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Rumex acetosa: A Comprehensive Review of its Ethnobotany, Chemistry, Pharmacology and Toxicity

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ABSTRACT

Rumex acetosa is a widely distributed perennial plant belonging to the polygonaceae family. It has been used as a food source, medicinal herb, and dye source due to its rich content of phytochemicals like flavonoids, anthraquinones, tannins, and oxalic acid. These compounds contribute to its antioxidant, anti-inflammatory, antimicrobial, antitumor, and antihypertensive properties. However, its high oxalic acid content can lead to health risks such as mineral deficiency and kidney stone formation, necessitating moderate and careful consumption. Sorrel is easy to grow and can be propagated by seeds or division. It holds potential for further cultivation and utilization as a vegetable, herbal remedy, and phytoremediator. The safety and effectiveness of sorrel extracts need to be confirmed, and further study is required to investigate the underlying molecular processes of their pharmacological actions, despite their intriguing pharmacological qualities and prospective use in disease prevention and therapy.

KEYWORDS – Rumex acetosa; Medicinal importance; Phytochemistry; Pharmacology; Toxicity.

Introduction:

Rumex is a widespread plant genus in the Polygonaceae family. It is the second biggest genus in this family. Most of its species may be found in the United States, Asia, Africa, and Europe, particularly in the northern hemisphere1. sorrel, a leafy green that has been consumed for centuries, is known for its unique, tart flavor due to the presence of oxalic acid. It's a versatile ingredient used in a wide range of dishes, and herbal remedies, and even as a source for various dye colours. Its sharp, sour-lemony taste complements many ingredients well, including meats, cheeses, and dairy products. due to its anti-inflammatory, antioxidant, diuretic, antibacterial, antihypertensive, analgesic, antiviral, and antifungal qualities, these compounds have been used in traditional medicine since ancient times. Numerous medical illnesses, including constipation, diarrhea, edema, diabetes, jaundice, infections, scurvy, and problems with the gall bladder and liver, have been treated with it. It has been suggested that the rhizomes and petals contain substances that might prevent the development of cancer2. The Polygonaceae family of plants is recognized for their production of different secondary metabolites that are biologically important. These metabolites include anthraquinones, stilbenoids, glycosides, naphthalenes, leucoanthocyanidins, steroids, flavonoids, and phenolic acids3. Various health conditions are treated using them in traditional medicine. Examples include infections, diarrhea, mild diabetes, edema, jaundice, and constipation as well as being used as a diuretic, antihypertensive, and analgesic. They are also used to address liver, skin, and gallbladder disorders, as well as inflammation. Researchers have shown interest in the Rumex genus because of its medicinal properties and phytoconstituents. The extracts and compounds obtained from these plants have displayed different pharmacological activities, which include antitumor, anti-inflammatory, antioxidant, antibacterial, antifungal, and antiviral properties, both in vitro and in vivo3,4.

Taxonomy:

R. acetosa is a perennial herb that is dioecious and wind-pollinated and thrives in a broad range of environments. It has a slender fibre root that originates from a short woody stock stem that is subsimple and It can reach heights between 30-60 cm with deep grooves. The leaves range in length from 5 to 15 cm. The radical leaves are oblong-obtuse, cordate, hastate, or sagittate in base, and they have petioles. Sessile cauline plants. The bottom leaves have a thin petiole with ragged stipules. With six to eight flowering whorls and a constricted anicle, the racemes are loose. The branches lack leaves and are rigid and upright. The male's outer sepals are reflexed, and its edges are scarious. There are orbicular valves. It is a triangular achene fruit. The large, ovate, mature female perianth can be either pink or scarlet in colour[5]. Plants known as docks or sorrel are currently categorized under the Rumex genus. *R. acetosa*, in particular, is known by a variety of names. These include common sorrels, garden sorrels, sheep sorrels, red sorrels, sour weed, and field sorrels. The Rumex species have numerous common names, some of which can be confusing due to their overlap. In English, it's also referred to as garden sorrel, in Ayurveda it's known as chuukaa, and locally it's called ambatchuka[6].

Fig. 1- Rumex acetosa

Taxonomical Classification:
Kingdom: Plantae
Order: Caryophyllales
Family: Polygonaceae
Genus: Rumex
Species: Rumex acetosa
Bionomial Name: Rumex acetosa Linn[7].

