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Phytochemistry and Pharmacological Activities of Sonchus maritimus: An Updated Review

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Abstract

Sonchus maritimus, a member of the Asteraceae family, is an annual herbaceous plant that exhibits a multitude of pharmacological properties, including anti-inflammatory, antioxidant, and hepatoprotective effects, attributed to its rich phytochemical composition. *S. maritimus* is a type of nutrient-rich wild plant widely found in Asia, Africa and Europe, with its leaves being edible and consumed as a healthy green vegetable. Research findings indicate that *S. maritimus* exhibits a wide range of significant phytochemical and pharmacological properties, underscoring its potential therapeutic value. According to scientific studies, this plant is rich in key bioactive compounds, including phenolic compounds, tannins, terpenoids, and flavonoids. Specifically, *S. maritimus* has been found to contain prominent flavonoids such as Rutin, Naringin, and Quercetin, which are known for their beneficial effects. The presence of these phytochemicals contributes to the plant's medicinal properties, highlighting its potential as a valuable natural resource for various health applications. Furthermore, extensive pharmacological studies have revealed that the plant exhibits a broad spectrum of biological activities, including anti-inflammatory, antibacterial, neuroprotective, hepatoprotective, and antitumor effects. Based on these findings, it can be inferred that *S. maritimus* holds considerable potential as a rich source of plant-derived pharmaceuticals, positioning it as a prime candidate for the development of novel therapeutic agents. Ultimately, *S. maritimus* may indeed be regarded as one of the most promising sources of plant-based medicines, given its impressive array of bioactive compounds and associated health benefits.

Keywords: *Sonchus maritimus*, phytochemicals, pharmacological activities

1.Introduction

Over the past two decades, research into herbal medicine has emerged as a major scientific priority [1]. With a rich history of use in preventing and treating a wide range of ailments, medicinal plants have been a cornerstone of traditional medicine for centuries. Indeed, ethnopharmacological studies have documented that over 1,200 plant species are utilized globally in traditional medicine, leveraging their biological activities to promote health and well-being [2]. Phytotherapy, or plant-based therapy, may offer a valuable approach to managing or preventing diseases, as herbal medicines often contain a diverse range of bioactive compounds that can work together to enhance each other's effects or produce a synergistic response, ultimately providing greater benefits than a single isolated compound [3]. According to World Health Organization (WHO) statistics, approximately 80% of the global population relies on traditional medicine for primary healthcare needs, with a significant proportion - around 85% - of these individuals using plant-based remedies [4]. These plants have been traditionally employed to treat various diseases, and the validation of their biological effects has paved the way for their therapeutic application. The active compounds present in these plants have been found to not only alleviate symptoms but also potentially cure diseases, making them a valuable resource for healthcare [5]. Further research into the bioactive components of these plants has confirmed that they are indeed utilized in both traditional and modern medicine, validating their long-standing use and opening up new avenues for therapeutic applications [6]. *Sonchus maritimus* is a member of the Asteraceae family, is renowned for its medicinal properties and economic significance [7]. The Sonchus genus is categorized as a type of edible wild plant that is widely found in Africa, Europe, and Asia. Notably, Sonchus species are rich in bioactive compounds, including antioxidants like phenolic compounds, flavonoids, tocopherols, and coumarins, as well as

fatty acids, steroids, and saccharides, which contribute to their potential health benefits [8]. Research has highlighted the potential of *S. maritimus*, which has been found to possess antioxidant, antimicrobial, and anticancer properties, making it effective against infections, pathogenic bacteria, and oxidative stress [9]. This paper presents an exhaustive and current review of the phytochemical constituents and pharmacological activities of *Sonchus maritimus*, based on a rigorous and systematic examination of the available literature retrieved from major databases such as PubMed, NCBI, Science Direct, and Google Scholar, with the aim of providing a detailed and informative summary of the plant's properties and potential applications.

