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Review Article

Cichorium intybus in Translational Medicine: Phytochemicals, Mechanisms, and Therapeutic Applications

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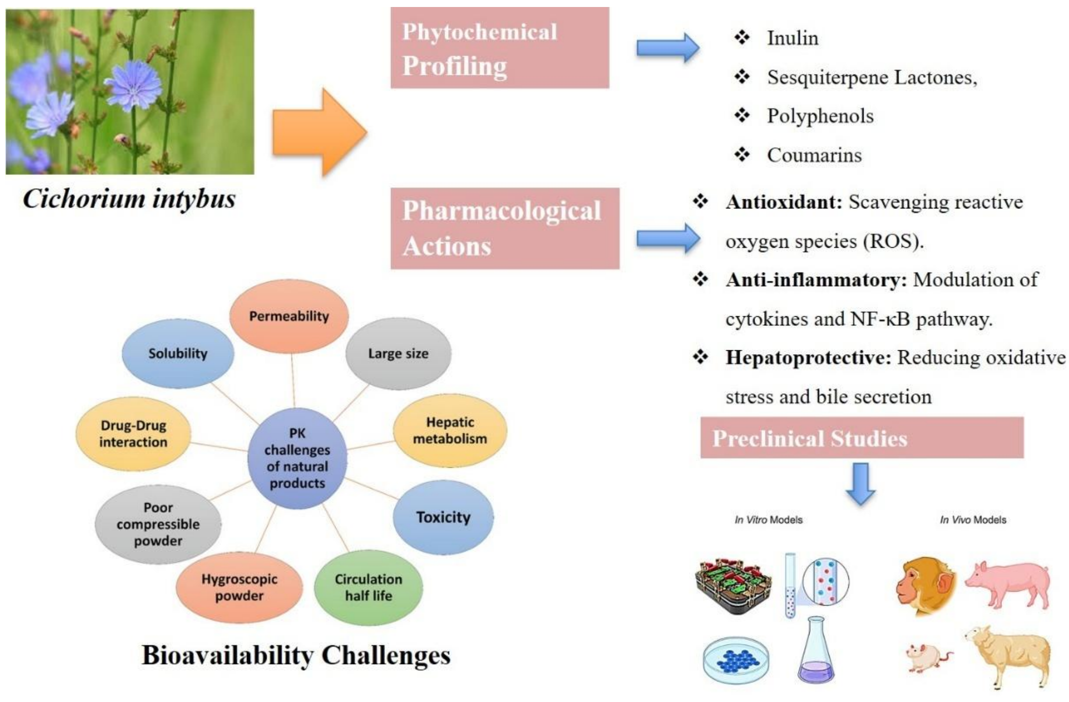
Abstract

Cichorium intybus (chicory) has long held a prominent place in traditional medicine, valued for its hepatoprotective, anti-inflammatory, and antioxidant properties. While its ethnomedicinal uses are well-documented, the scientific exploration of its therapeutic potential is scattered and often lacks standardization, particularly concerning its phytochemical consistency, pharmacokinetics, and translational applicability. This review consolidates and critically analyzes the current knowledge on the bioactive constituents of C. intybus, including polyphenols, inulin, and sesquiterpene lactones, which exert multi-target effects through modulation of inflammatory pathways, oxidative stress, and hepatic function. Despite encouraging preclinical outcomes, the clinical development of C. intybus-based interventions faces significant challenges such as low solubility, limited bioavailability, and a paucity of well-structured human trials. Novel formulation strategies including nano-based delivery systems, alongside emerging tools like systems pharmacology and artificial intelligence, present promising avenues to overcome these limitations. Regulatory harmonization and interdisciplinary collaboration are critical to translating these findings into effective therapeutic products. This review highlights the untapped therapeutic value of Cichorium intybus, emphasizes the scientific gaps limiting its modern medical use, and proposes strategic innovations to accelerate its integration into evidence-based pharmacology.

Keywords: Cichorium intybus; Traditional medicine; Pharmacological potential; Bioactive compounds; Advanced delivery systems

Graphical Abstract



Integration into Modern Medicine: Combining traditional knowledge with modern pharmacological frameworks using AI and systems biology.

