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Lamiaceae Plants and Cardiovascular Health: A Patent-Driven Path to Functional Foods †

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Abstract: The *Lamiaceae* family of medicinal plants holds immense promise in the development of functional foods aimed at preventing and treating cardiovascular diseases (CVDs). These plants are rich in bioactive compounds, such as phenolic acids, flavonoids, and terpenoids, which act as potent enzyme inhibitors and exhibit strong antioxidant, anti-inflammatory, and antihyperlipidemic properties. Key phenolic compounds, such as rosmarinic acid and caffeic acid, along with flavonoids like luteolin, apigenin, and quercetin, contribute to these health benefits. Essential oils derived from *Lamiaceae* species have demonstrated diverse biological activities, including vasorelaxant, thrombolytic, and cytotoxic effects, making them valuable in nutraceutical formulations. This study analyzes and investigates global patent trends related to *Lamiaceae* plants targeting cardiovascular health, focusing on applications in nutraceuticals and functional foods. Using patent databases, we examine the technological landscape, identify leading applicants, and evaluate the geographical distribution of innovations. Our analysis reveals a notable increase in patent filings since the late 1970s, peaking in 2007, indicating a growing interest in leveraging *Lamiaceae* plants for cardiovascular health. Tianjin Tasly Pharmaceuticals Co., Ltd. emerges as a leading applicant, reflecting active engagement by pharmaceutical companies alongside independent researchers and organizations. Geographically, China leads patent activity, followed by the United States and Europe, underscoring global interest and market potential. Key International Patent Classification (IPC) codes identified include A61K36/53 (*Lamiaceae* extracts), A61P9/00 (cardiovascular drugs), and A61P9/10 (treatments of ischemic or atherosclerotic diseases). These findings highlight the therapeutic and commercial relevance of *Lamiaceae* bioactives, offering insights into their potential in advancing cardiovascular health and shaping the future of the functional food and nutraceutical industries.

Keywords: cardiovascular diseases; *Lamiaceae*; bioactive compounds; functional foods; innovation; patent analysis

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1. Introduction

Medicinal plants from the *Lamiaceae* family show significant potential for developing functional foods to prevent and treat cardiovascular diseases (CVDs) [1]. These plants are rich in bioactive compounds, including phenolic acids, flavonoids, and terpenoids, which contribute to their diverse therapeutic properties, such as antioxidant, anti-inflammatory, and enzyme-inhibiting activities [2]. Notable phenolics like rosmarinic acid and caffeic acid, along with flavonoids such as luteolin, apigenin, and quercetin, are abundant in several *Lamiaceae* species [3,4]. These bioactives are known to target critical enzymes involved in CVDs, including angiotensin-converting enzymes (ACEs), which regulate blood pressure, and lipoxygenase, a key player in inflammatory processes [5]. Inhibiting these enzymes helps reduce hypertension and inflammation, key risk factors for CVD progression [1,5,6].

Additionally, *Lamiaceae*-derived compounds mitigate oxidative stress and inflammation—primary contributors to CVD—through their potent antioxidant and anti-inflammatory effects. These mechanisms, combined with their antihyperlipidemic activity, highlight the therapeutic potential of *Lamiaceae* species in cardiovascular health management [1,6,7].

Key species, including *Salvia*, *Ocimum*, *Lavandula*, and *Origanum*, have been extensively studied for their unique phenolic profiles and their contributions to cardiovascular health (Figure 1) [8]. Essential oils derived from *Lamiaceae* plants demonstrate diverse biological activities, including vasorelaxant, thrombolytic, antihyperlipidemic, and cytotoxic effects, making them valuable ingredients in nutraceutical formulations [9]. Beyond their medicinal properties, many *Lamiaceae* plants also serve as functional foods, providing essential nutrients such as omega-3 fatty acids, which are beneficial for cardiovascular health [2,10,11]. The integration of these herbs into daily diets has the potential to enhance cardiovascular health and reduce the risk of disease onset [1].

Figure 1. Examples of key species of *Lamiaceae* family. (Reproduced from El Boukhari and Fatimi, Medical Sciences Forum 2023 [8]; Copyright© 2023 by the authors. Licensee MDPI (Basel, Switzerland) under the terms and conditions of the Creative Commons Attribution (CC BY) license).