Ethnomedicinal Importance:

In Britain and Ireland, *R. acetosa* leaves are used to cure a range of conditions, such as warts, bruises, scurvy, jaundice, wounds, and sore throat[8]. They are also used to reduce fever and encourage the excretion of fluids. Sorrel, scientifically known as *Rumex acetosa,* is a highly versatile plant that has been used in Middle Eastern and South-Eastern cuisine for centuries. The plant is known for its nutritional and medicinal properties. Sorrel stems are consumed as an appetizer, while the leaves are utilized in soups and sauces. The plant contains a high amount of vitamin C, which makes it a valuable ingredient in treating diseases caused by vitamin C deficiencies, such as scurvy. Apart from its nutritional value, sorrel is also known for its medicinal properties. It has been used to treat a variety of health conditions such as bruises, jaundice, sore throat, scurvy, wounds, and warts. Sorrel is known to have a calming effect on the stomach and intestines, which makes it helpful against constipation, cramping, and diarrhea. Its seed is an effective remedy for managing hemorrhages due to its astringent property[4,6]. A study conducted by Hartwell in 1970 showed that several Rumex species, including *R. acetosa*, were used to treat various kinds of tumors among American locals. The plant can be prepared in various forms such as cataplasm, decoction, infusion, ointment, plaster, poultice, and powder using different parts of the plant, including barks, flowers, leaves, roots, and seeds[9]. Overall, the cultural and historical uses of *R. acetosa* are well documented, and its therapeutic uses have been reported in various studies. Sorrel is a valuable plant that is not only utilized in the culinary world but also in the medicinal world. It is an excellent source of nutrients and an effective remedy for various health conditions[1].

Nutritional Importance:

Rumex acetosa is a plant that is widely used as a food source for humans. One of the major concerns regarding the use of sorrel in the human diet is its nutritional properties. Several studies have been conducted to assess the nutritional and dietary properties of sorrel, which have indicated that this plant has the potential to be used as a functional food or in the food industry[10]. sorrel is a highly nutritious plant that provides a plethora of essential vitamins and minerals that are vital for maintaining good health. Its low sodium, potassium, and magnesium content, coupled with its high calcium and iron content, make it an excellent choice for those looking to maintain a healthy diet[11,12]. A fat-soluble vitamin, vitamin A is essential for good immune system development, bone maintenance, and eye health[13]. Alternatively, water-soluble vitamin C is essential for the body's production of collagen and antioxidant action. It was discovered that sorrel leaves have higher levels of calcium and iron and lower levels of potassium, sodium, and magnesium than most other popular vegetables. Additionally, all essential amino acids were found to be present in *R. acetosa* leaves and were compared favorably with the reference protein[11].

Chemical Composition:

A complex process of separation has been employed to obtain extremely potent compounds from both the above-ground and below-ground parts of the *R. acetosa* plant. This process has led to the discovery of 19 distinct substances, including naphthalenes, anthraquinones, and flavonoids. Among these, some of the noteworthy compounds are musizin, torachrysone-glucoside, emodin, chrysophanol, quercetin, and quercetin-3,3-dimethyl ether. The isolated compounds have undergone testing for their antibacterial activity, and the naphthalenes have demonstrated significant effects against specific bacterial species[14]. Additionally, after further examination of the methanolic extract of *R. acetosa*, several other important compounds have been identified, including tannin, saponin, alkaloids, polysaccharides, anthraquinones, soluble starch, and flavonoids. On the other hand, coumarin was not

found in the extract. These findings offer valuable insights into the potential therapeutic applications of *R. acetosa*[15].

Phytochemistry:

The *Rumex acetosa* species is known for its rich array of secondary metabolites, such as anthraquinones, polyphenols, naphthalene, and other compounds. At present, the wild vegetable was indicated to have over 50 different chemicals[1]. This plant has many substances in its leaves and stems that can protect cells from damage (antioxidant activity), while its roots have anthraquinones and polysaccharides that may help fight cancer cells (anticancer action) [2].

Anthraquinones

Anthraquinones and their derivatives are a group of organic compounds that occur naturally in various species of Rumex and are found in significant amounts. These compounds are most abundant in the roots of these plants[1]. Researchers Wegiera et al.,2007 conducted a study and reported the isolation of several anthraquinone derivatives like emodin(1), aloe-emodin(2), chrysophanol(3), barbaloin(4), physcion(5), rhein(6), palmatin(7), and sennosides A and B. They extracted these compounds from the methanolic extracts of leaves, roots, and fruits of six Rumex species (*R. acetosa*, *R. acetosella*, *R. crispus*, *R. confertus*, *R. obtusifolius*, and *R. hydrolapathum*) using Reverse Phase-High Performance Liquid Chromatography. The authors concluded that the roots had the highest levels of anthraquinones, while the fruits had the lowest levels[16]. Researchers isolated palmati, another anthraquinone, from the flowers of *R. acetosa*[17].