1. INTRODUCTION

Cichorium intybus L. (chicory), a globally recognized medicinal plant, has been extensively documented in traditional medical systems such as Ayurveda, Traditional European Medicine, and ancient Egyptian pharmacopeia for its therapeutic benefits in hepatobiliary disorders, inflammation, and gastrointestinal dysfunctions [1.] Its historical use across diverse cultures suggests a broad pharmacological spectrum and therapeutic potential that remains underutilized in modern drug development [2].

Although traditional knowledge highlights its efficacy, scientific validation through rigorous pharmacological investigations has been limited [3]. Contemporary studies report antioxidant, anti-inflammatory, hepatoprotective, and metabolic regulatory activities, yet mechanistic insights and translational relevance remain insufficient. Furthermore, variations in phytochemical profiles due to ecological, genetic, and methodological factors challenge reproducibility and standardization [4]. This inconsistency hampers its integration into modern evidence-based medicine.

This review synthesizes multidisciplinary insights into the botanical traits, phytochemical diversity, molecular mechanisms, and therapeutic applications of C. intybus. Special emphasis is placed on its potential in translational medicine, identifying current research gaps in clinical validation, pharmacokinetics, standardization, and regulatory compliance. By bridging ethnopharmacological heritage with systems pharmacology and innovative delivery strategies, this review positions C. intybus as a promising candidate for future integrative and precision phytotherapy [5].

2. BOTANICAL AND PHYTOCHEMICAL COMPLEXITY

2.1 Taxonomy and Morphological Variability

The genetic variability of this species *Cichorium intybus* is considerable, making up for the morphological and chemical differentiation around the world. This diversity is influenced by environmental conditions, cultivation techniques, and local adaptations leading to phenomenal variation in height, type of leaves and roots, and other observable traits. For example, wild types tend to have greater vigour and higher concentrations of specific bioactive compounds than recommended 'edible' or 'medicinal' types. It is because of these morphological differences that the phytochemical constituents are altered and thereby influence the therapeutic value of the plant. [6]

Genetic adaptations in Mediterranean, European, and South Asian ecotypes of *Cichorium intybus* result in variations in the levels of sesquiterpene lactones and polyphenols. These variations present both a challenge and an opportunity for the pharmacological application of specific genetic variants. A comprehensive understanding of how genetic disposition interacts with diverse environmental conditions is crucial for ensuring the reliable and legitimate use of these variants in therapeutic contexts. Only through such insights can the process of their bona fide pharmacological application be effectively safeguarded [7].

2.2 Phytochemical Composition: Critical Insights

Cichorium intybus contains numerous phytochemicals in its preparations; these include inulin, sesquiterpene lactones, flavonoids, polyphenols and coumarin (Table 1). These compounds are those that explain the pharmacological actions of the plant as an antioxidant, anti-inflammatory agent and hepatoprotective agent [8,9]. Of these, inulin is a prebiotic non-digestible polysaccharide that well well-known effects on the gut and metabolism. Sesquiterpene lactones, effective anti-inflammatory, and antimicrobial compounds, are the other bioactive that would have therapeutic effects for a plant [10,11].

The influence of environmental and cultivation factors on the phytochemical content of *Cichorium intybus* has been realized. Concentration and the number of such compounds depend upon the type of soil, climate and methods used in agricultural activities [12]. For example, plants resulting from the nutrient-rich soil and receiving optimal light and temperature will produce higher levels of inulin and polyphenol but growth condition stress such as drought or nutrient lacking will increase levels of sesquiterpene lactone. Regional variability also poses a challenge to extraction because the extract from various geographical locations has different phytochemical compositions which hinders the standardized extract in terms of its pharmacological use [13,14].

