International Journal of Food Sciences And Nutrition Innovations
Volume 1, Issue 2, 91-98.
e_ISSN: 3109-9025
https://e-journal.gomit.id/ijfsni

Cichorium intybus as a Functional Food: Bioactive Compounds and Antidiabetic Potential

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Article Info

Article history:

Received: August 20, 2025
Revised: September 15, 2025
Accepted: December 25, 2025

Keywords:

Cichorium intybus
functional food
bioactive compounds
antidiabetic activity

Abstract

Background of study: *Cichorium intybus* L., or chicory, is a nutrient-dense plant that has traditionally been used as a forage crop and vegetable. It is now gaining attention for its bioactive compounds, which have therapeutic potential, particularly for managing type 2 diabetes mellitus.
Aims and scope of paper: This systematic review examines the nutritional composition and phytochemical profile of chicory, as well as its antidiabetic mechanisms, to highlight its potential role in the prevention and management of diabetes as a functional food.
Methods: A systematic literature review was conducted in accordance with PRISMA guidelines. Peer-reviewed articles published between 2019 and 2022 were identified using the databases Scopus, PubMed, and Web of Science. The eligible studies focused on chicory's bioactive compounds and their metabolic effects. Data extraction and quality appraisal were performed using a standardized CASP checklist, and thematic synthesis was applied.
Result: 36 studies were included. Chicory was found to be rich in inulin, phenolic acids (e.g., *chicoric acid* and *caffeic acid*), *flavonoids* (e.g., *luteolin* and *quercetin*), and sesquiterpene lactones. These compounds improve insulin sensitivity, inhibit carbohydrate-digesting enzymes, regulate lipid metabolism, and protect pancreatic beta cells via antioxidant and anti-inflammatory pathways. Chicory-derived ingredients are used in prebiotic formulations, functional foods, and animal feeds.
Conclusion: Chicory has significant antidiabetic potential through multiple target mechanisms. However, the current evidence is primarily preclinical with few human trials. Standardized clinical studies are needed to validate its efficacy and determine the optimal dosage and long-term safety. Due to its accessibility and versatility, chicory is a promising functional food for supporting metabolic health and sustainable nutrition.

To cite this article: Amalyadi et al. (2025). Cichorium intybus as a Functional Food: Bioactive Compounds and Antidiabetic Potential. *Journal of Food Sciences And Nutrition Innovations, 1*(2), 91-98.

INTRODUCTION

Cichorium intybus L., commonly known as chicory, is a perennial herb from the Asteraceae family. It has long been cultivated as a forage crop, leafy vegetable, and food additive. Beyond its traditional uses, chicory has attracted considerable scientific attention due to its rich composition of bioactive compounds, including inulin, phenolic acids, flavonoids, and sesquiterpene lactones. These compounds contribute to the plant's nutritional and therapeutic value (Nawrot et al., 2021). As metabolic disorders, particularly type 2 diabetes mellitus, become more prevalent, there is growing interest in exploring natural dietary strategies for disease prevention and management. Given its multifaceted health benefits and accessibility across agricultural systems, chicory represents a promising candidate for functional food development (Kaur & Gupta, 2020).

Recent studies have highlighted the diverse biological properties of *C. intybus*, including antioxidant, anti-inflammatory, hepatoprotective, and antimicrobial activities (Salehi et al., 2020).

Inulin extracted from chicory roots is widely recognized as a prebiotic *fiber* that modulates gut microbiota and improves insulin sensitivity, thereby contributing to better glucose regulation (Panghal et al., 2019). Additionally, *chicoric acid, caffeic acid*, and *luteolin*, which are phenolic compounds found in chicory, exhibit inhibitory activity against α-amylase and α-glucosidase, key enzymes in carbohydrate digestion and postprandial glucose absorption (Abdel-Hameed et al., 2022). Together, these findings suggest that chicory and its derivatives could play a significant role in maintaining metabolic health by supporting *glycemic* control and lipid metabolism.

Despite these promising insights, the current literature on chicory is fragmented. Most studies have focused on chicory's role as either a prebiotic *fiber* or a medicinal herb. Integrative reviews synthesizing its dual role as a forage crop and functional food ingredient with specific antidiabetic potential are limited. Furthermore, the mechanistic pathways through which chicory bioactive compounds contribute to *glycemic* regulation are often investigated using isolated in vitro or animal models. Relatively few clinical trials provide confirmatory evidence (Mohammed et al., 2023). This knowledge gap underscores the need for a more comprehensive analysis of chicory's bioactive profile and the mechanisms by which it acts in relation to diabetes.

