BIOLOGICAL ACTIVITY AND FOOD POTENTIAL OF PLANTS *RUMEX CRISPUS* L. AND *RUMEX OBTUSIFOLIUS* L. – A REVIEW

SCIENTIFIC REVIEW

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DOI: 10.5281/zenodo.6923305

RECEIVED 2022-03-15 **ACCEPTED** 2022-04-18

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ABSTRACT:
***Rumex crispus* L. and *Rumex obtusifolius* L. (*Poligonaceae*) are perennial wild plants. For centuries these plants have been considered weeds in conventional agriculture. They have also been recognized as a serious problem in organic agriculture, as they are difficult to control without the use of chemical agents. However, *Rumex crispus* L. and *Rumex obtusifolius* L. are used worldwide in human nutrition and traditional medicine. They are available both in periods of abundance and in difficult times, and can be an important source of nutrients. As wild growing plants, with use in diet and traditional medicine, *R. crispus* and *R. obtusifolius* present potential sources of new therapeutic agents. This paper provides an overview of previous research for the plants *Rumex crispus* L. and *Rumex obtusifolius* L. in terms of their nutritional value, use in traditional medicine, as well as antioxidant and antimicrobial activity.**

KEYWORDS: *Rumex crispus* L.; *Rumex obtusifolius* L.; antioxidant; antimicrobial; nutritional potential

INTRODUCTION

The potentials of biological resources are still intensively explored for the benefit of mankind, and for improving the quality of human life in a sustainable way. The research „bioprospecting" involve the search for valuable compounds in nature [1].Thus, wild plants, which are traditionally used in human nutrition and treatment, become the subject of study. They represent potential sources of new and effective therapeutic agents, including new antibiotics and antioxidants. Phenolic components are considered to be the most important antioxidants of plants, so the antioxidant activity of plant material is correlated with the content of phenolic components [2]. Variability in the content of these components depends on: plant species, environmental factors and collection period [3]. It should be noted that phenols play a significant role in the fight against chronic human diseases [4].

Given that wild plant species *Rumex crispus* L. and *Rumex obtusifolius* L. (*Polygonaceae*) are still used in human nutrition, and have been used for years as medicinal plants in traditional medicine, there is a need for their more detailed study in terms of antioxidant and antimicrobial properties. There are a limited number of studies on the content of total phenols, as well as on the antioxidant and antibacterial activity of *Rumex crispus* L. An even smaller number of studies have been conducted for the plant *Rumex obtusifolius* L. The studies conducted so far show that both plants represent a significant source of antioxidants and compounds with antibacterial effect [5], [6]. Some of the research suggests that the consumption of both plant species may be beneficial due to the high content of proteins and antioxidants [7]. These plants' potential to inhibit pathogens in food is also pointed out.

This paper provides an overview of previous research for the plants *Rumex crispus* L. and *Rumex obtusifolius* L. in terms of their nutritional value, as well as antioxidant and antimicrobial activity.

RUMEX CRISPUS L. AND RUMEX OBTUSIFOLIUS L.

Polygonaceae (the knotweed family or smartweed–buckwheat family) are a family of dicotyledonous plants under the order *Caryophyllales*. This family includes 43 genera with over 1000 species, including the genus *Rumex*. Plants of the genus *Rumex* are represented worldwide, with about 200 plant species. Plants of the family *Polygonaceae* contain a large number of chemically complex and biologically active compounds. The root and aboveground parts of plants from the *Polygonaceae*

family, including the genus *Rumex*, are traditionally used worldwide for their: psychopharmacological, antioxidant, purgative, antidiarrheal, antitumor, antidermatitis, diuretic and antiviral effects [8]. Numerous phytochemicals have been isolated from plants of the genus *Rumex* [9].

Rumex crispus L. (the curly dock, curled dock, yellow dock) is a perennial wild plant, which can reach a height of 30-100 cm (Figure 1).

Figure 1. *Rumex crispus* L.

It has a well-developed root. The tree is bare, furrowed. The leaves are large, somewhat fleshy, on a stalk as long as the leaf blade (30 cm). The lower leaves are lanceolate and wrinkled, while the upper are linear. The flowers are bisexual, up to twice as short as the flower stalk. They are gathered in whorls, and these in loose panicles. The fruit is a nut, brown in colour, about 3 mm long. It is sharpened at the top. It blooms from June to August. It is widespread in Europe, Asia, North and South America. It grows in neglected places, ruderal habitats and meadows, mostly wet or mesophilic [10].