2.Research Methodology

This review provides a comprehensive overview of *Sonchus maritimus*, covering its botanical description, secondary metabolites, and biological activities, based on a thorough examination of existing literature. A comprehensive literature search was conducted using prominent scientific databases, including ScienceDirect, PubMed, SpringerLink, Scopus, Web of Science, Wiley Online, Google Scholar, and SciFinder, supplemented by patent office databases such as CIPO, WIPO, and USPTO, to gather all relevant published articles on the species. The search had no language restrictions. A thorough review of the collected data was conducted, involving screening of titles, abstracts, and contents, as well as examination of reference lists in retrieved papers, to identify and include relevant studies.

3. Definition and localization

Sonchus maritimus is a nutrient-dense, annual or perennial herb that is extensively distributed across Asia, Africa, and Europe, making it a valuable resource for various applications [10]. As a member of the Asteraceae family, which is one of the largest and most economically important plant families, Sonchus maritimus is a significant species with considerable medicinal impact [11]. The leaves of Sonchus species are not only edible but have also been utilized as a traditional potherb in Chinese folk medicine for centuries, capitalizing on their therapeutic potential to treat a range of diseases and promote overall health [12]. Notably, these plants are rich in bioactive compounds, which has led to their recognition as a valuable source of dietary supplements and nutraceuticals. Furthermore, research has highlighted the potential pharmacological effects of Sonchus species, including antioxidant, hepatoprotective, cardioprotective, anti-inflammatory, antimicrobial, and anticancer properties, underscoring their potential as a natural remedy for various health conditions [8].

4. Botanical Description and Taxonomy

Sonchus maritimus is simple or branched herb with 40 cm tall and have glandular hairs on cylindrical or ribbed stem. Leaves of this species are 10 x 4.5 cm^2, pinnatifid, slightly lanceolate, glabrous without margins or weakly spinulose rather denticulate. Companulate head is axillary and terminal with 1.4 x 0.9cm^2, involve ventrally glandular hairs and glabrous above. Flowers ligulate, consist of ligules yellow. Elliptic achenes with 0.3 x 0.1 cm^2. Pappus of this plant have 0.5 cm long, and they are deciduous, slender, whitish, without neck [13].

Sonchus maritimus belongs to the subgenus Sonchus and genus Sonchus, which is nested within the subtribe Crepidinae of the Lactuceae tribe, a subgroup of the Asteraceae family. This family is remarkably vast, encompassing more than 1,100 genus and 25,000 species that are distributed worldwide [11,14,15].

Table 1. Classification of *Sonchus maritimus*

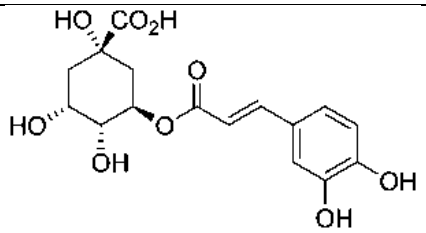
Kingdom	Plantae
Family	Asteraceae
Tribe	Lactuceae
Subtribe	Crepidinae
Genus	Sonchus
Subgenus	Sonchus
Species	*Sonchus maritimus*

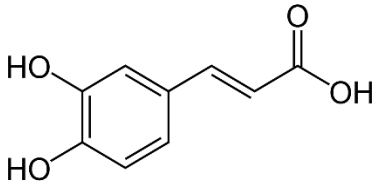
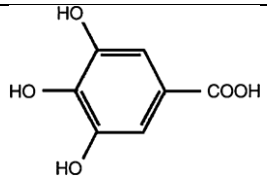
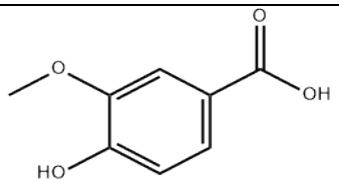
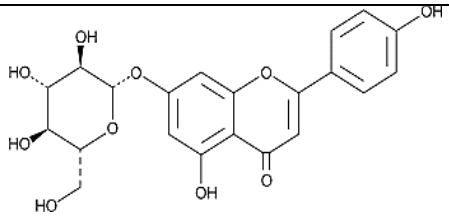
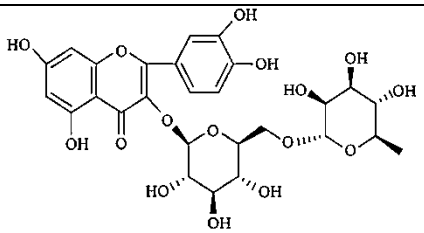
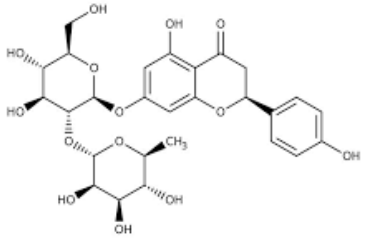
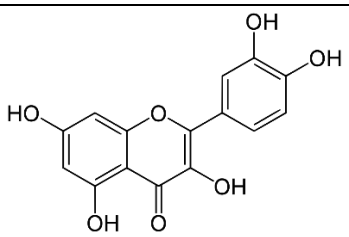
Figure 1. *Sonchus maritimus* leaves