Given the global burden of diabetes mellitus and the growing demand for natural, sustainable chronic disease management solutions, evaluating *C. intybus's* potential as a functional food is timely and relevant. Its dual role as a sustainable forage plant and a source of bioactive compounds places chicory at the intersection of agriculture, nutrition, and public health. This article aims to clarify the nutritional profile, bioactive composition, and antidiabetic mechanisms of chicory by systematically reviewing current evidence. The hypothesis is that regularly including chicory-derived products in human diets may improve *glycemic* regulation through the combined effects of inulin, phenolic compounds, and other phytochemicals.

METHOD

Research Design

This study used a systematic literature review (SLR) to summarize the latest scientific research on the bioactive compounds of *Cichorium intybus* L. and its potential as a functional food for managing diabetes mellitus. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed to ensure transparency and replicability.

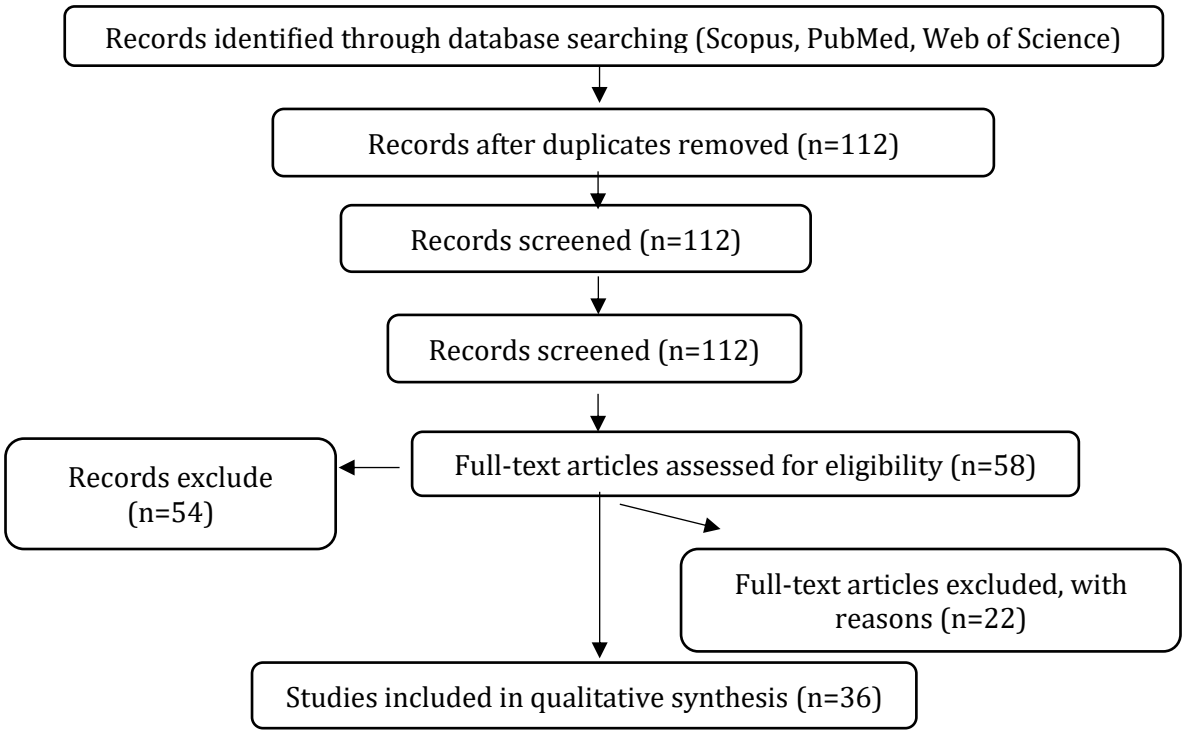

Figure 1. PRISMA flow diagram of study selection

Participant
Since this is a review study, no human or animal participants were directly involved. The "participants" of this study are the research articles selected from indexed databases such as Scopus, PubMed, and Web of Science.

Population and Methods of Sampling
The target population included peer-reviewed articles published between 2019 and 2023 investigating the nutritional composition, bioactive compounds, functional food applications, or antidiabetic effects of *Cichorium intybus*:

- Inclusion criteria included articles written in English and published in peer-reviewed journals. Articles had to be experimental or clinical studies or review articles focusing on chicory and its bioactive compounds related to diabetes.
- Exclusion criteria included non-English articles, conference abstracts, gray literature, and studies not directly related to chicory or diabetes. The sampling method was purposive, whereby relevant articles were systematically identified using search strings (e.g., "*Cichorium intybus*" OR "chicory" AND "diabetes" OR "antidiabetic" AND "functional food").

Instrumentation
A data extraction form was designed to collect consistent information from each included study. The extraction items included:

1. Bibliographic data (author, year, journal, and country).
2. Study design (in vitro, in vivo, clinical trial, or review).
3. Bioactive compounds investigated.
4. Reported antidiabetic mechanisms.
5. Outcomes related to glucose and lipid metabolism.