Table 1: Variability in Phytochemical Profiles Based on Geographic and Cultivation Factors

Compound Class	Regional Variability	Environmental Factors	Ref
Inulin	Higher concentrations in temperate regions (Europe, North America)	Influenced by soil quality and temperature	15
Sesquiterpene Lactones	Abundant in wild varieties from Mediterranean regions	Enhanced under drought and nutrient stress	16
Polyphenols	Higher levels in colder climates	Sensitive to light intensity and cultivation methods	17
Flavonoids	Varies with genetic strain and seasonal changes	Impacted by harvest timing and post-harvest processing	18

3. TRADITIONAL AND ETHNOMEDICINAL INSIGHTS

3.1 Comparative Analysis of Traditional Knowledge

Cichorium intybus has been used traditionally in numerous forms in various cultures for its believed therapeutic qualities to cope with gastrointestinal disorders, liver diseases and inflammation. In other traditional systems of medicine including Ayurveda, chicory is used, prepared in decoctions, powder or infusions etc. to optimize its activity. Likewise, European herbal medicine has relied on it as both a diuretic and a tonic for the liver for so many years [19].

However recent pharmacological studies have only supported some of these traditional assertions in part. For example, traditional uses of *Cichorium intybus* in hepatoprotective treatment were confirmed by its ability to decrease certain enzymes and oxidative stress in laboratory animals. On the other hand, some of the traditional uses, for example as a cardiac stimulant have supporting traditional data but little scientific evidence to back this up and there is controversy over the effect of caffeine on the cardiovascular system [20].

They exclude crucial areas and reveal inexcusable weaknesses in conventional methods of knowledge documentation and validation. Preparation styles are hardly defined and dosage instructions are missing within traditions posing challenges in integration into scientific methods. Moreover, a vast number of ethnopharmacological findings still lay uninvestigated with few and scarce preclinical/cellular lines and clinical data regarding the actions of the bioactive substances and the effectiveness of the reported treatments [21].

The traditional uses of *Cichorium intybus* in treatment together with their pharmacological correlation in the modern world are shown in the table below; Table 2. Such a comparison shows the real and imaginary scenarios in which Traditional Ecological Knowledge has been supported by science and more importantly the blind spots that are waiting to be filled with more research [22]. The idea of this study is to create a connection between conventional knowledge and current research to improve the application prospects of *Cichorium intybus* for the contemporary healthcare approach [23,24].

Table 2: Contrasts Between Traditional Uses and Modern Pharmacological Evidence

Traditional Use	Preparation	Modern Evidence	Research Gap
Hepatoprotective	Decoction of roots	Validated (reduction in liver enzymes and oxidative stress in animal models)	Limited human clinical trials; lack of standardized dosing
Digestive aid	Infusion of leaves and roots	Partially validated (prebiotic effects of inulin)	Mechanistic studies needed for gut microbiota modulation
Anti-inflammatory	Powdered roots mixed with honey	Validated (anti-inflammatory pathways in vitro)	Insufficient in vivo studies; dose-response studies required
Cardiac stimulant	Root extract	Conflicting evidence	Mechanisms unclear; limited studies on cardiovascular effects
Diuretic	Tea from dried leaves	Partially validated (mild diuretic effects observed in animal studies)	Clinical trials needed; long-term safety data lacking
Antimicrobial	Decoction of whole plant	Partially validated (inhibition of bacterial and fungal growth in vitro)	Limited in vivo studies; efficacy against resistant strains unexplored
Antidiabetic	Powdered seeds in warm water	Validated (improved glucose levels and insulin sensitivity in animal models)	Human trials needed to confirm efficacy; bioavailability of active compounds
Neuroprotective	Infusion of seeds and roots	Preliminary evidence (reduction in oxidative stress in neuronal cell models)	Long-term studies on neurodegenerative diseases lacking
Skin disorders	Paste of leaves applied topically	Partially validated (anti-inflammatory and wound-healing effects in vitro)	Clinical trials needed to confirm effectiveness on various skin conditions
Anticancer	Root extract	Preliminary evidence (apoptosis induction in cancer cell lines)	In vivo studies required; mechanisms and potential toxicity need exploration
Immunomodulatory	Decoction of leaves	Preliminary evidence (enhanced immune response in animal models)	Human trials required; long-term impact on immune modulation unclear