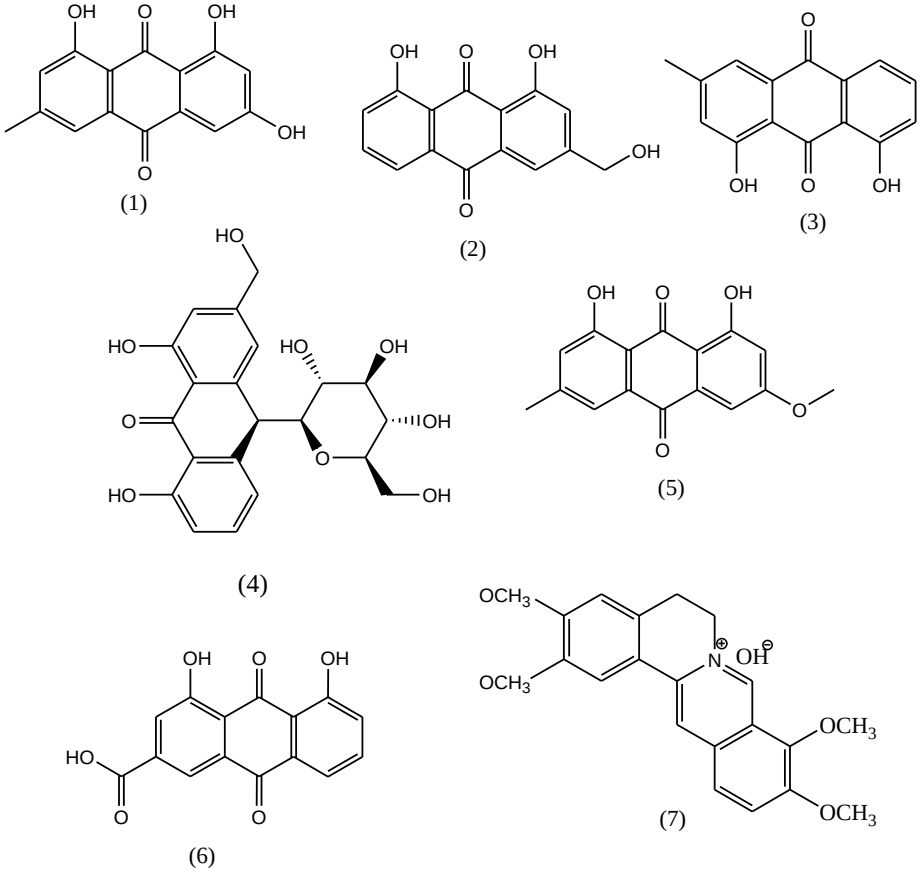

Fig. 2- Anthraquinones

Polyphenols

Flavonoids are a class of secondary metabolites that are abundant in polyphenols. These compounds offer numerous benefits to the human body, including aiding in the protection of cells from damage, controlling inflammation and tumors, and possessing antioxidant properties. Sorrel leaves are a rich source of several phenolic compounds, including flavan-3-ols(8), which provide additional advantages[18,19]. Sorrel is a herbaceous plant with polyphenolic compounds, including flavan-3-ols like epicatechin(9) and catechin(10), and phenolic acids such as gallic acid(11), ferulic acid(12), protocatechuic acid(13) and p-coumaric acid(14), which have potential health benefits[20].

