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Flavonoids in plants

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Abstract:
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Flavonoids belong to large group of plant's polyphenols. They have prominent role in pigmentation of plants and their protection from different external agents. In recent years, there is a raising interest in flavonoids, mostly because of their antioxidant, anti-inflammatory, antiallergenic, antimicrobal and anticancer activity. This paper will summarize current knowledge about flavonoids in plants.

Key words: flavonoids, polyphenols, plants

Introduction

Flavonoids are polyphenolic plant secondary metabolites. They are sintetized by the polypropanoid pathway with phenylalanine as startup molecule.

Biological effects of these compounds are various. They are involved in production of pigmentation in flowers. For example, blue colour results from presence of anthocyanin (delphinidin-based) in petals. Anthocyanins are, also, responsible for the autumn's colours in many plant species and photo-protection of leaf's cells. Their ability of acting as natural UV filters comes from their absorption in 280-315 nm region. Different plant flavonoids have role in protection from microbes and insects. Some of them (isoflavones, flavons and flavanones) are recognized as constitutive antifungal plant agents. Others (flavonoids, tannins, etc) play role in plant's protection from insects and mammalian herbivory (Harborne et al., 2000). Besides, many flavonoids have ability to alter enzymatic and chemical reactions, and thus impact on human health positively or negatively (Beecher, 2003).

Flavonoids classification

Over 5000 naturally occurring flavonoids have been characterized from various plants. They have been classified into six subgroups:

1. Flavones (luteonin, apigenin, tangeritin),
2. Flavonols (quercetin, kaemferol, myricetin, isorhamnetin, pachypodol, rhamnazin),
3. Flavanones (hesteretin, naringenin, eriodictyol),
4. Flavan-3-ols: (catechins (catechin, gallocatechin, catechin 3-gallate, gallocatechin 3-gallate) and epicatechins (epicatechin, epigallocatechin, epicatechin 3-gallate, epigallocatechin 3-gallate)),
5. Isoflavones (genistein, daidzein, glycitein) and
6. Anthocyanidins (cyanidin, delphinidin, malvidin, pelargonidin, peonidin, petunidin).

Most of them are present in our everyday's life (Manach et al., 2004, Dahan et al.,2004). For instance, flavones, such as luteolin and apigenin glycosides, are contents of parsley and celery. The richest sources of flavonols, like quercetin, are capers, lovage, apples, tea plant, onions, red grapes, citrus fruits, curly kale, leeks, broccoli, cherries, raspberry, cranberry and blueberry. Flavanones are abundant in high concentrations in citrus fruit

only (naringenin in grapefruit, hesperetin in oranges and eriodictyol in lemons) and also found in tomatos. Flavan-3-ols are famous as tea-plant component. Isoflavones are found almost exclusively in leguminous plants, like soya. Anthocyanidin cyanidin is blackberries-flavonoid.

Flavonoids in plants in Serbia

Many studies have been focussed on flavonoid's content of various plant species of Serbian origin.

Phytochemical analysis of *Linum capitatum* Kit. revealed five flavonoids: kaempferol, kaempferol-3-O-galactoside, rutin (quercetin-3-O-rutinosid), genistin (genistein-7-Oglucoside) and orientin (luteolin-8-C-glucoside) in its flower (Ilić et al., 2004).

Another study has shown that flower of endemic species *Cephalaria pastricensis* Doerfl. et Hay are rich in luteolin and its glycosides (Godjevac et al., 2004).

Analysis of *Mentha sp.* flavonoid's content revealed luteolin and apigenin (Dukić et al., 1996).

Study of fifteen maize (*Zea mays* L.) hybrids performed by Maksimović et al demonstrated abundance of polyphenols including flavonoids (2005).

Ethanol extracts from six *Hypericum* species from Tara mountain (*H. barbatum* Jacq., *H. androsaemum* L., *H. richerii* Vill. and H., *H. hirsutum* L., and *H. perforatum* L.) showed significant anti-inflammatory effects. Further analysis revealed that this activity belong to quercetin (Šavikin et al., 2007 & Smelcerović et al., 2006).

Thin-layer chromatography analysis of extracts from four Balkan endemic *Stachys* species (*S. anisochila* Vis. et Pančić , *S. beckeana* Dörfler & Hayek, *S. plumosa* Griseb. and *S. alpina* L. ssp. *dinarica* Murb.) identified flavonoids and phenolic acid as potent antioxidants (Kukić et al., 2006).

Separation and identification of antioxidant components in *Anthriscus sylvestris*

by thin-layer and column chromatography and spectral analysis demonstrated quercetin and apigenin as main flavonoid species (Milovanovic et al., 1996).

Teucrium montanum L., widely used as diuretic, analgesic and antispasmodic agent with antibacterial, antifungal, anti-inflammatory and antioxidative activity was analyzed by Čanadanović-Brunet et al (2006). Different methods showed rutin as major flavonoid in this plant.