Scoring method: Each article was evaluated using a standardized quality assessment checklist based on the Critical Appraisal Skills Programme (CASP). Scores were assigned to assess methodological rigor.

Psychometric Properties: Validity was ensured by adapting established checklists (CASP and PRISMA), and reliability was maintained by having two independent reviewers double-check the selection of articles and the extraction of data.

Instrument
The main instrument was the data extraction form developed by the authors and combined with standardized quality assessment tools, such as the CASP checklist and PRISMA flow diagram.

Procedures and Time Frame
The review was conducted between from January to June of 2025. The procedures included:

1. Database searching using Scopus, PubMed and Web of Science.
2. Screening of articles by title, abstract, and keywords.
3. Eligibility assessment using inclusion and exclusion criteria.
4. Data extraction into standardized forms.
5. Synthesize of findings through narrative and thematic analysis.

Analysis Plan
Descriptive statistics were used to analyze the data (frequency of bioactive compounds, study types, and reported mechanisms). Additionally, a thematic synthesis was performed to identify recurring mechanisms of action, including enzyme inhibition, improved insulin sensitivity, antioxidant effects, and modulation of lipid metabolism.

- Ordinary statistical methods (percentages and frequency counts) were used to summarize trends.
- No meta-analysis was performed due to the heterogeneity of the study designs; however, effect directions were compared across studies.

Scope and Limitations

The scope of this review is limited by the databases searched and the restriction to English-language publications, which may result in the exclusion of relevant studies in other languages. The heterogeneity in study design (in vitro, animal, and human trials) also limits direct comparisons of the findings. Additionally, the lack of large-scale clinical trials on chicory and diabetes limits the applicability of the conclusions. Despite these limitations, the systematic approach strengthens the validity of the findings and provides a comprehensive overview of the current state of knowledge.

RESULTS AND DISCUSSION

Results

Cichorium intybus, also known as chicory, is a nutrient-rich plant valued for its high dietary *fiber* content. It contains significant amounts of inulin, a type of *fructooligosaccharide* with prebiotic properties that enhances gut microbiota composition and supports glucose regulation (Kaur & Gupta, 2020; Sharma et al., 2020). Its leaves and roots contain significant levels of vitamins C, K, and B, as well as essential minerals, such as calcium, magnesium, potassium, and iron. These nutrients are important for maintaining metabolic health (Panghal et al., 2019;). Furthermore, chicory is rich in phenolic compounds that contribute to its antioxidant activity and play a role in glucose and lipid metabolism (Nawrot et al., 2021; Salehi et al., 2020). These nutritional attributes suggest that chicory offers considerable promise as a functional food ingredient with potential applications in the prevention and management of metabolic disorders.

Several classes of bioactive compounds have been identified as key contributors to chicory's pharmacological and functional properties. Inulin and other oligosaccharides are well documented for improving insulin sensitivity, reducing the *glycemic* index, and regulating lipid metabolism (Panghal et al., 2019). Phenolic compounds, such as *chicoric acid*, *caffeic acid*, and *flavonoids*, including luteolin and quercetin, exhibit strong antioxidant and anti-inflammatory activities. These activities modulate glucose metabolism (Abdel-Hameed et al., 2022; Mohammed et al., 2023). Additionally, sesquiterpene lactones found in chicory stimulate insulin secretion and enhance pancreatic β-cell function (Bais & Ravishankar, 2019). Phenolic acids, such as caffeic and ferulic acid, contribute to chicory's antidiabetic effects by inhibiting digestive enzymes, including α-glucosidase and α-amylase

The antidiabetic potential of *C. intybus* is attributed to several mechanisms. First, the inhibition of carbohydrate-digesting enzymes, such as α-amylase and α-glucosidase, reduces the absorption of glucose after a meal (Abdel-Hameed et al., 2022). Second, inulin and other prebiotic *fibers* modulate the gut microbiota and their metabolites, thereby improving insulin sensitivity and glucose homeostasis (Kaur & Gupta, 2020). Third, chicory's phenolic compounds have antioxidant and anti-inflammatory activities that protect pancreatic β-cells from oxidative damage, which is a critical factor in diabetes progression (Salehi et al., 2020; Mohammed et al., 2023). Finally, chicory's *bioactives* regulate lipid metabolism, alleviating the *dyslipidemia* commonly associated with diabetes mellitus (Panghal et al., 2019; Sharma et al., 2020).

Due to its bioactive composition, chicory has been widely explored in functional food applications. Inulin-based prebiotics derived from chicory roots are commonly incorporated into low-calorie foods and glucose control formulations. Extracts from chicory leaves and roots are also being developed as nutraceuticals and dietary supplements that support metabolic health (Bais & Ravishankar, 2019; Abdel-Hameed et al., 2022). Furthermore, integrating chicory into livestock feed has been shown to improve the nutritional quality of animal-derived products, such as milk and meat. This contributes to functional food systems based on livestock (Mohammed et al., 2023).

