgo leaves (*Ginkgo biloba* L.). After drying, we performed spectrophotometric analysis to determine the browning index, pigments, phenolic compounds and antioxidant activity, while HPLC-DAD was used for the identification and quantification of individual biflavones (amentoflavone, bilobetin, ginkgetin, isoginkgetin and sciadopitysin). The most abundant biflavonoids were isoginkgetin and bilobetin, the amounts of which exceeded 1000 μg/g dw in all leaf samples. They were followed by ginkgetin and sciadopitysin, the amounts of which were about 30% lower. The drying method did not influence biflavone content or the total carotenoids, total polyphenols and total flavonoids. Consequently, our study suggests that all three methods may be used for the preparation of yellow ginkgo leaves as a source of biflavones and other bioactive compounds.

Keywords: air drying; biflavonoids; freeze drying; ginkgo; oven drying

Optimizacija ekstrakcije- upotreba zelenih otapala za ekstrakciju







Using COSMOtherm software, a total of 250 DESs were tested and 15 tested and selected

Industrial Crops & Products 219 (2024) 119068

Contents lists available at ScienceDirect

Industrial Crops & Products

journal homepage: www.elsevier.com/locate/indcrop

Extraction of polyphenolic compounds from ginkgo leaves using deep eutectic solvents: A potential solution for the sustainable and environmentally friendly isolation of biflavonoids

Anita Šalić [a,*], Matea Bajo [a], Marina Cvjetko Bubalo [b], Mia Radović [b], Ana Jurinjak Tušek [b], Bruno Zelić [a,c], Dunja Šamec [c]

[a] University of Zagreb, Faculty of Chemical Engineering and Technology, Marulićev trg 19, Zagreb HR-10 000, Croatia
[b] University of Zagreb, Faculty of Food Technology and Biotechnology, Pierottijeva 6, Zagreb HR-10 000, Croatia
[c] University North, Trg dr. Žarka Dolinara 1, Koprivnica HR-48 000, Croatia

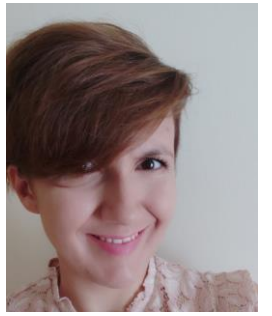
ARTICLE INFO

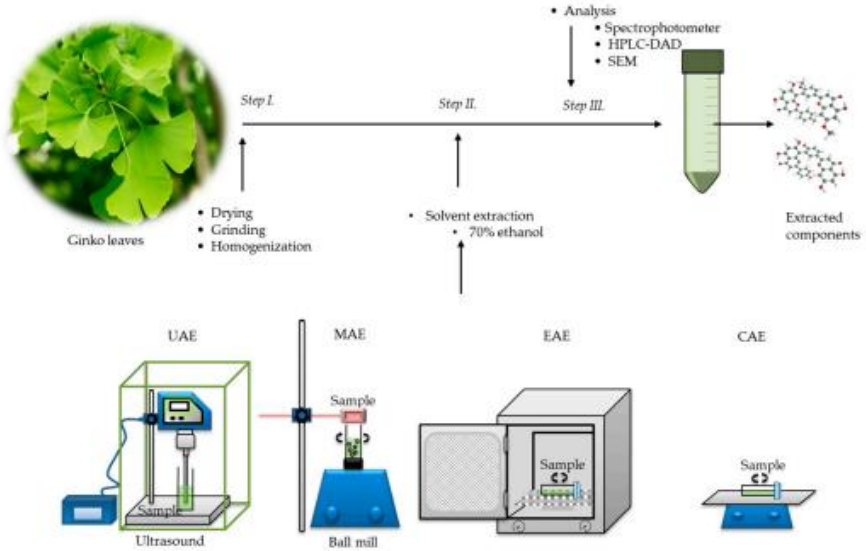
Keywords:
Biflavonoids
Ginkgo
DES
COSMOtherm
Extraction