Rumex obtusifolius L. (bitter dock, broad-leaved dock, bluntleaf dock, dock leaf or butter dock) is a perennial wild plant, up to 120 cm tall (Figure 2).

It has a spindle-shaped and strong root. The tree is erect, sometimes reddish. The leaves are large and long. They have longer stems at the bottom of the tree. The plant blooms from June to August. The red flowers are clustered in racemose inflorescence. The plant is widespread in temperate climates, thriving on moist, alkaline, humus and heavier soil [11].

For centuries, acetosa – especially *Rumex obtusifolius* L. and *Rumex crispus* L. – have been considered weeds in conventional agriculture [12], [13]. Recently, they have also been recognized as a serious problem in organic agriculture, as they are difficult to control without the use of chemical agents; [14] they grow rapidly, are resistant to cutting (in two to three weeks, they renew a supply of hydrocarbon that they used to re-grow), live long, and are capable of producing up to 80,000 seeds per plant per year. In this way, they form a „seed bank" in the soil, which allows them to survive for up to 80 years [15].

Figure 2. Rumex obtusifolius L.

THE USE OF *RUMEX CRISPUS* L. AND *RUMEX OBTUSIFOLIUS* L. IN HUMAN NUTRITION

In different parts of the world, wild plants play an important role in the diet of the population. Given that they are drought resistant, they are available both in periods of abundance and in difficult times. If used in the daily diet, they can be an important source of nutrients, macro and micro nutrients [7]. Plants of the *Polygonaceae* family are used worldwide in human nutrition. Young leaves of *R. crispus* L. and *Rumex obtusifolius* L. are used in the diet as vegetable, for the preparation of sour soups or meat wrapping [11,16-18]. Of the 26 wild plants used in the diet of Anatolia inhabitants, the leaves of *R. crispus* L. turned out to have the highest protein content (11.56% per gram of dry matter) and the highest nitrogen content (1.17%), even higher N content than some cultivated plants [7]. In general, plants from the family *Polygonaceae* had the highest content of N, S and Cu, in relation to other examined families [7]. In Brazil *Rumex obtusifolius* it is considered as an unconventional food plant, and can be used as a good source of nutritional components necessary for human diet, such as lipids, proteins and carbohydrates. Root of *R. obtusifolius* presented a high content of carbohydrates (30.6%), and the leaves presented more proteins (2.7%). *R. obtusifolius* is among these plants with excellent nutraceutical properties [19]. The plants from genus *Rumex* also contain oxalic acid, which can cause kidney damage in higher concentrations.

THE USE OF *RUMEX CRISPUS* L. AND *RUMEX OBTUSIFOLIUS* L. IN TRADITIONAL MEDICINE

Herbal remedies have been traditionally used around the world for thousands of years [20]. A significant number of indigenous wild plants are used in the treatment of various diseases [21], [22], [23], [24]. Wild plants, including the genus *Rumex* (*Polygonaceae*), are widely used in traditional medicine in rural parts of eastern Anatolia (Turkey). The flowers, stem, leaves and root of these plants are commonly used in the treatment of various disorders, which include: pain, edema, eczema, digestive problems, arthritis, colds, flu, and irritability. A tonic is prepared from root, and it is also used to „cleanse" the blood. Plants of this genus show laxative, diuretic, antipyretic, and anti-inflammatory effects [25], [26]. *R. crispus* dried roots are a gentle and safe laxative, useful for treatment of mild constipation, due to anthraquinone content which gives the roots yellow colored pigment [27].

The root of some species of the genus *Rumex* contains anthracene derivatives (0.2-1.7%) and catechin tannins (6-12%). Because the root does not contain toxic substances, it can be used as a safe natural remedy [16].