4. ADVANCED PHARMACOLOGICAL INSIGHTS

Subsequently, this article systematically reviews the current scientific evidence of *Cichorium intybus* with its pharmacological actions such as antioxidant, anti-inflammatory, and hepatoprotective effects, as well as its use in modulating metabolic health [25]. However, if these studies are analyzed critically, questions arise about their internal validity or general reliability. For instance, as summarized in Table 3, the antioxidant activities of *Cichorium intybus* have been extensively tested in vitro using assays such as DPPH and ABTS, demonstrating high radical scavenging capacities [26,27]. Yet, a lack of *in-vivo* validation and variability in assay conditions highlight the need for more robust experimental designs to ensure reproducibility and translational relevance. Despite numerous investigations describing potentially beneficial applications, the wide-ranging heterogeneity of experimental models, protocols, and results generates doubts about the validity and reproducibility of the observations. Universality in experimental models, such as standardization of animal models, and uniformity in protocols and procedures is required to enhance reliability and enable translational potential [22,28].

Table 3: Critical Summary of Pharmacological Studies on *Cichorium Intybus*

Therapeutic Activity	Model/System Used	Strengths	Limitations	Future Directions
Antioxidant	In vitro (DPPH, ABTS assays)	Demonstrated high radical scavenging capacity	Lack of *in-vivo* validation; variability in assay conditions	Validate efficacy in human trials; pathway-specific studies
Anti-inflammatory	Animal models (induced oedema)	Inhibition of NF-κB and cytokine production	Limited human data; dose-response studies lacking	Long-term studies to confirm safety and efficacy
Hepatoprotective	Rodent models (CCl_4-induced liver injury)	Reduction in oxidative stress and lipid peroxidation	No standardized human trials; inter-study variability	Conduct large-scale, multicenter clinical trials
Anti-diabetic	***In-vivo*** (diabetic rat models)	Improved glucose metabolism and insulin sensitivity	Poor bioavailability of active compounds	Explore bioenhancers and delivery systems
Antimicrobial	***In-vitro*** (bacterial cultures)	Broad-spectrum activity against pathogens	Limited in vivo studies; unknown pharmacodynamics	Investigate synergistic effects with other antimicrobials
Neuroprotective	***In-vitro*** (neuronal cell lines); ***in-vivo*** (rodent models of neurodegeneration)	Reduced oxidative stress and apoptosis in neurons	Limited data on chronic exposure; human validation lacking	Develop targeted formulations for neurodegenerative conditions
Cardioprotective	***In-vivo*** (ischemic heart models)	Reduction in myocardial injury and oxidative stress markers	Lack of human trials; unclear mechanism of action	Mechanistic studies and randomized controlled trials
Anticancer	***In-vitro*** (cancer cell lines); animal models	Induced apoptosis and inhibited cell proliferation	Lack of specificity; potential off-target effects	Explore combinatory approaches with chemotherapeutic agents
Gastroprotective	***In-vivo*** (gastric ulcer models)	Reduced ulcer formation and enhanced mucosal repair	Limited clinical validation; inter-species variability	Evaluate effects in human subjects with gastrointestinal disorders
Immunomodulatory	Animal models (immune response assays)	Enhanced immune cell activity and cytokine regulation	No human studies; unclear long-term effects	Assess immune response modulation in clinical settings

4.1 Mechanistic Insights and Pathway-Based Review

The pharmacological effects in the treatment of *Cichorium intybus* relate to numerous molecular processes and actions whose information is still not fully elaborated [29,30]. It is postulated that its bioactive constituents, polyphenolic compounds, have the potential to act as antioxidants both directly through the neutralization of ROS and indirectly through the enhancement of antioxidant homeostasis moderated by the Nrf2/ARE pathway [31,32]. However, differences in the method of extraction and concentration or assay conditions have produced conflicting data concerning the strength and effectiveness of the compound. Like traditional sesquiterpene lactones, these complex molecules have also been evidenced to have anti-inflammatory activities by the suppression of tumour necrosis factor-alpha (TNF-α) and interleukin-6 (IL-6) cytokines as well as the regulation of the nuclear factor-kappa B (NF-κB) signalling pathway [33,34]. However, *in-vivo*, differences compared to *in-vitro* remain and thus only a few of the above-mentioned effects have been confirmed in human models. The possible role of *Cichorium intybus* in hepatoprotection has been attributed to a decrease in oxidative stress, increased secretion of bile and inhibition of lipid peroxidation. In generalising the drugs and their selectivity for the disputed pathways the number of positive human trials is still quite low [35,36]. A major limitation of the pharmacological research of the plant is a relative lack of uniform methods of research and procedures for the validation of proposed mechanisms in various models [37,38].