5. Chemical Composition

Sonchus maritimus has emerged as a valuable resource for nutritional supplements owing to its exceptional richness in phytochemical compounds and essential mineral contents. Notably, this plant species has been found to possess a considerable amount of vital dietary mineral elements, including manganese (Mn), phosphorus (P), magnesium (Mg), sodium (Na), calcium (Ca), and potassium (K), which are crucial for maintaining optimal health and well-being. The presence of these minerals in *S. maritimus* underscores its potential as a nutritious and wholesome supplement, capable of providing essential nutrients and supporting overall nutritional balance [9]. Sonchus species are rich in a diverse array of bioactive compounds, including phenolic compounds, flavonoids, flavanols, proanthocyanidins, alkaloids, phytates, saponins, and sesquiterpene lactones with eudesmanolide and guaianolide structures. Additionally, these plants contain high levels of ascorbic acid (vitamin C), various fatty acids, carotenoids, oxalic acid, and essential mineral elements, making them a valuable source of nutrients and bioactive substances [16]. A variety of compounds, including anthraquinones, tannins and coumarins, as well as flavonoids like quercetin, myricetin, rutin, catechin, apigenin and kaempferol have been extracted and identified from various parts of Sonchus plants. Furthermore, nine sesquiterpene glycosides, namely sonchusides A, sonchusides B, sonchusides C, sonchusides D? glucozaluzanin-C, macrocliniside-A, crepidiaside-A, picrisides-B, and picrisides-C, have been isolated from the aerial parts of one Sonchus species. The presence of these compounds contributes to the valuable nutritional and pharmacological profile of Sonchus species, highlighting their potential as a rich source of bioactive molecules [17].

Table 2. Chemical structure of phenolic acids and flavonoids in *Sonchus maritimus*

Name	Scientific Name	Molecular Formula	Chemical Structure	Reference
Chlorogenic acid	3-O-caffeoylquinic acid	$C_{16}H_{18}O_9$		[18]

Caffeic acid	3-(3,4-dihydroxyphenyl)-2-propenoic acid	$C_9H_8O_4$		[18]
Gallic acid	3,4,5-trihydroxybenzoic acid	$C_7H_6O_5$		[7]
Vanillic Acid	4-hydroxy-3-methoxybenzoic acid	$C_8H_8O_4$		[7]
Apigenin-7glucoside	7-(beta-D-Glucopyranosyloxy)-5-hydroxy-2-(4-hydroxyphenyl)-4H-1-benzopyran-4-one	$C_{21}H_{20}O_{10}$		[18]
Rutin	3′,4′,5,7-Tetrahydroxy-3-[α-L-rhamnopyranosyl-(1→6)-β-D-glucopyranosyloxy]flavone, or Quercetin-3-O-rutinoside	$C_{27}H_{30}O_{16}$		[7]
Naringin	(2S)-5-hydroxy-2-(4-hydroxyphenyl)-4-oxo-3,4-dihydro-2H-chromen-7-yl 2-O-(6-deoxy-α-l-mannopyranosyl)-β-d-glucopyranoside	$C_{27}H_{32}O_{14}$		[7]
Quercetin	2-(3,4-dihydroxyphenyl)-3,5,7-trihydroxy-4H-1-benzopyran-4-one or 3,3',4',5,7-pentahydroxyflavone	$C_{15}H_{10}O_7$		[7]