Research into these plants has also emphasized the need for clinical validation of their efficacy in managing cardiometabolic risk factors, particularly those associated with obesity and CVD. The development of therapeutic strategies utilizing *Lamiaceae* plants holds promise for addressing these health concerns [7,12]. Ongoing studies and patent analyses are essential to uncover the full potential of these plants in naturopathic and biomedical applications [13].

To better understand the integration of these plants into nutraceutical and functional food formulations, this study conducted a comprehensive patent analysis, focusing on the application of *Lamiaceae*-derived bioactives for CVD prevention and treatment. Patent data were gathered from leading databases using the International Patent Classification (IPC) code A61K36/53, which pertains to medicinal preparations derived from *Lamiaceae* plants [14,15]. Additional IPC codes, such as A61P9/00 (cardiovascular drugs) and A61P9/10 (treatments for ischemic or atherosclerotic diseases), were employed to refine the analysis. This methodology allowed us to explore trends in patent filings, identify key applicants and jurisdictions, and map the technological fields related to these patents.

2. Materials and Methods

2.1. Search Protocols and Data Collection

This study utilized a systematic approach to patent analysis to examine the role of *Lamiaceae* plants in developing functional foods for CVD prevention and treatment. Patent data were collected from three major databases: Patentscope [16], The Lens [17], and Google Patents [18], chosen for their comprehensive coverage of global patent filings.

The search focused on documents indexed under the IPC code "A61K36/53", which pertains to medicinal preparations derived from *Lamiaceae* plants [19]. To refine the scope, IPC codes related to cardiovascular treatments, such as A61P9/00 (cardiovascular drugs) and A61P9/10 (treatments for ischemic or atherosclerotic diseases), were included [20]. Using classification codes, we identified relevant technological fields associated with these patents [21].

Key parameters for the search included patent document types (granted patents and patent applications), temporal coverage (until 20 October 2024), jurisdictions (regional trends, highlighting leading countries in patent filings), and applicants (including corporations, universities, and independent researchers to identify key contributors to innovation).

Data were compiled into spreadsheets for further analysis, ensuring that duplicates and irrelevant entries were removed through manual validation.

2.2. Data Analysis

Patent data were systematically analyzed to address the following objectives:

- Temporal trends: The number of patent filings was plotted over time to identify peaks and surges in innovation activity.
- Key applicants: Top contributors, including pharmaceutical companies, research institutions, and independent inventors, were identified.
- Geographical distribution: Patent filings were categorized by jurisdiction to determine leading regions for innovation.
- Technological domains: Associated IPC codes were examined to deduce the focus areas of the patents, particularly their applications in cardiovascular health.

Additional analyses were performed to explore the following:

- The role of specific *Lamiaceae* species and their bioactive compounds in the patents.
- The types of formulations, such as essential oils, extracts, or other plant-derived products, mentioned in the patents.

These analyses were visualized using graphs and charts to illustrate trends, distributions, and key insights.

3. Results and Discussion

3.1. Evolution of Patent Filings

From 1978 to 2024, we identified 260 patent documents related to *Lamiaceae* plants in CVD applications. Figure 2 illustrates the annual number of patent documents published, highlighting trends in innovation within the field of *Lamiaceae*-based functional foods for CVD. The data include both granted patents and patent applications, with a focus on key developments in the field.

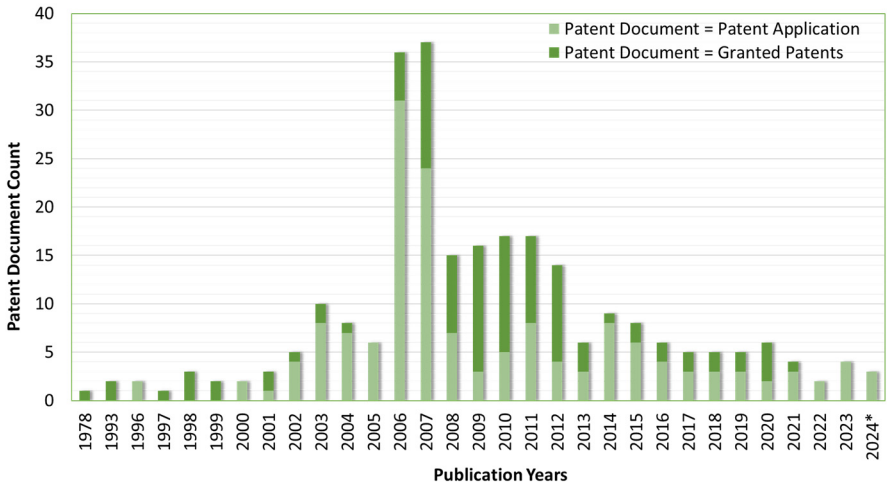

Figure 2. The evolution of patent filings related to the use of *Lamiaceae* plants for CVD prevention and treatment from 1996 to the present. * The data for the year 2024 are limited to 5 October.