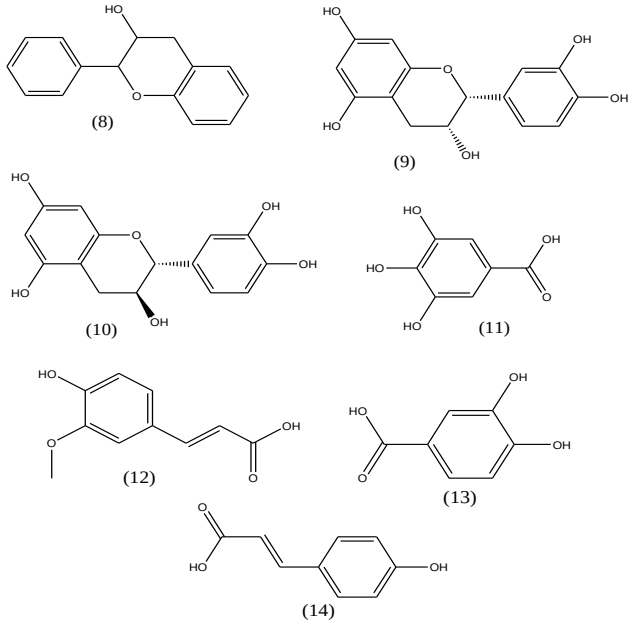

Fig. 3- Polyphenols

Naphthalenes

It has been observed through research that the genus Rumex contains naphthalene and its derivatives, specifically in the leaves and stem of *R. acetosa*. Some of the naphthalene derivatives that have been extracted from this plant include nepodin(15), physcion-1-O-β-D-glycopyranoside(16), physcion-8-O-β-D-glycopyranoside(17), and rhein(6). Additionally, *R. acetosa* has been found to contain 3-acetyl-5-hydroxyl-7-methoxy-2-methyl-1,4-naphthaquinone(18), and emodine-6-O-β-D-glucopyranoside(19)[4,17].

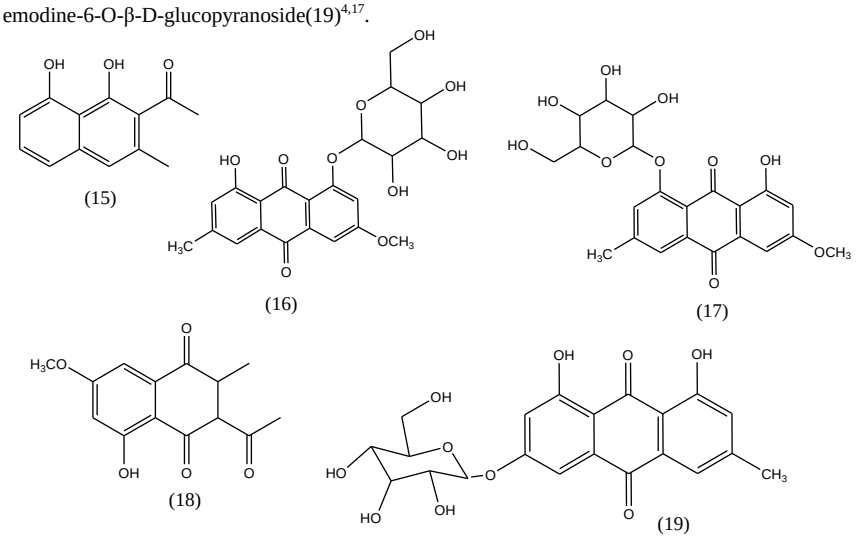

Fig. 4- Naphthalenes

Polysaccharides

Ito, a Japanese scientist, accomplished a significant feat in chemistry in 1986. He successfully extracted a polysaccharide called RA-P from the root of *R. acetosa*. The extraction process involved immersing the root in hot water and precipitating it with cold ethanol to obtain the crude compound. The method yielded a considerable amount of the target compound that underwent structural elucidation. The structural analysis revealed that the polymer predominantly comprised D-glucose, a type of sugar, with Darabinose present in a relatively lower proportion and had a molecular weight of around 300,000. The compound was amorphous, meaning it lacked any defined shape and structure. This discovery opened up new avenues of research and investigation in the field of polysaccharides and their biological activities[21].

Pharmacological Properties:

Antioxidant Activity:

The study investigated the effect of solvents on the antioxidant activity. In the methanolic extracts, the highest TEAC value was found to be 80%. Plant water extracts had TEAC values ranging from 14.2% to 65.8% of those in methanolic extracts. However, the amounts of solvent-soluble solids did not show any correlation with TEAC. Compared to other solvents, the methanolic extracts of plants contained higher concentrations of polyphenols, which are known for their antioxidant properties. The investigation further disclosed that the antioxidant activity of fruits was not enhanced by water-soluble compounds such as organic acids and sugars. Polyphenols such as flavonoids could be oxidized by polyphenol oxidases, which could lead to the corresponding quinones and loss of their antioxidant capacity. Plants extracted with 80% methanol showed significant variation in the TEAC and total polyphenolic values, ranging from <1 to 71 mM TEAC per g dry weight of the plant. Sorrel, thyme (wild), Pulicaria crispa, and sweet basil were found to have the highest antioxidant activity among the plants tested, corresponding to the antioxidant capacity of 5.6–47.1 mM Trolox or 5.1–42.8 mM BHA per g dry weight of the tested plants. The research has shown that the antioxidant properties of certain plant extracts that contain iron-binding antioxidants may be undervalued when using a particular testing method called ferrylmyoglobin/ABTS+. Tea, coffee, and mate, which are common world beverages, were significantly different in their antioxidative capacity or TEAC, which was related to their total phenolic content. Finally, the study concluded that commonly consumed plants contain antioxidants that can act as potential prophylactic agents and natural food additives[22].