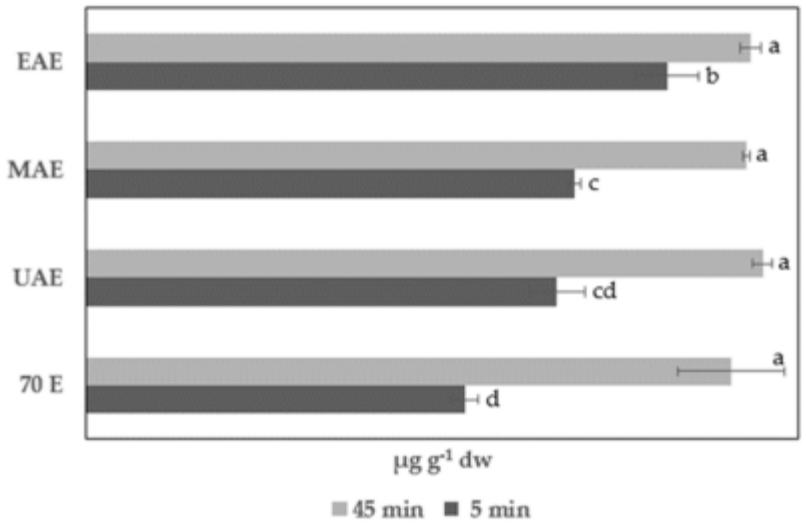
ABSTRACT

Ginkgo (*Ginkgo biloba* L.) is one of the oldest trees on earth and its leaves are traditionally used as herbal medicine. The beneficial effects of ginkgo leaves are attributed to the presence of flavonoids and terpene trilactones. Monomeric flavonoids are frequently studied, but recently much attention has been paid to biflavonoids, dimeric flavonoids, due to their biological activity and potential pharmaceutical use. The development of a suitable and effective extraction protocol focusing on biflavonoids is increasingly in demand. Therefore, in this study, we developed an optimized extraction protocol using deep eutectic solvents (DESs) to extract flavonoids from ginkgo leaves, with special attention to biflavonoids. Initially, 250 DESs were screened using COSMOtherm software to identify those that could strongly solubilize biflavonoids and flavonoids, and the results obtained indicated 15 DESs. Among them, betaine: ethylene glycol (B:EG) 1:2 with 30 % H_2O (w/w) showed higher extraction efficiency than the extraction performed with 80 % methanol. In a next step, the extraction with the selected DES was further optimized using a Box-Behnken experimental design. The results obtained showed that the optimum extraction conditions using the selected DES were as follows: Extraction time 45 minutes, the ratio of the initial mass of the shredded leaves to the volume of the DES 20:1 and the temperature 20 °C. Finally, the concentrations of the 5 most abundant biflavonoids in ginkgo leaves (amentoflavone, ginkgetin, isoginkgetin, bilobetin and sciadopitysin) in the extracts were determined using HPLC-DAD. The results showed that B:EG 1:2 with 20 % H_2O (w/w) and 30 % H_2O (w/w) were suitable for the extraction of all five biflavonoids.

Optimizacija ekstrakcije – moderne metode ekstrakcije







processes

MDPI

Article

Comparative Analysis of Enzyme-, Ultrasound-, Mechanical-, and Chemical-Assisted Extraction of Biflavonoids from Ginkgo Leaves

Anita Šalić [1], Lina Šepić [1], Iva Turkalj [1], Bruno Zelić [1,2] and Dunja Šamec [2,*]

[1] Faculty of Chemical Engineering and Technology, University of Zagreb, Marulićev trg 19, HR-10000 Zagreb, Croatia; asalic@fkit.unizg.hr (A.Š.); lsepic@fkit.unizg.hr (L.Š.); iturkalj@fkit.unizg.hr (I.T.); bzelic@fkit.unizg.hr (B.Z.)
[2] University North, Trg dr. Žarka. Dolinara 1, HR-48000 Koprivnica, Croatia
* Correspondence: dsamec@unin.hr