6. Pharmacological propriety

Sonchus species have been found to exhibit a notable antioxidant capacity, which can be attributed to their rich composition of bioactive compounds, including high levels of ascorbic acid, a diverse array of phenolic acids, and an abundance of flavonoids, tannins, and fatty acids. These compounds work synergistically to neutralize free radicals and mitigate oxidative stress through two primary mechanisms: direct free radical scavenging ability, where they directly neutralize reactive oxygen species, and reducing power, where they donate electrons to stabilize free radicals [9]. The antioxidant activity of Sonchus species has been shown to result in a decrease in reactive oxygen species (ROS) and malondialdehyde (MDA) levels, which are markers of oxidative stress. Furthermore, Sonchus species have been found to enhance the activity of antioxidant enzymes, including superoxide dismutase (SOD) and glutathione peroxidase (GPx), which play a crucial role in maintaining the body's antioxidant defense system. This multifaceted antioxidant profile highlights the potential benefits of Sonchus species in protecting against oxidative stress-related diseases [19].

The anti-inflammatory properties of Sonchus species are attributed to their ability to modulate key inflammatory pathways. Specifically, they reduce the production of inflammatory mediators, such as nitric oxide (NO), and pro-inflammatory cytokines, containing tumor necrosis factor-alpha (TNF-α), interleukin-1 beta (IL-1β), and interleukin-6 (IL-6). Furthermore, Sonchus species inhibit the gene expression of crucial transcription factors, namely nuclear factor kappa-light-chain-enhancer of activated B cells (NF-κB) and signal transducers and activators of transcription (pSTAT1 and pSTAT3). The bioactive compounds responsible for these anti-inflammatory effects include villosol, ferulic acid, ursolic acid, rutin, and β-sitosterol, which may serve as potential therapeutic agents for managing inflammatory diseases [20].

Sonchus species have been extensively researched for their antimicrobial properties, exhibiting a broad spectrum of activity, including antibacterial, antiviral, and antifungal effects [21]. Sonchus species extracts have shown broad-spectrum antimicrobial activity, inhibiting both Gram-negative and Gram-positive bacteria that commonly cause food damage. Specifically, some species have demonstrated antibacterial effects against a range of pathogens, including *Escherichia coli*, *Staphylococcus aureus, Klebsiella pneumoniae*, *Enterobacter cloacae*, *Micrococcus luteus*, and *Salmonella enterica* [22]. α-Amyrin and β-amyrin, compounds found in Sonchus plant leaves, are predicted to exhibit antiviral activity against SARS-CoV-2 by forming stable chemical bonds with target proteins, potentially triggering an inhibitory response [23]. Antifungal activity was also revealed against *Aspergillus niger and Aspergillus Jumigatus* due to actions of phytocompounds in Sonchus species like phenolic acids and flavonoids [21].

The potential benefits of Sonchus species in mitigating metabolic disorders, including antihyperglycemic and antihyperlipidemic effects, are likely attributed to the rich presence of secondary metabolites, such as flavonoids, terpenoids, carotenoids, and glycosides. These bioactive compounds may play a crucial role in modulating metabolic pathways, thereby rendering Sonchus species a promising therapeutic agent for the management of metabolic syndrome (MetS) [24]. Given that MetS is intricately linked to oxidative stress and chronic inflammation, the antioxidant and anti-inflammatory properties of these secondary metabolites may contribute to their potential efficacy in treating this complex condition [25]. As such, Sonchus species may offer a valuable adjunctive or alternative approach to addressing the multifaceted pathophysiology of MetS [24].

Previous research has highlighted the diverse pharmacological potential of the phytocompounds found in Sonchus species, which exhibit a wide range of beneficial activities. These include antibacterial effects, neuroprotection, liver protection, cardiovascular therapeutic benefits, antitumor properties, relief from rheumatism and pain, and general tonic effects. Additionally, these compounds have been shown to alleviate headaches, exhibit antinociceptive properties, and possess anti-aging benefits. The broad spectrum of bioactivities associated with these phytocompounds underscores their potential as valuable therapeutic agents for various health conditions [16,21].