Antiviral Activity:

Researchers evaluated the potential of polyphenol-enriched acetone-water extract R2, obtained from *R. acetosa L.*, to combat herpes simplex virus type-1 (HSV-1) and adenovirus 3. Results indicated that the extract exhibited strong antiviral activity against HSV-1 but had no effect on adenovirus 3. Flavan-3-ols and oligomeric proanthocyanidins present in the extract were the key components responsible for its antiviral properties. The extract demonstrated an IC50 of 0.8 µg/ml and a selectivity index (SI) of approximately 100 against HSV-1. The study also found galloylated flavan-3-ols and proanthocyanidins to be highly potent, while ungalloylated compounds were not effective against the virus. Furthermore, the research showed that R2 and a major proanthocyanidin, epicatechin-3-O-gallate-(4→8)-epicatechin-3-O-gallate, prevented virus entry into host cells by inhibiting attachment to the cell surface and penetration of HSV-1 into the host cell. R2 and epicatechin-3-O-gallate-(4→8)-epicatechin-3-O-gallate also interacted with viral particles, leading to the oligomerization of envelope proteins, including the essential viral glycoprotein gD. Additionally, treatment of cultures with R2 after infection with HSV-1 resulted in reduced viral spread in three-dimensional organotypic human skin equivalents[23].

Antimicrobial Activity:

Various plant-based bioactive compounds, such as anthraquinones and flavonoids, have been discovered to possess antimicrobial properties, which can combat various human pathogenic bacteria. In a study, the antimicrobial effects of different extracts of leaves and roots from various Rumex species were compared. Technically graded solvents were used to evaluate *in vitro* antibacterial activity of chloroform and n-hexane parts from 14 Rumex species, including *R. acetosa, R. acetosella, R. alpinus, R. conglomeratus, R. aquaticus, R. pulcher, R. crispus, R. obtusifolius subsp. obtusifolius, R. hydrolapathum, R. obtusifolius subsp. subalpinus, R. stenophyllus, R. patientia, R. scutatus,* and *R. thyrsiflorus*, against various bacterial strains such as *Staph. epidermidis, Bacillus subtilis, MRSA, S. aureus, Moraxella catarrhalis, S. pneumoniae, Streptococcus pyogenes, S. agalactiae, E. coli, Pseudomonas aeruginosa,* and *Klebsiella pneumoniae,* using the disc diffusion method[24].

Antiproliferative Activity:

The research study provides a detailed analysis of the antiproliferation activity of selected phenolic compounds present in various herb flowers. The growth media in the study had various amounts of PhC, such as 100, 75, 50, and 25 µg/ml[19]. High-Pressure Layer Chromatography was used to identify the phenolic component content. The results showed that PhC from the floral extract at lower doses (25 and 50 µg/ml) greatly inhibited cell growth. *R. acetosa* has an antiproliferative activity that varies with concentration. These plants are found to be a valuable source of phenolic compounds, and the quantity and makeup of these compounds can differ based on the type of plant studied. Furthermore, it provides compelling evidence that phenolic compounds present in medicinal herbs can significantly inhibit cell proliferation, thus making them an excellent candidate for the prevention and treatment of tumor diseases. Herb flowers such as *A. Schoenoprasum, T. Pratensis,* and *R. acetosa* are particularly effective in inhibiting cell proliferation. However, it also indicates that antiproliferation activity may not be solely dependent on the total phenolic compound content or composition. Other extracted active substances may also play a significant role in influencing antiproliferation activity, even though they may not have been detected during the study. It offers valuable insights into the potential benefits of using medicinal herbs as a natural remedy for tumor diseases[19].