Current findings demonstrate the remarkable potential of chicory as a functional food with antidiabetic effects. However, significant challenges remain. Research gaps include determining optimal dosages, ensuring long-term safety, and establishing clinical efficacy in humans, as most evidence is currently limited to in vitro and animal studies (Sharma et al., 2020). Advances in food processing technology and product standardization are essential for ensuring consistent delivery and efficacy of bioactive compounds (Salehi et al., 2020; Nawrot et al., 2021). Addressing these

challenges is essential for successfully integrating *C. intybus* into sustainable dietary interventions for diabetes prevention and management.

Discussion

The reviewed evidence highlights *Cichorium intybus* as a promising candidate for functional foods, especially for managing diabetes. Its rich nutritional profile, which includes dietary *fiber*, vitamins, minerals, and phenolic compounds, establishes it as a multifunctional plant that can address metabolic dysregulation. The synergistic actions of inulin, phenolic acids, flavonoids, and sesquiterpene lactones contribute to glucose regulation, antioxidant *defense*, and lipid metabolism. However, the current body of evidence relies heavily on preclinical studies and a limited number of clinical trials, restricting the ability to generalize findings to human populations (Sharma et al., 2020).

Implications

Incorporating *C. intybus* into dietary formulations has significant implications for public health and the functional food industry. In clinical nutrition, *C. intybus* may offer an affordable, natural way to improve *glycemic* control and prevent diabetes-related complications. For the food industry, the plant's bioactive compounds present opportunities to develop prebiotic supplements, *low-glycemic* index products, and nutraceuticals tailored to populations at risk for metabolic disorders. Furthermore, incorporating *C. intybus* into animal feed could indirectly improve the nutritional quality of livestock-based foods, aligning with the increasing demand for sustainable and functional food systems (Bais & Ravishankar, 2019; Mohammed et al., 2023).

Research Contribution

This review adds to the growing body of literature by systematically synthesizing evidence on the nutritional, biochemical, and pharmacological properties of *C. intybus*, as well as its applications as a functional food for managing diabetes. By emphasizing the plant's multi-target mechanisms, ranging from modulation of the gut microbiota to inhibition of enzymes and protection against oxidation, this work provides a comprehensive framework for understanding how *C. intybus* can be positioned as a natural, antidiabetic functional food.

Limitations

Several limitations must be acknowledged. First, much of the evidence is derived from in vitro or animal studies, which may not accurately reflect physiological responses in humans. Second, variations in extraction methods, plant parts used, and bioactive concentrations limit the comparability of findings across studies (Salehi et al., 2020; Nawrot et al., 2021). Third, the long-term safety profiles and potential interactions with conventional antidiabetic medications remain understudied. Finally, the lack of standardized clinical trials constrains our ability to determine effective dosage ranges and delivery formats.

Suggestions

Future research should prioritize well-designed, randomized clinical trials to validate the efficacy and safety of *C. intybus* in human populations. Investigations into dose-response relationships, bioavailability, and potential synergistic effects with existing antidiabetic therapies are particularly necessary. Additionally, developing standardized extraction and processing techniques is crucial for ensuring reproducibility and product consistency. From a translational perspective, integrating chicory into culturally appropriate dietary interventions could enhance acceptance and sustainability. Continued exploration of its role in livestock feed could lead to functional animal-derived foods.

CONCLUSION

Cichorium intybus L., or chicory, is a nutrient-rich plant with great potential as a functional food for managing type 2 diabetes. Its bioactive compounds, especially inulin, phenolic acids, flavonoids, and sesquiterpene lactones, act through multiple pathways, including modulation of the gut microbiota, inhibition of enzymes, providing antioxidant protection, and regulating lipids. These

actions support *glycemic* control and metabolic health. Chicory has applications in *low-glycemic* foods, nutraceuticals, and functional food systems for livestock. However, most of the available evidence comes from in vitro and animal studies, with limited standardized human trials. Future research should focus on clinical validation, dosage optimization, and long-term safety. Overall, chicory is an accessible, sustainable resource with promising implications for nutrition, public health, and the fight against diabetes.

ACKNOWLEDGMENT

The authors sincerely thank all individuals and institutions who have provided guidance, resources, and support during this research. Special appreciation is extended to the co-authors for their meaningful contributions and collaboration, which were essential to the completion of this review.

AUTHOR CONTRIBUTION STATEMENT

Rezki Amalyadi: Conceptualization, Investigation, and Writing. Ine Karni: Conceptualization. Aminurrahman: Visualization. I Gede Nano Septian: Resources, writing-review & editing.

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