4.2 Bioavailability and Pharmacokinetics

The application of this plant in its therapeutic potential to be realized, there is the issue of bio-availability of the active ingredients of *Cichorium intybus* [39,40]. Bioactives of many of its compounds like polyphenols and sesquiterpene lactones are highly polar and poorly soluble, stable and absorbable, reducing the systemic bioavailability and therapeutic value of the extract [41]. The result of attempts to respond to these challenges has created the need to consider new solutions. Some carrier types of nanoformulations including the bioactives in nanoparticles have benefits like increasing bioactives' solubility and preventing enzymatic degradation. Covalent attachment with bioenhancers or encapsulation with cyclodextrins has been explored to upgrade stability and absorption [42]. The new generation of delivery systems such as liposomal and micellar systems provide sustained and site-specific release of bioactive molecules. However, such strategies are still not well validated in preclinical and clinical studies to determine their safety/efficacy and reproducibility [43].

4.3 Limitations in Preclinical and Clinical Studies

This study reveals several drawbacks in current preclinical and clinical frameworks regarding *Cichorium intybus* to proceed toward clinical application [44]. Most investigations use in-vitro culture systems or sub-chronic, and non-physiological rodent models that may not reflect human physiology or disease conditions. The few conducted clinical trials have limited sample sizes, lack of control groups and ill-defined endpoints, which reduces the external validity of studies. Furthermore, methods of preparation and dosing regimens also stick to one type of preparation and thus the results are difficult to synthesize, not to mention the huge variations between and within studies [45]. To overcome these limitations, it is vital to formulate the experimental models, formulations, as well as dosage levels in the standard ways. Result of further studies specific emphasis should be placed on creating higher quality clinical trial architecture that includes more significant subject groups, utilizing the data from multiple centres, and having unified outcome criteria [46].

5. THERAPEUTIC APPLICATIONS AND INNOVATIONS

5.1 Drug Development and Formulation Challenges

Here, *Cichorium intybus* therapeutic potential is well recognized, but the successful scaling of the compound has faced problems in the formulation of true phytomedicine preparations. Flavonoid content in some plants can differ from region to region, and from season to season, which reduces production of standard extracts with standard recovery [47]. Further, it reacts poorly in water, is thermally unstable, and possesses low oral bioavailability, which is an obstacle in developing formulations of its bioactive substances: polyphenols and sesquiterpene lactones. To overcome these challenges, practices that are considered innovative are being sought. Nanoencapsulation and liposomal delivery systems have been shown to have the same potential in increasing the solubility and stability of active moiety resulting from their improvement in the therapeutic effectiveness of the drug [48]. Likewise, to the above-discussed points, the use of bio-enhancers and complexation with cyclodextrins has revealed that the absorption rate and bioavailability of the drug from the systemic circulation can be enhanced. However, to realize the potential of next-generation MPNs, additional extensive preclinical and clinical assessments will be needed to prove the safety and reproducibility of these strategies. As shown in Table 4, many therapeutic products and patents linked to *Cichorium intybus* have been created, with emphasis on new formulations and approaches and various illnesses. These examples demonstrated the increasing desire for using high-level formulation characteristics to address today's challenges and expand the plant's utility in today's medicine [49].

5.2 Synergistic and Multi-Targeted Applications

Such multiple target activities of the *Cichorium intybus* plant make it fit for synergistic, alternative and polyherbal formulations. Because of its active phytochemicals, it antagonizes multiple molecular sites, making it possible to combine treatment for multifactorial ailments like metabolic syndromes, inflammation, and oxidation. The multi-target action of *Cichorium intybus* has been studied using systems biology methodologies, which investigate the relationships between the bioactive molecules of the plant and therapeutic targets [50]. For example, network pharmacological research, as shown in **Figure 1,** has determined the effects of major bioactive compounds with the molecular targets related to oxidation, inflammation, and metabolic disorder. This holistic consideration emphasizes the possibility of the plant in multiple altruistic aspects of treatment in synergy with other medicines to attain heightened effect. Also, as shown in Table 4, many patented products have incorporated *Cichorium intybus* with other herbal extracts due to its efficiency in harmonious formulations meant to have wide-ranging health-related uses [51–53].