Antiulcer Activity:

Rumex acetosa is an herbaceous perennial plant that grows predominantly in eastern Asia. Although traditional medicine employs its hot water extract to treat gastric ulcers and gastritis, scientific evidence to support the herb's medicinal properties is lacking. A research study was conducted to explore the potential anti-ulcer effects of water and 70% ethanol extracts derived from *R. acetosa*. The study made use of an HCl/ethanol-induced gastric ulcer model in mice to investigate the extracts' efficacy. Additionally, the extracts' anti-inflammatory and free radical-scavenging properties were compared. The study findings showed that *R. acetosa* extracts were effective in reducing the incidence of gastric ulcers. However, the degree of protection against ulcers varied between the two extracts. Specifically, the group administered a 100 mg/kg dose of ethanol extract exhibited a higher protective effect

(90.9%) compared to the water extract (41.2%). Upon histological examination, it was observed that *R. acetosa* extracts were capable of reversing the negative effects of inflammation, edema, moderate hemorrhaging and loss of epithelial cells caused by HCl/ethanol treatment of stomachs. Additionally, *R. acetosa* extracts demonstrated potent DPPH radical-scavenging activity and dose-dependent inhibition of NO production in murine macrophage cell line RAW 264.7, without affecting cell viability. Ethanol extracts exhibited greater anti-ulcer and NO production inhibitory activities than water extracts, which could be attributed to higher levels of emodin, a major anthraquinone component of this herb[10].

Anti-Inflammatory and Antipyretic activity:

This investigation aimed to explore the potential anti-inflammatory properties of six distinct species of Polygonaceae, including *R. acetosa, R. patientia, R. obtusifolius, R. crispus, R. balcanicus,* and *R. acetosella*. To assess the anti-inflammatory effects of these species, the researchers employed LC/MS/MS to monitor the development of specific metabolites, such as 12-(S)-HHT, 12(S)-HETE, PGE2, and TXB2, which are formed during the COX-1 and lipoxygenase pathways of arachidonic acid metabolism. To elicit an inflammatory response, calcimycin was employed to induce inflammation[1]. The researchers discovered that the rhizome extracts of *R. acetosa* and *R. acetosella* were the most effective in inhibiting the COX-1 enzyme, with both extracts exhibiting an IC50 value of 0.37 and 0.36 mg/mL, respectively, indicating their potent anti-inflammatory properties[1]. Additionally, the authors identified several anthraquinones, emodin, chrysofanol, and epigallocatechine in the root of *R. acetosa* and *R. acetosella*, which may contribute to their anti-inflammatory effects[1]. In conclusion, this study suggests that *R. acetosa* and *R. acetosella* show significant promise as anti-inflammatory agents, potentially due to the presence of specific compounds within their roots. Further investigation is necessary to explore the mechanisms by which these compounds interact with the COX-1 enzyme and to determine the suitability of these plants as natural remedies for inflammation-related conditions[1].

Emesis and Gastrointestinal Motility Disorders:

The study aimed to explore the possible medicinal properties of *R. acetosa*, a traditional herb, in treating various gastrointestinal disorders like constipation, diarrhea, and emesis. These conditions can cause significant discomfort and inconvenience to those affected by them. To assess the effectiveness of *R. acetosa* in treating these disorders, both *in vitro* and *in vivo* experiments were conducted. The methanolic extract of *R. acetosa* was tested on rabbit jejunum preparations. The results of the study demonstrate a biphasic effect of the compound at varying concentrations. At concentrations between 0.01-1.0 mg/mL, the compound exhibited a temporary spasmogenic effect, followed by a spasmolytic effect at higher concentrations (3-10 mg/mL). The data suggest that the spasmogenic effect is likely mediated through the activation of muscarinic receptors, while the spasmolytic effect is not. These findings are of significance in the context of therapeutic applications of this compound. The extract was also found to inhibit the contraction induced by K^+ (80 mM), indicating calcium channel blockade. It has been ascertained that the extract has the ability to shift the Ca^{2+} concentration-response curves to the right, which is analogous to the effects of verapamil. In addition to these findings, *R. acetosa* showed significant antiemetic activity compared to chlorpromazine when tested against different emetogenic stimuli, suggesting the presence of gut modulator (spasmogenic and spasmolytic) and antiemetic activities, which supports its traditional use. To investigate its antiemetic properties, a pharmacological study was conducted on a chick emetic model. The findings of the study demonstrate that *R. acetosa* (100 mg/kg) exhibited a more significant antiemetic response compared to copper sulfate and Brassica compestris-induced emesis. The results were found to be analogous to chlorpromazine. It is postulated that *R. acetosa's* antiemetic effect is probably due to the inhibition of the chemoreceptor trigger zone, although the precise mechanism remains poorly understood. Overall, the study provides evidence that *R. acetosa* has potential therapeutic benefits for various gastrointestinal disorders and helps provide a better understanding of its underlying pharmacological mechanisms[6].