During the period studied, a noticeable upward trend in patent applications began to emerge in the early 2000s, culminating in a significant peak in 2007, with 24 applications filed and 13 patents granted. This surge reflects the advancements in phytochemical research during the early 2000s that significantly enhanced the understanding of bioactive

compounds in *Lamiaceae* plants, such as phenolics and flavonoids, and their potential for preventing and treating cardiovascular diseases. This period coincides with a surge in scientific publications and clinical studies exploring the therapeutic effects of plant-based compounds, fostering innovation in related industries and market demand for functional foods. After the peak in 2007, a gradual decline in filings was observed, stabilizing at a lower activity level in subsequent years, with an average of 2–4 patent applications per year between 2018 and 2024. This trend illustrates an initial rapid growth phase, followed by a plateau, potentially due to market saturation or evolving research priorities in related fields.

3.2. Top Applicants

Figure 3 highlights the major pharmaceutical companies, research institutions, and independent entities, as well as natural applicants, contributing to the growing body of patent filings in this field. The data emphasize key players who lead in the number of patents, showcasing the active role of both industry and academia in advancing cardiovascular health through the use of *Lamiaceae* bioactive compounds. In this regard, Tianjin Tasly Pharmaceuticals Co., Ltd. (Tianjin, China) emerged as the leading applicant, followed by several prominent organizations, including Beijing Qi Yuan Yi Pharmaceuticals Research (Beijing, China) and Access Business Group Int. LLC (Ada, MI, USA). This indicates active interest from pharmaceutical companies and research institutions in the therapeutic applications of *Lamiaceae* plants, underscoring their commercial and health potential.

Figure 3. Top patent applicants for innovations using *Lamiaceae* against CVD. Data present the leading patent applicants involved in the development of *Lamiaceae*-based innovations for CVD prevention and treatment. * Patent applicant is a natural person.

3.3. Geographical Distribution

The patent jurisdictional analysis of *Lamiaceae* plants for cardiovascular health reveals a broad global interest in utilizing these medicinal plants for functional foods and nutraceuticals aimed at CVD prevention and treatment. Figure 4 highlights the leading regions where patent filings related to the use of *Lamiaceae* plants for CVD have been concentrated. This distribution not only highlights the leading regions but also reflects the international scope of innovation. The analysis is based on the number of patent applications and grants filed up to 5 October 2024.

Geographically, China stands out as the top jurisdiction for patent filings related to *Lamiaceae* and cardiovascular health. This reflects China's strong emphasis on integrating traditional medicine into modern health solutions, supported by substantial investment in research and development. China's active participation underscores a significant market demand for natural and plant-based therapies aimed at cardiovascular conditions.

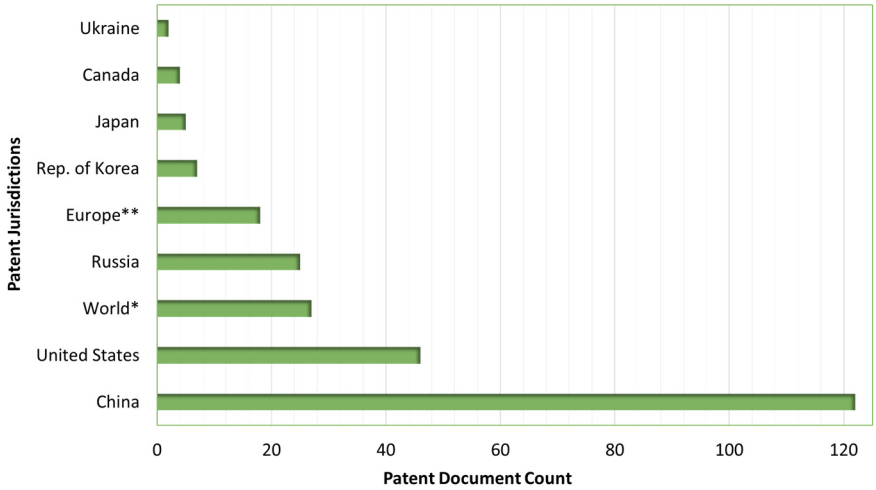

Figure 4. Top jurisdictions focusing on CVD and *Lamiaceae* innovations. Data highlight the leading regions where patent filings related to the use of *Lamiaceae* plants for CVD prevention and treatment have been concentrated. * Patents filed through the PCT system administered by the World Intellectual Property Organization (WIPO). ** Patent protection is primarily obtained through the European Patent Office (EPO).

