Scientific Bulletin. Series F. Biotechnologies, Vol. XXV, No. 2, 2021
ISSN 2285-1364, CD-ROM ISSN 2285-5521, ISSN Online 2285-1372, ISSN-L 2285-1364

BIOLOGICAL ACTIVE COMPOUNDS OF THE *POLYGONACEAE* FAMILY - A REVIEW

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Abstract

The Polygonaceae family includes 800 species of plants, mainly herbaceous, annual, or perennial. These plants are cultivated in temperate regions of the globe. One of the most popular genera of this family is Rumex. About 200 species of the genus are widespread throughout the world. Some species of Rumex are grown as vegetables, while others are used for their biologically active compounds in traditional medicine or pharmaceutical industry.
The aerial parts, the leaves, or the roots of Rumex plants contain various biologically active compounds such as anthraquinones, naphthalenes, flavonoids, stilbenoids, triterpenes, carotenoids, phenolic acids, and vitamins. These biological compounds of Rumex plants are involved in certain diseases' treatment, like diabetes, infections, skin disorders, liver diseases, inflammation, etc.
This study is reviewing the biological active compounds extracted from Rumex plants, their biochemical profile, as well as medical uses.

Key words: *biologic active compounds, Polygonaceae family, Rumex spp.*

INTRODUCTION

Medicinal plants have a rich tradition in all human cultures. They can offer an alternative solution to recover from several health problems, due to easy availability, low costs, and rare side effects (Baig et al., 2011). Such plants deliver biologic active compounds capable of treating or preventing various diseases. Such biologic active compounds are at the basis of traditional medicine and have been tested in several fields of science (Bhalodia et al., 2011; Idris et al., 2019). Therefore, medicinal plants are considered a potential source of novel drugs (Bhalodia et al., 2011; Afolayan, 2003; Selvamohan et al., 2012; Idris et al., 2019). Depending on the plant species, the bioactive compounds are produced by one or more organs, such as seeds, fruits, flowers, leaves, roots, or certain stems (Borchardt et al., 2008). The major bioactive compounds secreted by plants are anthraquinones, flavonoids, phenolic compounds, tannins, polysaccharides, vegetal pigments, plant gums, phytoalexins, essential oils, hydrolytic enzymes, and vitamins (Mostafa et al., 2011).

In recent years due to the social and food habit changes, wild species of edible plants is becoming fashionable for consumption (Sánchez-Mata et al., 2012; Morales et al., 2014). New trends towards gastronomy led the search for novel flavours and textures of different vegetables and increase the appeal of wild plants as an alternative to the common cultivated ones (Spínola et al., 2018).
The *Polygonaceae* family has 56 plant genera with 5835 species, of which only 1384 are accepted species names. The Plant List includes a further 1777 scientific plant names of intraspecific ranks in the *Polygonaceae* family (Bello et al., 2019; The Plant List, 2021). One of the taxons included in this family is *Rumex* genus.

MATERIALS AND METHODS

This study aims to review the biological active compounds that could be found in one of the taxon included in *Polygonaceae* family. *Rumex* spp. and its biochemical profile, as well as its use were evaluated. All data collected in this study derives from research articles published

since 1967, featuring the importance of *Rumex* spp. biologic active compounds and their use in prevention and treatments of various diseases.

RUMEX SPP.

Rumex genus comprises around 200 plant species with worldwide distribution (Vassas et al., 2015; Spínola et al., 2018). *Rumex* plants are herbaceous, annual or perennial, with spontaneous growth (Spínola et al., 2018). It can rise up to 1 m. Its leaves are dark green, fleshy, long, with a fringed cone at the base. They have high chlorophyll content. However, some species or varieties have deep red or purple veins. The leaves alternate on the reddish grooved stem. The plants have green flowers, mostly hermaphrodite or unisexual, arranged in whorls on simple or branched inflorescences (Baig et al., 2011; Vasas et al., 2015). Fruits are trigonous nuts (Koperlainen & Pietilainen, 2020).