Table 1 - Ethnomedicinal Importance of *Rumex acetosa*[15].

Plant part	Medicinal use	Pharmacological activity	Phytochemical present
Whole plant	Gastrointestinal disorder, dermatological infections, cure for cutaneous diseases, jaundice, vomiting, liver problem	Antimutagenicity or antigenotoxic activity, antiperiodontitis, anti-cancer, antipyretic, diuretic, mild purgative.	Polyphenols, dimeric and trimeric proanthocyanidins
Flower	Used to treat tumours and lumps.	Antiproliferation activity	Polyphenol
Leaf	Treatment of diarrhoea, cramps, and constipation. Fever, worms, anorexia, blood purifier, used for tumour and lump treatment.	Bruises, warts, abscesses, wounds, itchy skin, jaundice, laxative	Polyphenol Tannins and phenolic acids
Stem	Treat stomach discomforts and distress. Treatment for constipation, diarrhea and cramping		Tannins and phenolic acids
Root	Fever, tenesmus, gonorrhea, dysentery, ulcer,	Antioxidant, hemostatic, astringent	Polyphenol

	scabies, kidney diseases, skin itch, against gastritis and gastric ulcers	Anthraquinones
Plant juice	Clearing acne, Lowering High Blood Pressure	

Uses:

Sorrel, scientifically known as *Rumex acetosa*, is a plant species that is widely popular in horticulture and cuisine circles due to its distinct sour taste, which comes from its high oxalic acid content. This sour-lemony flavor complements various ingredients such as meat, cheese, and milk, making it a versatile culinary ingredient. Young immature leaves and sprouts have a mild flavor that works well in salads and sandwiches, while mature leaves are generally cooked and used in soups, stews, or sauces. Apart from its culinary uses, many species of the genus Rumex possess biological activities. For centuries, the roots and other tissues of these plants have been used in folk remedies due to their anti-inflammatory, antiviral, diuretic, antioxidant, analgesic, antimicrobial, antihypersensitive, and anti-fungal properties. These properties have made them useful in treating health disorders such as constipation, diarrhea, diabetes, edema, infections, jaundice, and scurvy, as well as liver and gallbladder disorders[4,10,16,19,23.] According to research, the antioxidant capacity of sorrel is roughly equivalent to that of Japanese green tea[22]. The flowers and rhizomes of the plant are known to contain specific compounds that exhibit tumor-arresting properties. These compounds have been suggested to possess significant potential in the development of novel anti-cancer agents[19,25]. Historically, boiled sorrel water has been applied topically for the treatment of chickenpox, shingles, boils, poison ivy, blisters, acne, and other skin sores. Its analgesic and anti-inflammatory properties are thought to alleviate pain and itching and speed up the healing process. Additionally, drinking sorrel water infused with honey has been traditionally used to reduce fever and relieve sinus infections[1,2]. Several Rumex species possess potent biological traits such as antioxidant, anti-cancer, antiviral, immunostimulating, antiscorbutic, and antipyretic properties. The following characteristics have contributed to the widespread use of these natural remedies to cure a diverse range of medical conditions, such as urinary inflammation, chronic cutaneous ailments, skin burns, gallstones, hepatitis, jaundice, fever, and osteomyelitis, as well as their ability to function as anti-cancer, diuretic, and laxative agents[15]. The plants belonging to the sorrel genus exhibit various medicinal properties such as anticancer, antidiarrheal, antioxidant, analgesic, anti-inflammatory, anthelminthic, and antibacterial effects. They can function as tonics, diuretics, or hypertensive agents. Sorrel is a potent remedy for several medical conditions, including scorpion stings and gastrointestinal distress. It is worth noting that sorrel and mallow, two members of the same family of plants, share several similar characteristics[15]. A biologist named Avicenna, who is 35 years old, has been incorporating sorrel in his treatment regimen for irregular uterine bleeding[26]. Interestingly, studies have suggested that sorrel might have beneficial effects in the treatment of cervical cancer[15].