In some parts of Italy, the leaves of *R. crispus* L. are used for medicinal purposes – in the treatment of dermatitis, injuries, and in cosmetics [28]. Reuter et al. (2010) state that *R. crispus* L. is used in acne treatment [29]. *R. crispus* is also useful for treating a wide range of skin problems such as fungal disorders, spring eruption and scrofula [27]. Bussmann and Glenn (2010) mention that the whole plant *R. crispus* L. is used in medicinal purposes in northern Peru in the treatment of reproductive problems in women [30]. This plant is used fresh to treat uterus infections, inflammation of the female reproductive organs, and vaginal infections. In form of decoction or tincture *R. crispus* is used for the treatment of microbial infections, malaria, and sleeping sickness [31]. The infusion or decoction of *R. crispus* is commonly used for the treatment of helminths, wound, internal bleeding and vascular diseases in folk medicines of South Africa [32]. The mean phytochemical content of the root of *R. crispus* is higher than that of the leaf and this may also justify the frequent use of the root more than the leaves in South Africa traditional medicine for the cure of helminthic infections [33].

Šarić (1991) stated that the leaf and ripe fruit of *R. crispus* L. are used in area of former Yugoslavia in the treatment of diarrhea, hemorrhoids, anemia, as well as to improve digestion and appetite [11]. *R. obtusifolius* L. is used in treatments in the same way as *R. crispus* L. It has a medicinal root [11]. *R. obtusifolius* has therapeutic indications, because its use cleanses toxins, has laxative, diuretic, calming effect, decrease the incidence of chronic skin diseases, liver disorders and anemia [19].

ANTIMICROBIAL POTENTIAL OF *RUMEX CRISPUS* L. AND *RUMEX OBTUSIFOLIUS* L.

Throughout human history, infectious diseases have been treated with herbal remedies [34]. Since numerous studies indicate a significant increase in bacterial resistance to several antibiotics [35], there is significant interest in medicinal plants, traditionally used in folk medicine, which are a potential source for the discovery of new and effective therapeutic agents. They are also interesting from the aspect of the use of plant extracts in fight against plant pathogens [36], [37], [38].

Studies examining the antibacterial activity of some *Rumex* species – such as *R. crispus* L. [39], *R. nervosus* L., *R. abyssinicus* L. [40], *R. japonicus* L. [2] and *R. alveollatus* L. [8] – showed significant inhibitory activity against majority of tested microorganisms. Extracts of these plants can be used as natural antibiotics in the treatment of some diseases, especially localized skin diseases.

The extracts of *R. crispus* have been declared to possess an antioxidant, antimicrobial and antifungal activities [27]. A study conducted by Yildirim et al. (2001) showed that extracts of *R. crispus* L. leaves in ether, ethanol and hot water are active against *Staphylococcus aureus* and *Bacillus subtilis*. The extracts do not show activity against *Escherichia coli*, *Pseudomonas aeruginosa* and *Clostridium albicans* [41].

Ulukanli et al. (2005) investigated the antibacterial activity of extracts of *R. crispus* L. root and aboveground parts [39]. According to them, *R. crispus* L. root extract in hexane shows *in vitro* activity against Gram-positive bacteria: *Micrococcus luteus*, *Mycobacterium smegmatis*, *Bacillus subtilis*, and *Bacillus subtilis* var. niger, as well as three species of Gram-negative bacteria: *Aeromonas hydrophila*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa*. The extract in hexane shows no activity against *S. aureus*. The root extract in methanol does not inhibit the growth of the bacterial species *A. hydrophila* and *P. aeruginosa* only, while the acetone extract shows activity against all the aforementioned Gram-positive and Gram-negative bacteria. The effect of methanolic extracts of *R. crispus* L. root against the examined Gram-positive is more pronounced than against Gram-negative bacterial cultures. The extract

of the aboveground parts of *R. crispus* L. in hexane shows only antibacterial activity against *M. smegmatis*, *B. subtilis* and *B. subtilis* var. niger. Acetone extract of aboveground parts does not prevent the growth of *S. aureus*, *B. subtilis* var. niger and *P. aeruginosa*. Methanolic extract of aboveground parts of *R. crispus* L. does not show antibacterial effect against *P. aeruginosa* only. The acetone extract activity of *R. crispus* L. root has shown promising results against mostly Gram-positive pathogens. This indicates the presence of strong antimicrobial substances in the solid extract of this plant. Thus, its further purification and isolation is necessary in order to determine the types of substances responsible for the antimicrobial activity of this medicinal plant [39]. Research of antibacterial activity conducted by Coruh et al. (2008) revealed that the aqueous extract of the aboveground parts of *R. crispus* L. does not show antimicrobial activity, while the methanol extract shows an inhibitory effect on the growth of 15 tested microorganisms [3]. The extract has shown a very strong antibacterial effect against bacterial cultures: *Agrobacterium tumefaciens*, *Bacillus cereus*, *Bacillus subtilis*, *Pseudomonas corrugate*, *Pseudomonas syringae* pv. tomato, *Salmonella typhimurium*, *Serratia liquefaciens*, *Vibrio cholerae*, *Yersinia frederiksenii* and *Yersinia pseudotuberculosis*. *Xanthomonas compestris* was most sensitive to the extract activity. Its MIC (minimum inhibitory concentration) value was lower than the MIC value of the standard.