Abstract: The biflavonoid extraction from ginkgo (*Ginkgo biloba* L.) leaves using solvent-based extraction with 70% ethanol, alone and in combination with enzyme-assisted, ultrasound-assisted, mechanical-assisted, and chemically assisted methods was investigated and the influence of extraction duration was explored. The total content of polyphenols, flavonoids, and phenolic acids in the extracts was determined spectrophotometrically, while individual biflavonoids were identified and quantified using HPLC-DAD. Amentoflavone, bilobetin, ginkgetin, isoginkgetin, and sciadopitysin were identified in all our extracts. Among these, sciadopitysin emerged as the most prevalent biflavonoid with an amount above 1 mg g^{-1} dw, followed by isoginkgetin. Comparative analysis of the extraction methods revealed that, except for chemically assisted extraction, similar levels of compounds were obtained after 45 min of extraction. However, enzymatic (EAE) and mechanical-assisted extraction (MAE) exhibited significantly higher individual (EAE: 19–41% higher; MAE: 22–67% higher) and total biflavonoid (EAE: 29% higher; MAE 50% higher) levels after just 5 min, suggesting their potential to abbreviate extraction duration and facilitate the efficient retrieval of target compounds. However, as extraction efficiency varies between individual biflavonoids, our findings also underscore the importance of considering specific compounds and extraction kinetics in the optimization of ginkgo leaf extraction processes.

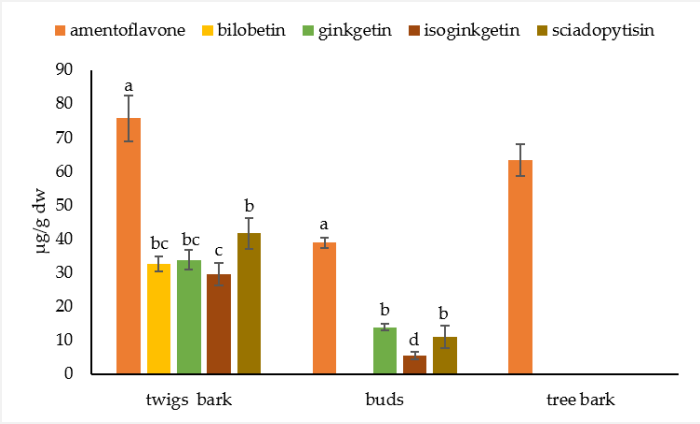
Keywords: amentoflavone; assisted extraction; biflavonoids; bilobetin; ginkgo; ginkgetin; isoginkgetin; sciadopitysin

check for updates

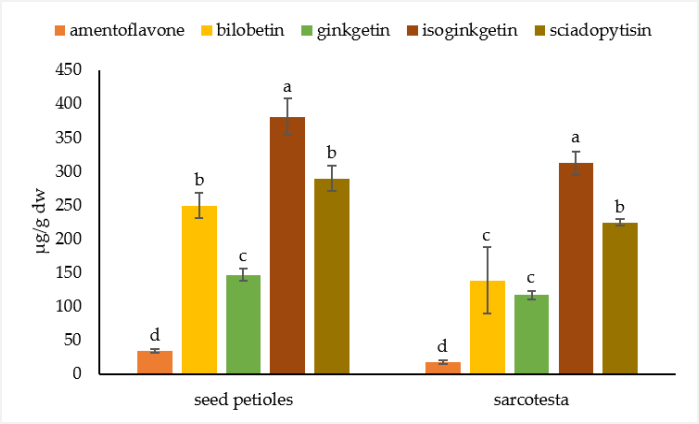
Citation: Šalić, A.; Šepić, L.; Turkalj, I.; Zelić, B.; Šamec, D. Comparative Analysis of Enzyme-, Ultrasound-, Mechanical-, and Chemical-Assisted Extraction of Biflavonoids from Ginkgo Leaves. *Processes* **2024**, *12*, 982.