Dj. Malenčić et al. were investigating the antioxidant properties of wild sage species *Salvia reflexa* Hornem. (2000). They found high total flavonoid content.

Sideritis montana L. from Suva Planina and hills around Vranje was tested for flavonoids presence by qualitative chemical tests and thin-layer chromatography. Preliminary characterization in combination with spectrophotometric analysis showed that flavonoid constituents belong to the group of flavons. The most abundant compound in flavonoid fraction was isolated and identified as diosmetine**.**

Antioxidant properties from *Picris echoides* belongs to flavone apigenin and its glucoside demonstrated by Milovanović et al. (2002)

High-pressure liquid chromatography screening of phenolic compounds in *Satureja montana* L. revealed presence of flavonols, (±)-catechin and (-)-epicatechin (Ćetković et al., 2007).

Analyses of flavonoid's content showed apigenin, its derivatives and luteolin in *Salvia officinalis* L. and apigenin, luteolin, kaempherol and quercetin in *Salvia glutinosa* L. (Veličković et al., 2007).

Medicinal properties of flavonoids

Oxidative stress is considered to be substantial, if not crucial, in initiating and developing of many conditions and diseases of modern time: inflammation, autoimmune diseases, cataract, cancer, Parkinson's disease, arteriosclerosis and aging. Having all that in mind, it is reasonable to believe that exogenous antioxidants could play important role in preventing oxidative damage in cells and tissues. Flavonoids are well known for their antioxidant activity. Antioxidants are compounds that protect cells against the damaging effects of reactive oxygen species. An imbalance between antioxidants and reactive oxygen species results in oxidative stress, leading to cellular damage (Kukić et al., 2006).

Epidemiological studies have described the beneficial effects of dietary polyphenols (flavonoids) on reduction of chronic diseases, including cancer (Ramos, 2007).

Luteolin is a flavone with important role as antioxidant, free radical scavenger, anti-inflammatory agent, immune system modulator and cancer prevention agent.

Flavonol quercetin it the most active of the flavonoids. Many medicinal plants owe their activity to their high quercetin content. Several studies revealed quercetin's significant anti-inflammatory activity due to direct inhibition of initial processes of inflammation. Potent antioxidant activity of quercetin is demonstrated, too. Some tests showed antitumor properties of

quercetin including the inhibition of cancer cell proliferation and migration (Lim et al., 2006). Problem with this new type of chemotherapeutic agent is low potency and poor selectivity. Combinatorial application of quercetin and ultrasound on skin and prostate cancer showed 90 % mortality within 48 hours with no visible mortality on normal cells (Paliwal et al., 2005). In addition, quercetin may have positive effects on prostatis, heart disease, cataracts, allergies, bronchitis and asthma.

Genistein and daidzein, well known soya isoflavones, function as antioxidants, antiestrogen, antiangiogenic and anticancer agents. For later, it is reported that genistein exhibits significant reduction (44%) in experimental lung tumor metastasis (Ogasawara et al., 2007).

Flavan-3-ols from tea, cocoa, chocolate, fruits, vegetables and wine, are highly potent antioxidant compounds. They reduce incidence of stroke, heart failure and diabetes and cancer. Their anticancer effects are thoroughly investigated. Epigallocatechin 3-gallate and gallocatechan 3-gallate induces reduction in experimental lung tumor metastasis (77% and 46%). Epigallocatechin 3-gallate is effective antiangiogenesis agent which inhibits tumor cell invasion and proliferation (Ogasawara et al., 2007 & Tang et al., 2006). It, also, inhibits growth of the NBT-II bladder tumor cells and breast cancer cell lines (Chen et al., 2004 & Kavanagh et al., 2001).

Cyanidin is anthocyanin pigment found in many berries (grapes, blackberry, blueberry, cherry, cranberry, raspberry etc.), apples, plums and red cabbage. It exerts antioxidant, anti-inflammatory and anticancer effects. It may have an important role in future cancer treatment (Fimognari et al, 2005).

Conclusion

Flavonoids are powerfull agents against oxidative stress, inflammation, allergies, microbes and cancer. Different studies of flavonoids in plants from Serbian territory, such as *Linum capitatum*, *Cephalaria pastricensis*, *Hypericum* species, *Zea mays*, endemic *Stachys* species, *Mentha sp.*, *Anthriscus sylvestris*, *Teucrium montanum*, *Salvia reflexa*, *Sideritis montana*, *Picris echoides*, *Satureja montana*, *Salvia officinalis* and *Salvia glutinosa,* have showed their high content. Having in mind demonstrated medicinal effects of many flavonoid compounds mentioned species and probably lots of others in the nature waiting to be analyzed for their potential therapeutic or preventive use.

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