The study of Cowan (1999) showed that methanol extract is a strong antibacterial inhibitor, with high phenol content [42]. The antibacterial activity of the methanolic extract of *R. crispus* L. can be attributed to the presence of several compounds. Thus, the phenolic compound pyrogallol has a toxic effect on microorganisms – by inhibiting enzymes, and reacting with a sulfhydryl group [42].

Methanolic extract of *R. obtusifolius* L. shows antibacterial activity against *B. cereus*, *B. subtilis*, *E. coli*, *S. aureus* and *Salmonella tryphi* [43]. Aqueous fractions of *R. obtusifolius* L. herb extract showed weak inhibition against *S. epidermidi*, *S. aureus*, and MRSA, while aqueous fractions of *R. obtusifolius* L. root extract showed moderate inhibition against the same bacterial species [6]. The ethanolic extract of *R. obtusifolius* L. fruits possessed potential activity against the reference and clinical staphylococcal strains (MIC=500 μg/mL), also aggainst *P. mirabilis* (MIC=500 μg/mL), lower inhibitory effect on the growth of Gram-negative bacteria – *E. coli* ATCC 3521, *P. vulgaris* and *P. aeruginosa* (MIC > 500 μg/mL), and higher antifungal activity against *T. menthagrophytes* with MIC=250 μg/mL in agar dilution method [44].

It has been reported that three substances isolated from roots of *R. crispus* exhibit antifungal activity. They are identified as two anthraquinones - chrysophanol and parietin, and nepodin. These compounds in experiments *in vivo* screened for antifungal activity were effective in controlling of the disease development comparable to synthetic fungicide fenarimol, at similar concentrations [9].

ANTIOXIDATIVE POTENTIAL OF *RUMEX CRISPUS* L. AND *RUMEX OBTUSIFOLIUS* L.

Oxidative damage – a primary as a result of metabolism, or a secondary caused by environmental contaminants – leads to the formation of free radicals, which are thought to play a central role in the development of diseases such as cancer and atherosclerosis. Therefore, antioxidants, which can neutralize free radicals, can help prevent these diseases [45].

Although synthetic antioxidants – such as butylhydroxytoluene (BHT) and butylhydroxyanisole (BHA) – are used in food production, there are reports on their side effects [46]. Therefore, the substitution of synthetic antioxidants by natural ones, as well as the screening of new plant species with the aim of identifying new antioxidants, are of particular importance in recent years [47].

Reactive oxygen species (ROS) are formed in cells during normal aerobic metabolic processes. Endogenous sources of ROS are numerous membrane and cytosolic oxidoreductases, and the largest ROS production in the cell is related to mitochondria (respiratory chain), peroxisomes, and microsomes [48]. At low and moderate concentrations, ROS have numerous roles in the cell: defense against infectious agents and the functioning of regulatory mechanisms and intracellular signaling pathways. At low and moderate concentrations, ROS have numerous roles in the cell: defense against infectious agents as well as the functioning of regulatory mechanisms and intracellular signaling pathways.

ROS can also occur under the influence of various exogenous influences, such as various biotic and abiotic factors. Their activity can upset the balance between prooxidant and antioxidant reactions, resulting in increased production and accumulation of ROS. This condition is known as oxidative stress. Increased ROS production, along with decreased cell antioxidant protection, can lead to oxidative damage to cellular constituents such as: lipids, proteins, and DNA.

Phenolic components are considered to be the most important plant antioxidants, and thus the antioxidant activity of plant material is correlated with their content of phenolic components [2]. Phenols play a significant role in the fight against chronic diseases [4]. Variability in phenol content may be the result of: environmental factors, plant species, and collection periods [3].