The United States (US) is the second-largest jurisdiction in terms of patent filings, driven by a growing nutraceutical industry and an increased interest in natural remedies for cardiovascular health. US-based pharmaceutical and nutraceutical companies, alongside independent researchers, contribute significantly to patent activity in this field, suggesting a competitive market for *Lamiaceae*-derived products.

The International Patent Cooperation Treaty (PCT) system ranks as the third most active jurisdiction in terms of filings [22]. Administrated by the World Intellectual Property Organization (WIPO), this system indicates a strong international interest in protecting innovations involving *Lamiaceae* plants for cardiovascular health across multiple countries. The PCT route allows inventors to streamline the patent process globally, which is particularly advantageous for companies and researchers targeting markets in various regions. The prominence of PCT filings highlights the appeal of *Lamiaceae*-based solutions on a global scale, with inventors seeking intellectual property protection beyond national borders.

Russia ranks as the fourth jurisdiction, demonstrating a notable interest in *Lamiaceae*-based cardiovascular treatments within its pharmaceutical and nutraceutical sectors. This points to a growing awareness in Russia of the therapeutic potential of bioactive compounds found in *Lamiaceae* plants, particularly as functional foods gain popularity as preventive health solutions.

Europe, represented through filings via the European Patent Office (EPO), is the fifth-leading jurisdiction. This European activity reflects a commitment to botanical and plant-based therapies within the European Union (EU), where natural health products are in high demand. The EPO system allows inventors to gain patent protection across multiple European countries, which is advantageous for innovations intended for the European market. European interest in *Lamiaceae*-based cardiovascular treatments underscores a regional emphasis on health and wellness through natural products, aligning with the EU's regulatory framework that supports the development of plant-based functional foods and nutraceuticals.

3.4. Technological Fields

Figure 5 presents the technological fields covered by this study's patents, which categorize the patents based on IPC codes [19]. Data illustrate the distribution of patents across different IPC codes, providing insights into the specific therapeutic and medicinal applications of *Lamiaceae* in functional foods for CVD. The analysis reveals three main technological areas within the patents for *Lamiaceae* plants targeting CVD:

1. Medicinal preparations (A61K36/53) associated with particular formulations.
2. Drugs for specific cardiovascular conditions (A61P9/00, A61P9/10), including treatments for thrombosis and ischemia.
3. Medicinal preparations with *Lamiaceae* combined with other plant families, focusing on synergy for enhanced health effects.

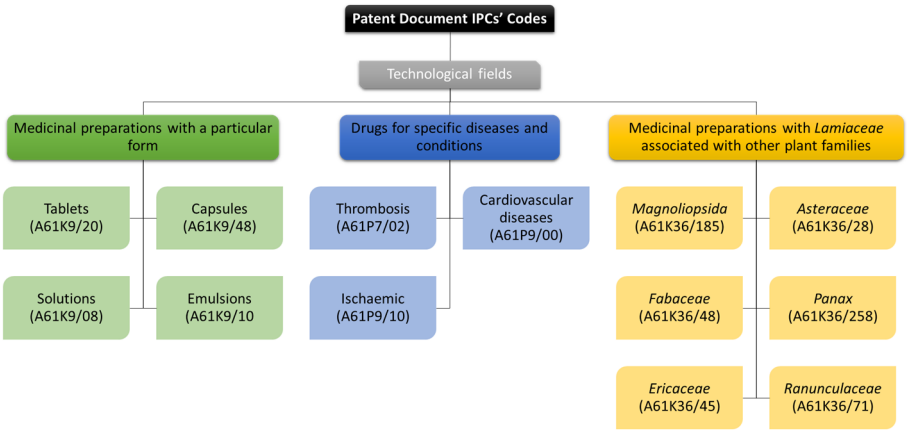

Figure 5. The technological fields covered by this study's patents across different IPC codes. Data categorize the various technological domains associated with patent filings related to *Lamiaceae* plants for CVD prevention and treatment.