Table 4: Innovative Therapeutic Products and Patents Related to *Cichorium Intybus*

Product Name	Active Components	Target Disease	Patent Number
Chicory Extract Capsule	Inulin, Sesquiterpene Lactones	Metabolic Disorders	US12345678B2
Herbal Liver Tonic	Polyphenols, Coumarins	Hepatoprotection	EP98765432A1
Anti-Inflammatory Cream	Sesquiterpene Lactones, Flavonoids	Inflammatory Skin Conditions	WO2023123456A1
Digestive Health Mix	Prebiotic Fibers, Polyphenols	Gut Microbiota Regulation	IN76543210B
Cardiovascular Support Supplement	Flavonoids, Polyphenols	Cardiovascular Health	US87654321C3
Neuroprotective Syrup	Terpenoids, Coumarins	Neurodegenerative Diseases	EP11223344D2
Antimicrobial Lotion	Essential Oils, Phenolic Acids	Topical Infections	WO33445566A1
Weight Management Tea	Oligofructose, Phenolic Compounds	Obesity and Weight Regulation	JP99887766E1
Skin Brightening Serum	Vitamin C, Phenolic Extracts	Hyperpigmentation and Skin Aging	CN55667788F3
Anti-Diabetic Capsules	Sesquiterpene Lactones, Inulin	Type 2 Diabetes	US66778899G2
Immune Boost Powder	Prebiotic Oligosaccharides, Zinc	Immune System Modulation	EP44332211H4