Rumex young leaves are harvested for fresh consumption, and used raw in salads, either boiled in soups or used as filling in pies (Spínola et al., 2018).

In Europe, species of *Rumex* are used for different treatments. In Romania, they are used to control intestinal transit, kidney disorders, or skin conditions and to reduce rashes (Butura, 1979, Dénes et al., 2013; Vasas et al., 2015,).

In other European countries, *Rumex* plants are used for the treatment of scurvy, as a "blood purifier", cancer cure, eczema, acne, sunburns, and colds, for their antiseptic activity or hypoglycaemic effect, and even for certain cancer cure (Vasas et al., 2015).

In traditional Chinese medicine, *Rumex* species are used in the therapy of different kinds of bacterial, fungal, or viral infection, dysentery, enteritis, acariasis (Zhang et al., 2012; Vasas et al., 2015).

In Africa, the aqueous extracts of *Rumex* species are used as remedies for various types of stomach disorder, hepatic and spleen diseases, and as an antihypertensive, diuretic, and analgesic (El-Hawary et al., 2011; Vasas et al., 2015).

In 1970, Hartwell reports that many plants belonging to the *Rumex* genus can be used against different types of cancer. For each treatment, plants formulations are very diverse, as powder, cataplasm, decoction, infusion, poultice, ointment, plaster, and unguent prepared from the roots, seeds, leaves, flowers, and barks of the plant or the whole plants (Vasas et al., 2015,).

Based on their biological and chemical profile, the most common species of *Rumex* used for medicinal purposes are: *R. abyssinicus, R. acetosa, R. acetosella, R. alpinus, R. aquaticus, R. bequaertii, R. chinensis, R. confertus, R. crispus, R. dentatus, R. ecklonianus, R. hastatus, R. hydrolapatum, R. hymenosepalus, R. japonicus, R. madarensis, R. maritimus, R. napalensis, R. nervosus, R. obtusifolius, R. patientia, R. scutatus, R. stenophyllus, R. steudelii, R. tuberosus, R. usambarensis, R. verticillatus, R. vescarius, R. woodii* (Hartwell, 1970). The medicinal properties of these plants are due to their biologic active compounds (Srivastava et al., 2014; Idris et al., 2019).

For chemical and biological characterization of *Rumex* species, various parts of the plants were examined, the active compounds were determined and their extraction methods were studied, their potential uses were analyzed, along with the dosage and application methods. Some aspects related to the cultivation area and its influence on the biologic compounds is also mentioned.

BIOCHEMICAL PROFILE OF *RUMEX*

To understand the importance of *Rumex* plants as food or in therapy, it is essential to know the biochemical profile of these species.

Anthraquinones

Among *Rumex* bioactive compounds, anthraquinones and their derivatives are the most common. They are mainly found in roots, followed by fruits (Fairbairn & Muhtandi, 1972; Vasas et al., 2015). Emodin, chrysophanol, and physicon are the most common and well documented (Liu et al., 1997).

Naphthalenes

Phytochemical investigation of Rumex plant parts revealed that naphthalenes are found in whole plant. From the roots were isolated naphthalene-1,8-diols depodin, nepodin monoglucoside, methoxynepodin (Berg &

Labadie, 1981), 3-acetyl-2-methyl-1,5-dihydroxy-2,3-epoxynaphathoquinol (Zee et al, 1998), torachrysone (Jiang et al., 2007), musizin, torachrysone, 2-methoxystypandrone (Nishina et al 1993), aloesin, rumexoside, orientaloside, torachrysone (Mei et al., 2009), rumexneposide A and B (Liang et al., 2010). Bioactive compounds such as musizin-8-O-β-D-glucopyranoside (Yoon et al., 2005) and nepodin were extracted from the aerial parts of plants. (Lee et al., 2013).