Although the antimicrobial activity of some species of the genus *Rumex* has been investigated, the number of studies on the total phenols content, as well as the antioxidant and antibacterial activity of *R. crispus* L. is limited [3].

Research, conducted by Coruh et al. (2008), showed that the aboveground parts of the plant *R. crispus* L. are a rich source of phenol compounds. The difference in the antioxidant activity of the extracts in water, and methanol, is not statistically significant compared to BHA and BHT. The results indicate that the aboveground parts of the plant *R. crispus* L. have strong antioxidant activity, which can be significant for both human consumption and food safety [3].

The study of Idris et al. (2015) shows the presence of alkaloids, phenols (16.9 to 240.7 mg GAE/g), flavonoids (19.4 to 526.23 mg QE/g), saponins and proanthocyanidins in the solvents extract (methanol, ethanol, acetone, and water extract) of the root and leaf of *R. crispus* [33]. The root of the plant has higher content of phytochemicals than the leaf and also showed a slightly higher antioxidant activity compared with the leaf tested by ABTS, DPPH and FRAP, total antioxidant capacity, and nitric oxide scavenging assay. The study of Suh et al. (2011) revealed that curly dock seed extremely play an important role in reactive oxygen species (ROS) scavenging against oxidative stress [49].

The cyclohexane, dichloromethane, and methanol extracts of *R. crispus* L. aerial parts were rich in phenolic compounds (13.0 to 249.8 mg GAE/g of dry weight), and MeOH extract has presented remarkable activity in DPPH asay (IC_{50} 6.2 μg/mL) [50].

A study on the antioxidant activity of ripe fruit extracts of *R. crispus* L., and their influence on lipid peroxidation in liposomes, conducted by Maksimović et al. (2011), revealed that methanol extracts of *Rumex crispus* L. fruit show antioxidant activity similar to BHT activity. Pre-treatment with the extract *in vivo* inhibits oxidative stress induced by carbon tetrachloride, bringing the level of antioxidant enzymes close to control values [51].

The aqueous extract of curly dock fruits evaluated for its antioxidant activity by *in vitro* assays for ferric-reducing antioxidant power (FRAP), NO•, OH• and 2,2-diphenyl-1-picrylhydrazyl (DPPH)-free radical scavenging activities and the influence on lipid peroxidation in liposomes showed a potential antioxidant activity manifested in scavenging of free radicals as well as an ability to decrease lipid peroxidation in liposomes [27].

Methanolic extract of *R. obtusifolius* L. shows a high level of antioxidant activity [43]. In study of Sganzerla et al. (2019) phenolic, flavonoids, flavonols were quantified, and antioxidant activity by DPPH, ABTS and FRAP asays was tested in aqueous, ethanolic and hydroethanolic extracts. The best solvent tested in this study was the hydroethanolic extract to root and ethanolic extract to leaf. The hydroethanolic extract from root presents more antioxidant activity by ABTS (2695.3 mg TEAC 100 g-1) and FRAP (13579.2 mg TEAC 100 g-1) comparing to the other extracts. Compared to other examined extracts the TPC (981 mg GAE 100 g-1), TFC (155.1 mg QE 100 g-1) and TF (136.7 mg QE 100 g-1) were more concentrated in hydroethanolic (70% ethanol) extract [19]. The antioxidant activity of the studied parts of plants *Rumex crispus* L. and *Rumex obtusifolius* L. by DPPH, ABTS and FRAP asay can be arranged in the following order: the generative part (flowers, seeds) > leaves > root > stem (for flowering and fruiting stages). It this study was found that parts of the root closer to the stem differed in higher activity [5].

CONCLUSION

Rumex crispus L. and *Rumex obtusifolius* L. are widespread weed plants. They have long been used in the diet and traditional medicine of people from different areas. Studies have shown that these plants have a rich nutritional composition and can be a good source of nutrients and bioactive compounds. The extracts of *R. crispus* and *R. obtusifolius* have been declared to possess antioxidant, antimicrobial, and antifungal activities, offering remarkable protection activity. The level of phenolic compounds and other phytochemicals identified in these plants contributed to their radical scavenging activity and medicinal properties. Research to date indicates that *R. crispus* and *R. obtusifolius* can be potential sources of biologically active molecules intended for use in the pharmaceutical and food industry. Further work needs to be established to identify other molecules responsible for the biological activity of these plants.

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