Sadržaj biflavonoida u različitim tkivima ginka

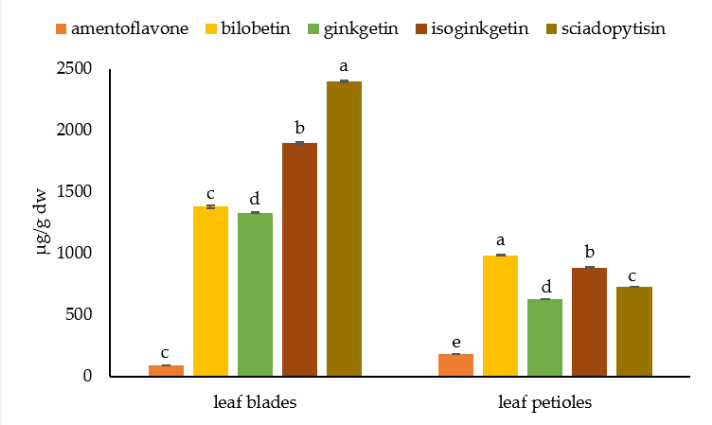
Twigs, buds



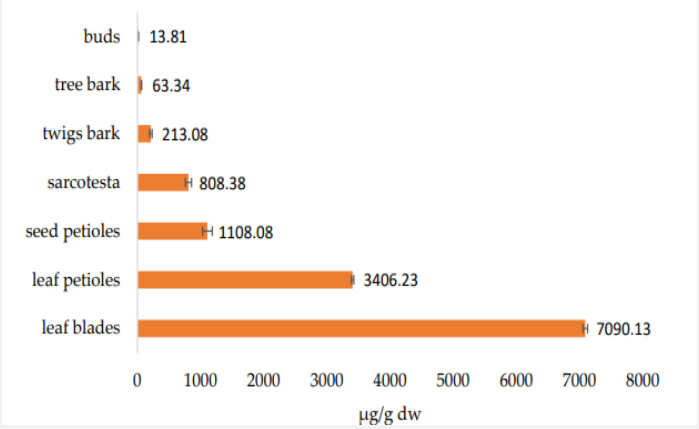
Seed petiols and sarcotesta

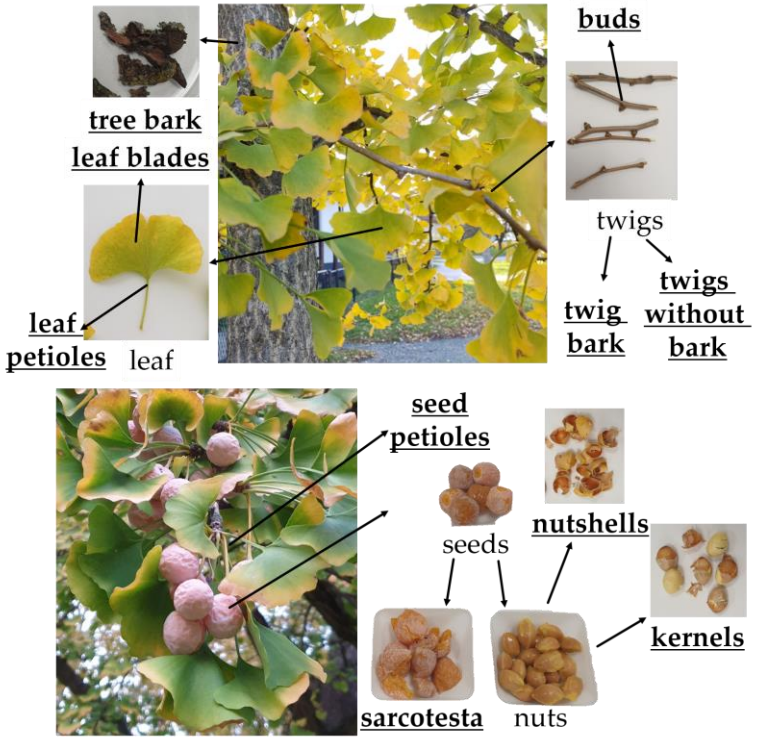


Leaves blades and petiols



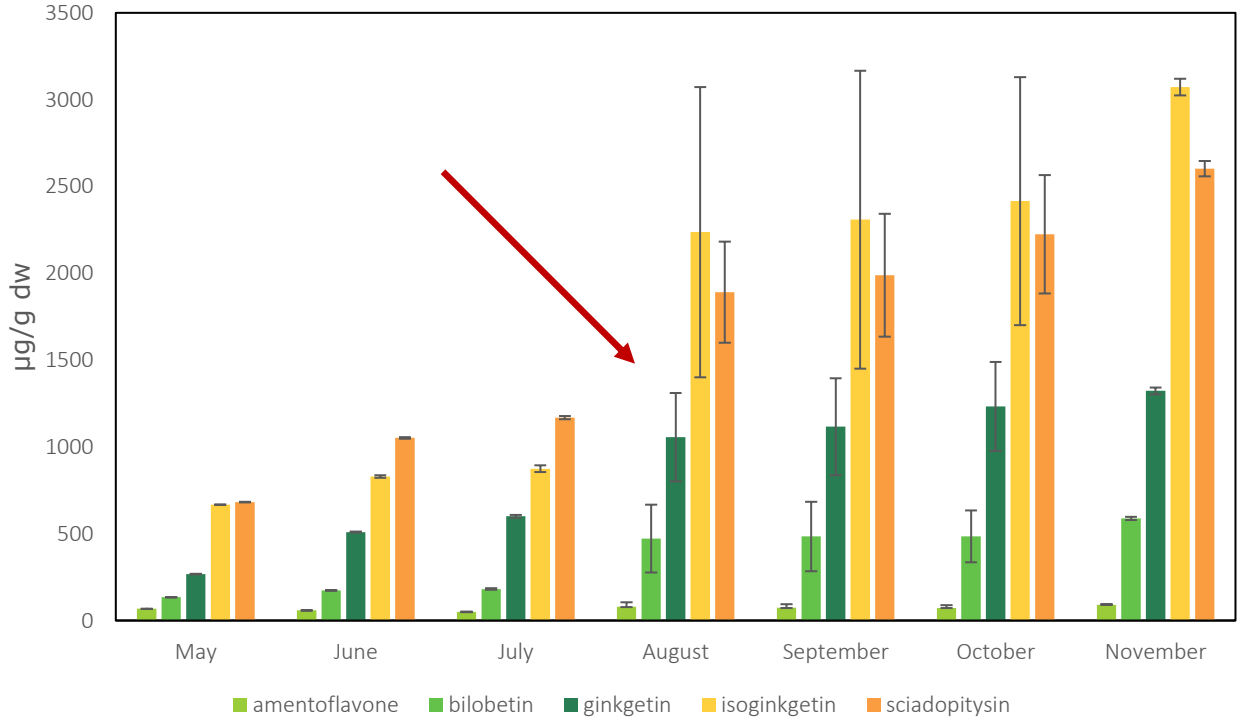
Total biflavonoids





→ **Biflavonoidi nisu identificirani u djelovima biljke koji nisu u direktnom kontaktu s okolinom**

Sezonska varijacija u sadržaju biflavonoida



→ Više biflavonoida u žutom lišćuintenzivna akumulacija tijekom srpnja/kolovoza

Ključne poruke

- Biljke se upotrebljavaju za liječenje, održavanje higijene i ljepotu koliko i postoji čovječanstvo
- Većina biljaka nije znanstveno istražena te nema znanstvenih dokaza o (ne)djelovanju – pitanje jel zbilja „prirodno", „biljno" opravdava višu cijenu?
- Valja biti oprezan kod upotrebe biljnih proizvoda te se informirati o podrijetlu, sastavu, načinu ekstrakcije, načinu upotrebe i sl..

Most men, like plants, possess hidden qualities which chance discovers.
(*François de La Rochefoucauld*)

Hvala na pažnji!

Istraživanja na Sveučilištu Sjever financirana su iz sredstava Hrvatske zaklade za znanost za projekt „„Uloga biflavonoida u biljkama: *Gingko biloba* L. kao modelnu sustav” HRZZ-UIP-2019-04-1018 (voditelj doc. dr. sc. Dunja Šamec)”

Suradnici:

SVEUČILIŠTE SJEVER
Koprivnica

Izv. Prof. dr.sc. Bojan Šarkanj
Dr. Marija Kovač Tomas
Iva Jurčević Šangut

Lana Pavličević
Rebeka Oreški

FAKULTET KEMIJSKOG INŽENJERSTVA I TEHNOLOGIJE
Zagreb

Doc. dr. sc. Anita Šalić
Prof. dr. sc. Bruno Zelić

studenti

PMF, SVEUČILIŠTE U SARAJEVU
Sarajevo, B&H

Prof. Dr. Erna Karalija