Flavonoids

Besides naphthalenes and anthraquinones, other important biochemical constituents of the *Rumex* plants are flavonoids, either flavonols or their O/C-glycosides (Vasas et al., 2015).

From the leaves and other aerial parts of *Rumex* spp. were isolated flavonoids such as vitexin, quercitrin, quercetin, isoquercitrin, and catechin (Tavares et al., 2010).

The roots are producing rutin, epicatechin (Jiang et al., 2007; Vasas et al., 2015), and guaijiverin (Orbán-Gyapai et al., 2014).

Studies on biochemical changes during plant cycle and compound variation, depending on the growth areas, revealed that flavonoids concentration increases throughout the plant cycle (Guerra et al., 2008; Vasas et al., 2015).

Stilbenoids

Due to their therapeutic effects, stilbenoids are considered the most important group of plant-derived polyphenols. Such an important biologic active compound is resveratrol. Studies have showed that resveratrol can prevent cardiovascular diseases due to its lipid-lowering effect (Fremont et al., 1999). It is also a potent inhibitor of tyrosine kinase and possesses antifungal properties (Jayatilake et al., 1993; Gonzales et al., 2003).

Resveratrol and its derivatives were isolated from dry roots and leaves of *Rumex* spp. in concentration between 165 μg/g and 239 μg/g (Rivero-Cruz et al., 2005).

Tannins, carotenoids, and polysaccharides

Roots and tubers of *Rumex* species are producing tannins such as leucocyanidin, leucopelargonidin, and leucodelphinidin. These compounds were studied due to their antitumor activity (Buchalter & Cole, 1967).

Important carotenoids such as lutein and β-carotene are frequently isolated from leaves of *Rumex* species (Molnár et al., 2005; Bélanger et al., 2010), and anhydroluteins I and II from stems (Molnár et al., 2005). The lutein content in *Rumex* spp. ranges from 53 μg/g fresh weight to 127 μg/g cooked weight. On the other side, the β-carotene content was 45 μg/g fresh weight to 139 μg/g cooked weight (Bélanger et al., 2010).

A high content of polysaccharides was isolated from the roots, D-glucose being the most representative (Ito et al., 1986).

Other compounds

Several acids, minerals, vitamins, and essential aminoacids were isolated from *Rumex* spp. Such compounds were obtained from all aqueous, acetone or ethanol plant extracts.

Acids were isolated from whole plants. The most abundant is the oxalic acid. However, caffeic, neochlorogenic, citric, malic, shikimic, and ascorbic acids are also present (Yoon et al., 2005; Khare, 2007; Guerra et al., 2008). Sorrel is known to contain a high level of oxalic acid (300 mg/100 g). When absorbed, this acid has a corrosive action upon the digestive tract. It also reacts with the calcium in plasma and the insoluble calcium oxalate tends to precipitate in kidneys, blood vessels, heart, lungs, and liver. This reaction can produce hypocalcemia (Farré et al., 1989). Therefore, it is important to have a moderate consumption of such plants.

However, leaves are a good source of minerals, such as calcium (2840 mg), cooper (2.5 mg), iron (36.2 mg), magnesium (1900 mg), potassium (2950 mg), sodium (1010 mg), zinc (5.4 mg), a moderate source of proteins (18.6 g/ 100 g of dry weight) and a low source of lipids (Alfawaz, 2006).

Depending on the growth conditions, the sorrel total vitamin C content is between 22.2 mg and 29.7 mg /100 g of fresh leaves (Sánchez-Mata et al., 2012).

BIOLOGIC ACTIVE COMPOUNDS

The biologic active compounds found in different plants of the *Rumex* genus and their utilization for different diseases treatments are presented in the following table (Table 1).