7. Toxicology profile

Following intraperitoneal administration of the *Sonchus maritimus* leaves aqueous extract at varying doses, the subjects were closely monitored over a 24-hour period. Remarkably, the extract did not induce any mortality or observable behavioral abnormalities, such as drowsiness, allergic reactions, or hyperexcitability [26,27]. The absence of adverse effects during the observation period suggests a favorable safety profile for the aqueous extract of *S. maritimus* leaves, which is an important consideration for potential therapeutic applications [28].

8. Discussion

A substantial body of research has confirmed that medicinal plants are rich in bioactive compounds, including phenols, flavonoids, tannins, and terpenoids [29]. As scientific understanding of herbal medicine continues to evolve, these phytochemicals are being increasingly utilized as therapeutic agents, offering promising alternatives or complementary approaches for disease management. The growing recognition of herbal treatments as viable options for healthcare underscores the potential of these plant-derived compounds to contribute to modern medicine [30]. The phytoconstituents present in *S. maritimus* including phenols, flavonoids, terpenoids, tannins, saponins, unsaturated steroids, and derived steroids [31]; exhibit a range of pharmacological activities, including protection of the liver, regulation of blood sugar levels, modulation of lipid profiles, and safeguarding of neural function. These bioactive compounds demonstrate potential therapeutic benefits, highlighting the value of *S. maritimus* as a source of natural remedies for various health conditions [32]. Phenols, flavonoids, and terpenoids have been consistently shown to possess a range of beneficial properties, making them crucial components of various medicinal plants and natural remedies [33]. The antioxidant activity of phenolic compounds including phenolic acids like vanillic acid, gallic acid, caffeic acid and chlorogenic acid [34], can be attributed to the presence of hydroxyl groups (-OH) in their molecular structure, which enables them to effectively scavenge free radicals and neutralize oxidative stress. As a result, the total phenol content of a substance can serve as a valuable indicator of its antioxidant potential, providing insights into its capacity to mitigate oxidative damage and promote overall health [35]. Flavonoids, a widespread group of polyphenolic compounds, are believed to play a crucial role in mitigating oxidative damage associated with various diseases [36], thanks to their potent antioxidant activity [37]. Among the flavonoids detected in the Sonchus genus are apigenin, apigenin-7-glucoside, luteolin, isorhamnetin, quercetin, and quercetin-3-glucoside[12]. Additionally, flavonoids have been demonstrated to exhibit a range of beneficial properties, including antibacterial, vasodilatory, antithrombotic, anti-inflammatory, and anticancer effects [37]. Terpenoids, a diverse group of natural compounds composed of isoprene units (C5), are widely utilized in various industries, including cosmetics, food, and pharmaceuticals [38]. With a rich history in traditional medicine, terpenoids exhibit a broad spectrum of biological and pharmacological activities [39], such as anti-inflammatory, anticancer, antimalarial, antiviral and antibacterial effects [40]. The terpenoids responsible for the pharmacological activities of Sonchus species include lupeol, loliolide, 1β-(p-hydroxyphenylacetyl)-15-Oβ-D-glucopyranosyl-5α,6Bheudesma-3-en-12,6α-olide, and 1β-sulfate-5α,6βH-eudesma-3-en-12,6α-olide [41,42]. Phytosterols such as palmitic acid and linoleic acid play a significant role in lipid management, contributing to their potential benefits in cardiovascular health by reducing cholesterol levels and promoting overall lipid balance [43]. Condensed tannins have garnered attention for their potential to promote animal health through antioxidant activity, their nutritional value lies in their ability to modulate gut health, reduce inflammation, and enhance immune function, ultimately contributing to improved animal performance and health outcomes [44]. Saponins have been found to contribute to overall well-being through exhibiting a multifaceted profile of bioactivity. These compounds are characterized by their ability to induce relaxation in the nervous system, modulate immune responses, regulate blood glucose levels, and exert hypotensive effects [45].

9. Conclusion

The findings indicate that Sonchus maritimus possesses a diverse array of bioactive compounds and demonstrates significant pharmacological activities, including antioxidant, anti-inflammatory, neuroprotective, and immunomodulatory effects. The antioxidant properties may play a key role in its protective effects, and its neuroprotective properties are likely attributed to its anti-inflammatory and antioxidant properties. However, the

existing scientific evidence is insufficient, underscoring the necessity for additional studies to uncover the full therapeutic potential of this remarkable medicinal herb.

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