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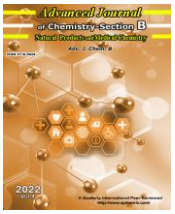

Review Article

Applications of *Justicia secunda* Extracts in Functional Foods and Natural Products: A Review

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ABSTRACT

The search for natural bioactive compounds with potential applications in functional foods and natural products has gained significant interest in recent years. *Justicia secunda*, a plant known for its traditional uses, has been identified as a promising source of such bioactive compounds. This review aims to explore the potential applications of bioactive components present in *Justicia secunda* extracts, with a focus on their antioxidant and antimicrobial properties. It discusses about the identification of key bioactive compounds and provide an overview of their antioxidant and antimicrobial effects. Emphasizing the role of antioxidants in promoting health, this review explore how *Justicia secunda* extracts can be integrated into functional food formulations to enhance nutritional value and shelf-life. Furthermore, it examines the significance of natural antimicrobials in food preservation and the development of health products, showcasing the potential of *Justicia secunda* extracts in these areas. This review considers the potential synergistic effects, combinations with other natural ingredients, and addresses challenges in incorporating *Justicia secunda* extracts into products, including safety and regulatory considerations. It concludes by underscoring the importance of continued research to validate the efficacy and safety of these applications, highlighting *Justicia secunda*'s potential to contribute to the advancement of functional foods and natural products. This review provides valuable insights into harnessing the bioactive potential of *Justicia secunda*, paving the way for innovative and sustainable applications in the realm of health-promoting products.

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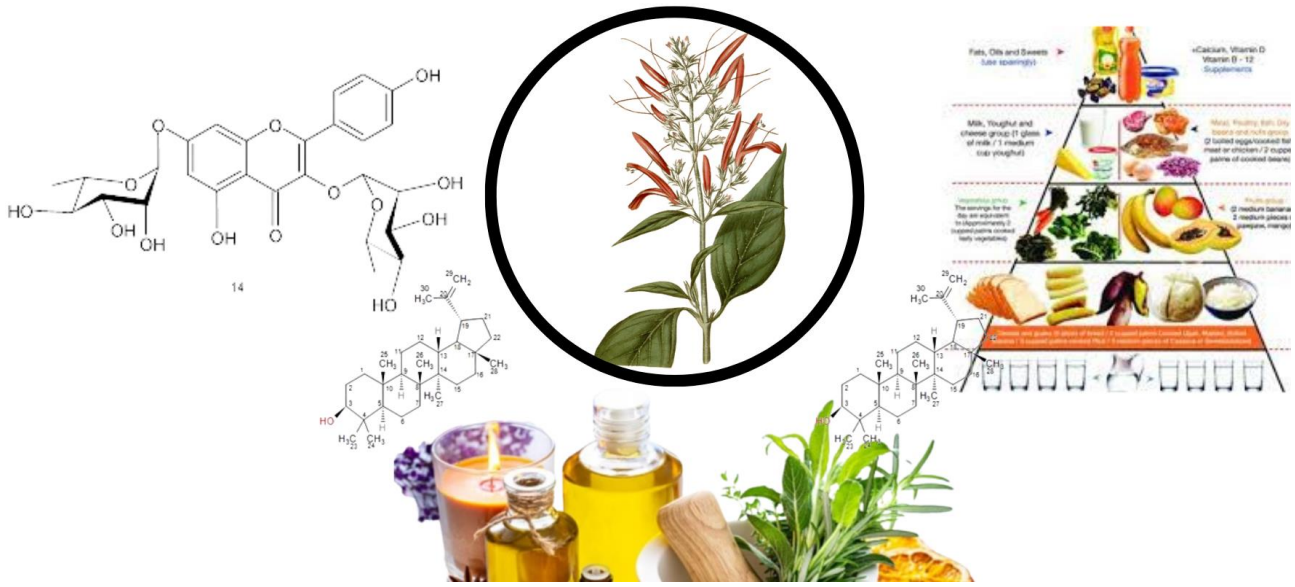
GRAPHICAL ABSTRACT



1- INTRODUCTION

Functional foods and natural products play a crucial role in promoting human health and well-being. These substances are rich sources of bioactive compounds, which are natural chemicals that have specific beneficial effects on the body beyond basic nutrition [1]. Functional foods are designed to provide health benefits beyond their nutritional content, often due to the presence of bioactive compounds. Natural products, on the other hand, encompass a wide range of substances derived from plants, animals, and microorganisms that have been used for centuries in traditional medicine and have gained increasing recognition for their potential health-promoting properties. The significance of functional foods and natural products lies in their potential to prevent or mitigate various health issues, including chronic diseases like cardiovascular disease, diabetes, and cancer, as well as supporting overall health and vitality [2]. These substances are often rich in antioxidants, which help combat oxidative stress and reduce the risk of cellular damage. In addition, many natural products exhibit antimicrobial properties, making them valuable in the development of alternative treatments to combat infections [3]. *Justicia secunda* is a plant species that has gained attention for its potential as the source of bioactive compounds. It belongs to the Acanthaceae family and is found in various regions, including parts of Africa and Asia [4]. It has been traditionally used for its medicinal properties in different cultures. The plant's leaves, roots, and other parts contain various bioactive compounds such as flavonoids, alkaloids, and phenolic compounds, which have shown antioxidant and antimicrobial activities [4-6].