Table 1. Bioactive compounds, traditional use and plant cultivation area of *Rumex* species (after Vasas et al., 2015; Mishra et al., 2018)

Species	Plant part	Bioactive compounds	Traditional use	Formulation	Plant cultivation area
R. abyssinicus	roots	rhein, chrysophanol, emodin, emodic acid, aloe emodin, alizarin, physcion, damnacanthal, catenarin, anthraquinone, plamidin C, chrysophanol-8-β-D-glucoside, emodin-8-β-D-glucoside,8-C-Glucosyl-apigenin, 8-C-glucosyl-luteolin, 6-C-hexosyl-quercetin, 3-O-rutinosyl-quercetin, 7-O-rhamno-hexosyl-diosmetin	stomach disorders, diabetes, diuretic, analgesic, cancer	n.a.	East Africa
R. acetosa	leaves, roots	emodin, chrysophanol, physcion, emodin-8-O-β-d-glucopyranoside, sennoside A, sennoside B, vitexin, catechin, gallocatechin, epicatechin, epigallocatechin, procyanidin B2, gallate, vanillic acid, sinapic acid	Cataneu diseases, jaundice, warts	n.a.	Asia, Europe (Romania)
R. acetosella	leaves, seeds	emodin, crysophanol, pyscion, sennoside A, sennoside B	analgesic, diuretic, jaundice, warts, fever, dysentery	fresh leaves, decoction	North America, Europe (Britain, Ireland, Turkey, Hungary, Romania)
R. alpinus	seeds, roots	2-acetyl-3-methylnaphthalene-1,8-diol	stomach problems, dysentery, eczema	n.a	Europe (Hungary)
R. aquaticus	n.a.	anthraquinones (emodin, chrysophanol, physcion, citreorosein, chrysophanol-8-O-glucoside), flavonoids (quercetin, quercetin-3,3′-dimethylether, isokaempferide, quercetin 3-O-arabinoside, quercetin 3-O-galactoside, quercetin 3-O-glucoside catechin), stilbenes (resveratrol, piceid) and 1-stearoylglycerol	stomach problems, infection, oedema	n.a	Europe (Bulgaria, Ukraine, Turkey)
R. bequaertii	roots	n.a.	stomach disorders, cancer	n.a.	East Africa
R. chinensis	roots, leaves	n.a.	constipation, inflammation, acne, eczema	powder or decoction, maceration in alcohol	Asia
R. confertus	seeds	pyscion, sennoside A, sennoside B	diarrhoea	infusion	Europe (Hungary)
R. crispus	roots, leaves, seeds, fruits	rumicin, chrysarobin, β-sitosterol, hexadecanoic acid, hexadecanoic-2,3-dihydroxy propyleste, chrysophanol, chrysophanol-8-O-β-D-glucopyranoside, physcion, physcion-8-O-β-D-glucopyranoside, emodin, emodin-8-O-β-D-glucopyranoside, gallic acid, (+)-catechin, kaempferol, quercetin, kaempferol-3-O-α- L-rhamnopyranoside, quercetin-3-O-α-L-rhamnopyranoside	cleanser, skin diseases, icterus, astringent, eye infection, vermicide, skin diseases, rheumatism, tonic	infusion	Europe (Romania, Hungary, Britain, Ireland, Turkey) North and South Africa, North America
R. dentatus	roots	helonioside A, gallic acid, isovanillic acid, p-hydroxycinnamic acid, succinic acid, n-butyl-β-D-fructopyranoside, quercetin, hexadecanoic acid 2,3-dihydroxy propyl ester, β-sitosterol, daucosterol, anthraquinones, flavonoids, phytosterols, phytosteryl esters, free fatty acids, chromones, anthrones, kaempferol 3-O-β-galactoside, kaempferol 3-O-β-glucoside, kaempferol 3-O-rutinoside, isorhamnetin 3-O-β-galactoside, isorhamnetin 3-O-β-glucoside, isorhamnetin 3-O-rutinoside, chlorogenic acid, myricetin, vitamin C.	bacterial and fungal infections	n.a.	Asia
R. ecklonianus	roots	n.a.	sterility, purgative	n.a.	South Africa
R. hastatus	roots, whole plant	leucodelphinidin, leucopelargonidin	laxative, tonic, diuretic, skin disorders, cough, headache, fever	n.a.	Asia
R. hymenosepalus	leaves, roots	emodin, pyscion, rutin, leucopelargonidine, leucocyanidin, eticatechin, epigallocatechin, trans-resveratrol	skin irritation, “purify the blood”, astringent, cough	n.a.	Europe (Britain And Ireland)