These findings align with the broader therapeutic applications of *Lamiaceae* plants in cardiovascular health, underscoring their value in treating conditions like hyperlipidemia and hypertension.

3.4.1. Medicinal Preparations with a Particular Form

One significant area of technological focus involves the medicinal preparation forms used for *Lamiaceae*-based cardiovascular treatments. Patents in this category include tablets (A61K9/20), which provide a stable, controlled-dosage form for bioactive compounds extracted from *Lamiaceae* species. Tablets are commonly used in supplements and medications where consistent dosing is essential. Capsules (A61K9/48) offer another popular delivery form, particularly for encapsulating sensitive *Lamiaceae* extracts or essential oils. Capsules enable controlled release and protect active ingredients from degradation, making them suitable for cardiovascular health applications. Solutions (A61K9/08) represent a liquid formulation that allows for rapid absorption, commonly used in liquid supplements aimed at cardiovascular benefits. Lastly, emulsions (A61K9/10) are preparations where oil- and water-soluble ingredients are combined, enabling the effective delivery of hydrophobic *Lamiaceae* compounds. This range of medicinal forms demonstrates a versatile approach to administering *Lamiaceae*-based therapies, tailored to meet different consumption preferences and pharmacokinetic needs.

3.4.2. Drugs for Specific Diseases and Conditions

Another significant technological area identified is drugs for specific diseases and conditions linked to cardiovascular health. Patents classified under thrombosis (A61P7/02) focus on formulations that prevent or treat blood clot formation, an essential strategy in reducing the risk of heart attacks and strokes. The natural anticoagulant properties of *Lamiaceae* plants make them promising candidates for thrombosis prevention and treatment. Patents under the broad category of cardiovascular diseases (A61P9/00) cover various cardiovascular applications, including antihypertensive and cholesterol-lowering effects, both crucial in managing and reducing cardiovascular risks. Additionally, ischemia (A61P9/10), a condition of reduced blood supply to tissues, especially the heart, is another target area. Formulations here aim to improve blood flow, reduce oxidative stress, and alleviate

ischemic symptoms, leveraging the vasodilatory and antioxidant effects observed in *Lamiaceae* compounds. These patents underscore the therapeutic versatility of *Lamiaceae*-based formulations in managing cardiovascular conditions.

3.4.3. Medicinal Preparations Combining *Lamiaceae* with Other Plant Families

The third area focuses on combining *Lamiaceae* with other botanical families to create synergistic formulations for cardiovascular health. These patents reflect an innovative approach where *Lamiaceae* species are paired with other plant families known for their health benefits. For instance, *Magnoliopsida* (A61K36/185) encompasses formulations that pair *Lamiaceae* with species from the magnolia family, potentially enhancing cardiovascular and metabolic effects through complementary bioactive profiles. Combinations with *Asteraceae* (A61K36/28), another plant family rich in anti-inflammatory properties, aim to maximize the cholesterol-lowering and cardiovascular benefits of *Lamiaceae*. Similarly, *Poaceae* (A61K36/48) plants, including various grasses, are used alongside *Lamiaceae* to leverage fiber content and antioxidant properties, making the formulation more effective for heart health. Furthermore, patents also include *Panax* (A61K36/258), commonly known as ginseng, paired with *Lamiaceae* to combine adaptogenic and cardiovascular benefits, which may support stress reduction and improve cardiovascular function. *Ericaceae* (A61K36/35), such as blueberries, adds potent antioxidant benefits, enhancing the anti-inflammatory potential of the *Lamiaceae* formulations. Finally, *Ranunculaceae* (A61K36/71), including species with cardiovascular applications, adds to the potential anti-inflammatory and blood pressure-lowering effects. This collaborative botanical approach indicates a rich area of innovation and highlights the adaptability of *Lamiaceae*-based cardiovascular treatments.

4. Challenges and Opportunities in the Development of *Lamiaceae*-Based Functional Foods

The cultivation of *Lamiaceae* plants for large-scale use in functional foods holds significant potential for promoting cardiovascular health, thanks to their rich bioactive compounds. However, as the demand for these plants grows, it is crucial to consider the environmental, ethical, and economic dimensions associated with their cultivation and commercialization.