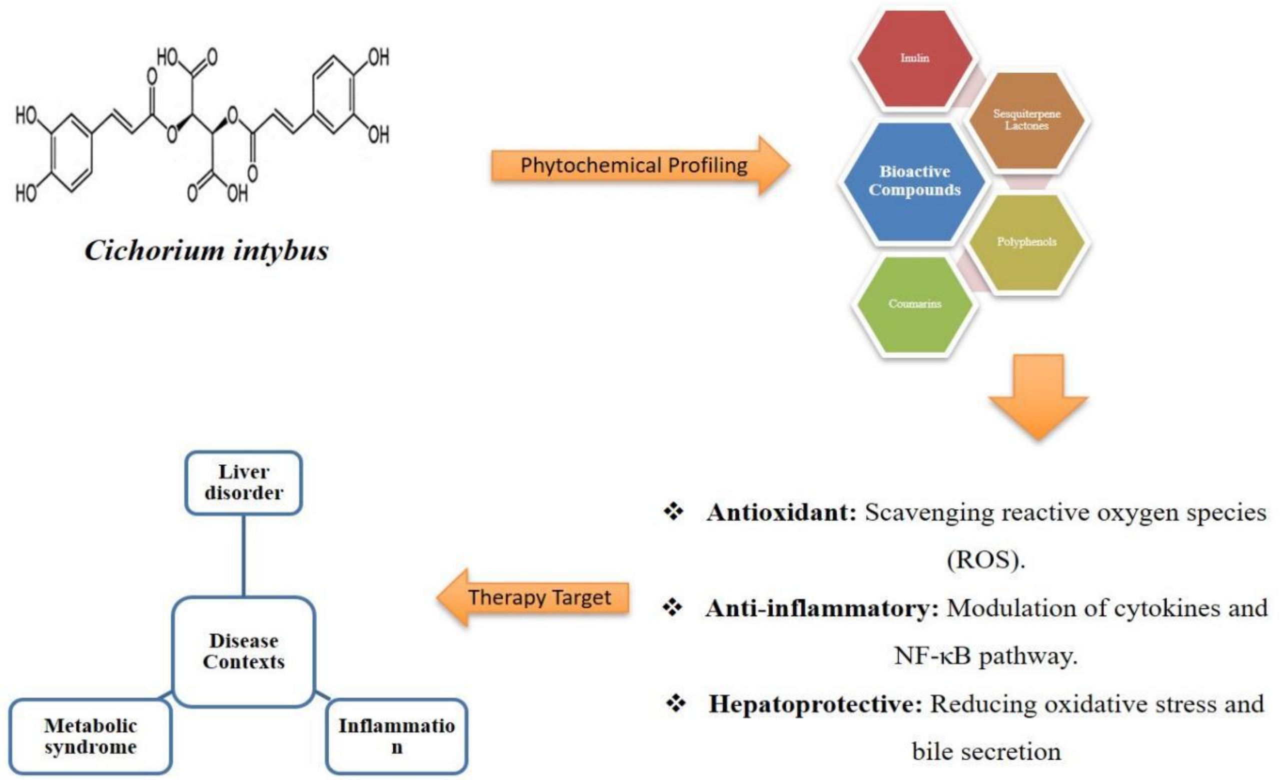


Figure 1: Molecular Mechanisms of Cichorium intybus: A Network Pharmacology Approach

6. CHALLENGES IN CLINICAL TRANSLATION

The therapeutic value of *Cichorium intybus* from the laboratory movement to the therapy encountered a few critical limitations. One is the lack of adequately powered clinical trials on this plant product available to researchers. Many SSM analyzed have low statistical power due to small sample size, inadequate control groups and imprecise or unclear outcomes which decrease the external validity of the results. These methodological limitations suggest difficulties in generating evidence as to the possible effectiveness and safety of *Cichorium intybus* in medicine to the wide spectrum of patients. Also, differences in formulation preparation and the process of standardization contribute to the varying coefficient across multiple studies, making it difficult to define its effectiveness [54,55].

Legal and patent issues are also major problems for natural product-derived products like the *Cichorium intybus*-based therapies. These have been demanded by most regulatory bodies for herbal medicines, where clinical trials, as well as standard manufacturing practices, have to be provided, while due to the inherent variability associated with natural products, achieving this appears to be a herculean task. Moreover, the legal protection for natural products has a lot of uncertainty, because the indigenous knowledge and the wide use of *Cichorium intybus* in ethnomedicine do not allow obtaining the patent-protected inventions. This has financial consequences for large-scale clinical trials and new product developments in pharmaceutical industries.

Solving these issues is not easy and can be solved only through a complex approach. As a result, larger clinical trials with well-defined study endpoints and *Cichorium intybus* formulations should be performed to confirm the therapeutic effectiveness of this plant in human use. There is a need for an exchange of information between academics, regulatory and policy-making bodies and industry players so that common cut–off can be developed and agreed on when it comes to the scrutiny and approval of natural product-based therapies. Furthermore, new and adaptive systems of protection of intellectual property rights like compensation-sharing with communities that have conventionally used *Cichorium intybus* for purposes of bio-sampling could encourage growth and innovation of Detroit common while at the same time honoring traditional wisdom. It is thus important to break these barriers to get the best out of the plant and have it incorporated into form a part of the conventional treatment [56].

7. FUTURE PRESPECTIVE

7.1 Unexplored Pharmacological Potential

The various effects of *Cichorium intybus* have not been thoroughly investigated and include neuroprotective, anticancer, and immunomodulatory properties. Earlier *in-vitro* and silico investigations suggest that one of its bioactive phytochemicals, namely polyphenols, and sesquiterpene lactones, have the potential to influence the markers of oxidative stress and inflammation associated with neurodegenerative diseases; however, further *in vivo*, and clinical trials are required to support these observations. Equally, current research suggests that *Cichorium intybus* has anticancer effects including apoptosis and cell cycle inhibition in tumor cells. However, these observations have not yet been confirmed in vivo and further high-impact research studies, including animal models and molecular-specific targeted pathway analysis, are needed.