Species	Plant part	Bioactive compounds	Traditional use	Formulation	Plant cultivation area
R. japonicus	n.a.	emodin, rutin, rumejaposide, epoxy-naphthoquinol, chrysophanol, physcion, 8-O-β-glucopyranoside.	constipation, hematemesis	n.a.	Asia
R. madarensis	n.a.	ascorbic acid, neoclorogenic acid	diuretic, "blood depurative", dermatitis	n.a.	Asia
R. maritimus	leaves, seeds, roots	n.a.	burns, purgative, tonic, analgesic,	n.a.	Asia
R. nepalensis	roots, leaves	rumexneposide A, physcion, chrysophanol-8-O-β-D-glucopyranoside, torachrysone, emodin-8-O-β-D-glucopyranoside, emodin-8-O-β-D-(60-O-acetyl) glucopyranoside, chrysophano, emodin, citreorosein, resveratrol, nepodin-8-O-β-D-glucopyranoside, torachrysone-8-O-β-D-glucopyranoside, chrysophanol-8-O-β-D-(60 -O-acetyl) glucopyranoside	stomach, haemostasis, purgative, colic, skin disorders	infusion, decoction	South Africa, Asia
R. nervosus	n.a.	n.a.	acne, diabetes, ophthalmic, antiseptic, eczema	n.a.	Europe
R. obtusifolius	aerial parts	anthracene derivatives, flavonoids, procyanidins, oxalic acid	astringent, laxative, antidote to nettle, sores, blisters, burns, cancer, tumour skin eruption, blood purifier	infusion	Europe
R. patientia	roots, seeds, leaves, shoot	emodin-6-O-β-d-glucopyranoside, flavan-3-ol, 6-chlorocatechin, 2-acetyl-3-methyl-6-carboxy-1,8-dihydroxynaphthalene-8-O-β-D-glucopyranoside, labadoside (4,4''-binaphthalene-8,8''-O,O-di-β-D-glucopyranoside), orientaloside (2-acetyl-3-methyl-1,8-dihydroxynaphthalene-8-O-β-D-glucopyranoside), patientosides A and B.	skin problems, anaemia, fever, respiratory disorders, rheumatism	juice, infusion	Europe, North America
R. scutatus	Whole plant	n.a.	antipyretic, astringent, antiscorbutic	juice	Europe, Asia
R. stenopyllus	seeds	n.a.	cough	n.a.	Europe (Romania)
R. tuberosus	Leaf	n.a.	antihypertensive,	infusion, fresh leaves	Europe
R. vescarius		flavonoids, C-glycosides: vitexin, isovitexin, orientin, iso-orientin; anthraquinones: emodin, chrysophanol, rumicin, lapathin; oxalic acid, tannins, mucilage, mineral salts and vitamin C.	tonic, analgesic, hepatic diseases, poor digestion, spleen disorders, asthma, alcoholism	n.a.	East Africa, North America
R. woondii	seeds	n.a.	Dysentery	n.a.	South Africa
Where n.a. = not available					

Species of the *Rumex* genus are widespread throughout the world, mainly in Asia and Central Europe. Such plants are frequently grown for dietary purposes, and used as fresh food or cooked. The common ways of consumption are in salads, soups, snacks, but can also be prepared as decoction, infusion, juice, or powder (dehydrated plants). As medicinal plants, *Rumex* species can be used in for the treatment of gastrointestinal disorders, skin diseases, improving eyesight and stabilizing blood pressure, as well as preventing diseases such as scurvy (Figure 1).