4.1. Environmental Impacts

The large-scale cultivation of *Lamiaceae* plants presents both ecological benefits and environmental challenges. On the one hand, these plants can contribute positively to ecosystems by supporting biodiversity and improving soil health, preventing erosion, and enhancing nutrient cycling [9,23]. On the other hand, large-scale production can place a strain on natural resources, requiring significant water, land, and chemical inputs, which may lead to habitat destruction and water scarcity [1,24]. Sustainable agricultural practices, such as organic farming and efficient water management, are essential to mitigate these environmental concerns and ensure that *Lamiaceae* cultivation aligns with long-term ecological sustainability.

4.2. Role of Ethical Sourcing and Sustainable Farming Practices

Ethical sourcing and sustainable farming practices are critical to the development of *Lamiaceae*-based functional foods. Ethical sourcing ensures that raw materials are harvested in a manner that preserves biodiversity and ecosystem health while also providing economic benefits to local communities [25]. Sustainable farming practices, such as organic farming, crop rotation, and the use of organic fertilizers, help maintain soil quality, reduce the use of harmful chemicals, and promote the cultivation of bioactive compounds essential for the cardiovascular benefits of *Lamiaceae* plants [1,23]. These practices not only contribute to the environmental sustainability of the functional food industry but also enhance the marketability of *Lamiaceae* products, as consumers increasingly demand ethically sourced and sustainably produced goods.

4.3. Challenges in Commercializing Lamiaceae-Based Functional Foods

Despite the promising health benefits of *Lamiaceae*-based functional foods for CVD, several challenges remain in their commercialization. Key issues include the low bioavailability and stability of essential oils and bioactive compounds, which can limit their effectiveness in functional food applications [26]. Additionally, consumer awareness of the health benefits of these plants is still limited, and sensory attributes such as taste and aroma can hinder consumer acceptance [27]. Regulatory barriers and gaps in research further complicate the commercialization process. Stringent approval processes and the need for more robust scientific evidence on the health benefits of *Lamiaceae* compounds can delay market entry and increase costs [1,6].

4.4. Outlook

While these challenges are considerable, they are not insurmountable. Future research into improving the bioavailability and stability of *Lamiaceae* compounds, as well as optimizing the sensory characteristics of functional food products, is essential to enhance their commercial viability. Innovations in sustainable farming practices and the adoption of ethical sourcing frameworks will ensure that the environmental impact of large-scale cultivation is minimized. Furthermore, advancing regulatory frameworks and bridging research gaps will facilitate the approval of new functional foods and increase consumer trust in the products. In conclusion, with ongoing efforts to address these challenges, *Lamiaceae* plants hold great promise in contributing to the global functional food market, particularly for cardiovascular health.

5. Conclusions

This patent analysis of *Lamiaceae* plants for CVD reveals a marked increase in patent filings since the late 1970s. The primary applicants include both pharmaceutical companies and independent researchers, highlighting the industrial and academic interest in these plants. China and the United States lead patent activity, while the PCT system, Russia, and Europe also play significant roles. The global interest represented by these jurisdictions reflects the broad therapeutic and commercial potential of *Lamiaceae* plants for cardiovascular health. This study's findings align with key IPC classifications, such as A61K36/53, A61P9/00, and A61P9/10, affirming the relevance of *Lamiaceae* plants in therapeutic innovations for cardiovascular health. Generally, the patents reveal three categories that collectively highlight the versatility of *Lamiaceae* plants in cardiovascular health. They cover various delivery methods (e.g., tablets, capsules, emulsions, etc.), specific health conditions (e.g., thrombosis, ischemia, general cardiovascular diseases, etc.), and innovative combinations with other plant families to enhance the therapeutic effects. This detailed focus on both formulation types and combinations with other botanical families indicates a rich area of innovation and reflects the diverse approaches used to maximize the efficacy of *Lamiaceae*-based treatments in cardiovascular applications.

This work underscores the potential of *Lamiaceae* in the nutraceutical industry, driven by their rich bioactive compositions and diverse health benefits. Future research should explore the commercialization of these innovations to address global cardiovascular health challenges through plant-based functional foods.

Despite the challenges in this area, the potential of *Lamiaceae*-based functional foods to promote cardiovascular health remains substantial. Ongoing research into bioactive delivery systems, sensory improvements, and consumer education, alongside policy reforms to streamline regulatory processes, could pave the way for innovative and commercially viable solutions that capitalize on the therapeutic promise of *Lamiaceae* plants.

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