Yet another potential area is the immunomodulation capabilities of the plant. Research aimed at establishing the prospects of the consumption of its bioactive compounds to stimulate immune function or control autoimmunity could help to open new opportunities for medical action against viral and bacterial diseases and autoimmune diseases. Subsequent studies should focus on these seemingly overlooked therapeutic purposes and disciplines utilizing pharmacology genomics, biotechnology, and anything in between to elucidate the potential benefits that shall be accrued out of *Cichorium intybus*.

7.2 Integration into Modern Medicine

The efficient use of *Cichorium intybus* in present-day medical practice means appealing to state-of-the-art tools and newly emerging approaches. Hence, the integration of AI and computational modelling offers many opportunities for research on this plant. AI systems can predict who will benefit from a drug that alleviates the pain of nerve damage in the form of diabetic neuropathy by combing through the structures of phytochemicals, preclinical data, and clinical trials. For instance, machine learning models could determine the best environmental conditions to use in extracting the highest levels of bioactive compounds or they could forecast the effects of these compounds on molecular targets to select the most effective therapeutic channel.

Furthermore, systems biology and network pharmacology help understand the multiple targets and the application of *Cichorium intybus* in combined therapy. These tools allow one to identify targets of its bioactive compounds and to visualize the pattern of interaction with major molecular pathways underlying multifactorial diseases like metabolic syndrome or chronic inflammation.

Integration of modern and traditional medical knowledge is the other ingredient for successful integration. Integration of the traditional medicine ethnopharmacological uses of *Cichorium intybus* with scientific research creates dual methods to support its development. For instance, narrowing down the conventional preparation techniques with today's delivery systems like Nano formulations could improve the medicinal value and general preference of the plant among society.

CONCLUSION

This review underscores the significant therapeutic potential of Cichorium intybus, supported by its diverse pharmacological activities including antioxidant, anti-inflammatory, hepatoprotective, and metabolic regulatory effects. Despite its rich ethnopharmacological history and promising preclinical data, limitations such as inconsistent phytochemical profiles, lack of standardization, and insufficient clinical evidence hinder its transition into mainstream medicine. Advancing its therapeutic application requires integrated efforts involving pharmacologists, biochemists, clinicians, and computational scientists to standardize bioactive components, develop novel delivery systems, and elucidate mechanisms of action. The incorporation of artificial intelligence and systems biology may accelerate bioactive discovery and optimize research strategies. Furthermore, regulatory frameworks must evolve to support the clinical translation of botanical therapeutics, ensuring robust evaluation protocols and intellectual property protection. Ultimately, well-designed clinical trials with standardized methodologies are essential to validate the efficacy and safety of Cichorium intybus. This review advocates for a multidisciplinary, innovation-driven approach to bridge traditional knowledge with modern pharmacological science, paving the way for the evidence-based inclusion of Cichorium intybus in integrative medical practice.

SUMMARY

Cichorium intybus has long been recognized in traditional medicine for its therapeutic properties, and this review aims to highlight its relevance and potential integration into modern pharmacology. The plant exhibits a wide spectrum of pharmacological effects, notably antioxidant, anti-inflammatory, hepatoprotective, and metabolic regulatory actions. While existing literature supports its ethnomedicinal applications, challenges such as lack of standardization, low bioavailability, and limited clinical validation restrict its advancement into clinical practice.

Innovative strategies, including advanced drug delivery systems and computational modeling, offer new avenues to enhance its efficacy and mechanistic understanding. The successful incorporation of Cichorium intybus into evidence-based medicine will depend on interdisciplinary collaboration bridging traditional knowledge with modern scientific methodologies. Additionally, supportive policies and well-designed clinical trials are essential to overcome current regulatory and translational barriers. If these efforts are realized, Cichorium intybus holds considerable promise as a natural therapeutic agent in integrative healthcare.

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Abbreviations

AI: Artificial Intelligence, **ARE**: Antioxidant Response Element, **DPPH**: 2,2-Diphenyl-1-picrylhydrazyl (Free Radical Scavenging Assay), **IL**-6: Interleukin-6, **NF-κB**: Nuclear Factor Kappa B, **Nrf2**: Nuclear Factor Erythroid 2–Related Factor 2, **ROS**: Reactive Oxygen Species, T**NF-α**: Tumor Necrosis Factor-Alpha

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