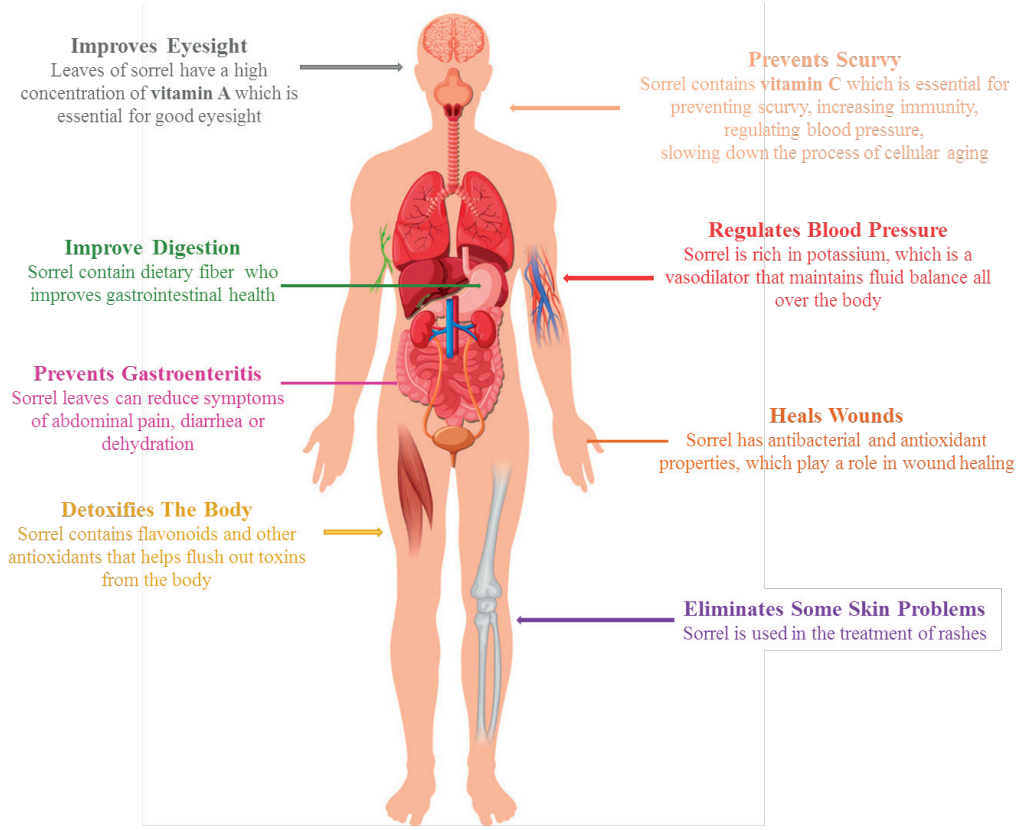

Figure 1. Utilization of *Rumex* spp. in traditional medicine

Note: This figure was created by authors usig various sources: https://niosrcranchi.org.in. and https://www.vectorstock.com

Nowadays, around 130 bioactive molecules have been identified from *Rumex* plants (Vasas et al., 2015). These include anthraquinones, naphthalenes, flavonoids, stilbenoids, tannins, carotenoids, polysaccharides, and other compounds.

CONCLUSIONS

The present review provides the current stage of knowledge regarding biologic active compounds, biochemical profile and safety use of *Rumex* species.

Among edible plants of *Polygonaceae* family, *Rumex* species are more and more cultivated, and consumed as innovative food.

Rumex spp. can also be considered an important source of bioactive substances with medicinal purposes. Therefore, the interest for this plant extracts are taken into consideration for the pharmaceutical industry.

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