Table 2 - Medicinal Applications for *Rumex acetosa*

Uses/effects	Plant part	Bioactive chemicals, possible pathways	References
Tumour growth arrest, apoptosis, and antimutagenic properties.	Aerial parts	Anthraquinones (esp. Emodin)	[25, 27]
Positive nutrient and weight gain	Leaf	Amino acids, minerals	[11]
Antiproliferative (tumor growth inhibition)	Flowers	Phenolic compounds (flavan-3-ols)	[19]
Antibacterial, cytotoxic, antitumor	Leaf	Producing silver nanoparticles with leaf extract.	[28]
Antihypertension	Leaf	Vasodilator and NO and COX enzyme inhibitors	[29]
Antioxidant activity	Leaf	Not known	[22]
Antiviral (HSV-1 virus)	Aerial parts	Oligomeric proanthocyanidins, Flavan-3-ols	[23]
Anti-inflammatory (periodontitis)	Aerial parts	Galloylated proanthocyanidins	[30]

Gastritis, gastric ulcer	Leaf	Anthraquinones	[31]
Viral infections, acute viral rhinosinusitis	Whole plant	Not known	[32]
Emesis, gastrointestinal motility disorders	Green parts	Activation of muscarine receptors, Ca2+ blockage	[6]
Astringent (diarrhoea, skin irritations), infections	Aerial parts		[18]

Toxicity:

Certain plant species of the Oxalis, Rumex, and Chenopodium genus are found to contain high concentrations of oxalic acid, which can pose a significant threat to human health. Oxalic acid, when ingested, can induce a drop in blood calcium levels and trigger the formation of calcium oxalate crystals in the kidneys, which can lead to renal damage and other complications. Consequently, it is imperative to exercise caution while consuming these plant species and to ensure that the levels of oxalic acid intake remain within permissible limits. More than 100 aromatic and therapeutic plants have been cultivated within the last 30 years. Vulnerable populations, including youngsters and pregnant women, are advised not to use these plants (Committee on Herbal Medicinal Products (HMPC), 2007). Plants that flourish in nitrogen-rich situations, such as Urtica dioica, Chenopodium bonus-Henricus, and Rumex sp., are especially attractive to vegetables. These are frequently eaten as cooked vegetables, in salads, and in soups[15]. When compared to other areas of the plant, the more developed and bigger leaves of both types showed greater amounts of total, soluble, and insoluble oxalates. There were also high levels of oxalates in the stems. Even plants with deficient oxalate levels maintained their unique sour flavor, but oxalate content varied significantly throughout categories. Preventing aluminum from entering the tips of the roots and being able to withstand elevated aluminum concentrations in tissues are two aspects of *R. acetosa's* resistance to aluminum. Aluminum may be changed into non-toxic forms by the phenolics in shoots and the citrate in roots. Strong antioxidants known as anthraquinones may be involved in a broader defensive reaction to root stress. Because of these tolerances, sorrel may be employed in phytoremediation[2]. Sorrel, also known as *R. acetosa*, is safe for consumption in normal amounts, as it is not considered poisonous[33]. However, consuming large quantities of sorrel can lead to different health problems such as dermatitis, nausea, polyuria, gastrointestinal problems, and diarrhea. The high tannin content in sorrel can cause some drugs to precipitate when taken orally[34]. Plants with tannin levels exceeding 10% can trigger severe side effects, including renal damage, hepatic necrosis, stomach upset, and an elevated risk of esophageal and nasal cancer. Sorrel leaves contain approximately 8-16% tannins[35]. Sorrel also contains oxalic acid, with a concentration of 300mg per 100g. Ingesting oxalates can lead to calcium precipitation in human blood, resulting in severe renal damage. Sorrel leaves contain about 0.3% oxalic acid[36]. Domestic animals such as goats, sheep, and poultry have also been poisoned due to high oxalic acid content in sorrel[36,37]. Regularly consuming herbs that are high in oxalate, such as sorrel, may have an adverse effect on the absorption of calcium and iron in the human body. Cooking is an effective way to reduce oxalic acid concentration and make sorrel consumption safer[38].

Conclusion:

There are numerous uses for the versatile plant *Rumex acetosa*. It is known for its unique tart flavor and is used in various dishes, herbal remedies, and as a dye source. Due to its many health advantages, including its anti-inflammatory, antihypertensive, antiviral, antioxidant, antibacterial, analgesic, diuretic, and antifungal properties, it has been utilized in traditional medicine. However, because of the elevated oxalic acid concentration, there may be risk factors for health, including the development of kidney stones and mineral deficiencies. Therefore, consumption should be moderate and careful. The plant *Rumex acetosa* is abundant in flavonoids, and naphthalenes, among other bioactive substances. These compounds have been found to exhibit significant antibacterial, antiviral, antioxidant, antiproliferative, antiulcer, anti-inflammatory, and antipyretic activities. The plant's rich phytochemical profile contributes to its potential therapeutic applications in combating various diseases.

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