The objective of this review is to explore the potential applications of *Justicia secunda* extracts in functional foods and natural products, with a specific focus on their antioxidant and antimicrobial properties. By examining the scientific evidence surrounding the bioactive compounds found in *Justicia secunda* and their effects on health, we aim to determine the viability of incorporating these extracts into functional food products and natural remedies.

Fig1. *Justicia secunda* plant

This review will contribute to a deeper understanding of the potential benefits of *Justicia secunda* and provide insights into its use as a source of bioactive compounds for improving human health.

2- Bioactive Compounds in Justicia secunda Extracts

Justicia secunda extracts are known to contain a diverse range of bioactive compounds, many of which have been the focus of scientific investigation due to their potential health benefits. Some of the key bioactive compounds found in *Justicia secunda* include flavonoids, alkaloids, phenolic compounds, and other secondary metabolites [5, 7]. These compounds contribute to the plant's medicinal properties and are of significant interest for their potential applications in functional foods and natural products.

The bioactive compounds present in *Justicia secunda* extracts, such as flavonoids and phenolic compounds possess strong antioxidant properties [6]. Antioxidants play a vital role in protecting the body against oxidative stress, which is linked to the development of various chronic diseases. These compounds scavenge harmful free radicals, preventing cellular damage and reducing the risk of oxidative-related health issues. Incorporating *Justicia secunda* extracts into functional foods may enhance the antioxidant content of these products, potentially providing consumers with additional health benefits [8]. In a literature review of studies examining *Justicia secunda* extracts, various bioactive compounds, including flavonoids, phenolic compounds, and alkaloids were found. These compounds were shown to provide potential health benefits such as antioxidant, anti-inflammatory, and antimicrobial effects [9-10]. Furthermore, high levels of flavonoids and phenolic compounds with strong antioxidant activity were discovered in the extracts, which could protect against damage caused by free radicals [11]. Another study demonstrated potent antioxidant and antiproliferative activities in human breast cancer cells, suggesting that *Justicia secunda* extracts may hold promise as cancer treatments [12]. Moreover, the extracts were found to possess antioxidant and anti-inflammatory activities, potentially serving as treatments for diseases like arthritis and inflammatory bowel disease [13]. Likewise, antimicrobial activity against foodborne pathogens was observed, suggesting that *Justicia secunda* extracts could be used to preserve food and prevent food poisoning [14]. Lastly, antimicrobial activity against pathogenic microorganisms was also discovered, indicating the potential development of new antibiotics from *Justicia secunda* extracts [15].

Overall, these studies highlight the diverse bioactive properties of *Justicia secunda* extracts and the potential for their use in various health applications. In addition to their antioxidant properties, the bioactive compounds in *Justicia secunda* extracts exhibit notable antimicrobial effects. Research has shown that certain

compounds found in *Justicia secunda* have the ability to inhibit the growth of pathogenic microorganisms.

In their research, [16] explored the antimicrobial potential of compounds within *Justicia secunda*, revealing significant inhibitory effects against pathogenic microorganisms. Their finding underscores the importance of natural sources in drug discovery and suggests a promising avenue for developing novel antimicrobial agents. This antimicrobial activity is of particular interest in the context of natural products and functional foods, as it may contribute to food preservation and offer alternative strategies for combating microbial infections [17]. Understanding the antimicrobial effects of these compounds can provide valuable insights into their potential applications in various products.

3- Importance of Natural Antimicrobials in Food Preservation and Health Products

Natural antimicrobials are substances that can inhibit the growth or kill microorganisms, such as bacteria, fungi, and parasites. They are used in a variety of applications, including food preservation, health products, and cosmetics [18].

The utilization of natural antimicrobials in food preservation and health products is of paramount importance. Synthetic preservatives and antimicrobial agents have raised concerns due to potential health risks and environmental impacts [19].

Natural antimicrobials, derived from sources such as plants like *Justicia secunda*, offer a safer and more sustainable alternative. These natural compounds can help extend the shelf-life of food products while maintaining their safety and quality. Furthermore, in health and personal care products, natural antimicrobial agents can provide effective protection without the drawbacks associated with the synthetic chemicals [19].

There are many reasons why natural antimicrobials are important. First, they are generally considered to be safer than synthetic antimicrobials. Synthetic antimicrobials can have side effects, and some have been linked to health problems, such as antibiotic resistance. Second, natural antimicrobials are more sustainable than synthetic antimicrobials. Synthetic antimicrobials are often produced using petroleum-based chemicals, which can have a negative impact on the environment [20]. Third, natural antimicrobials can be more effective than synthetic antimicrobials in some cases. For example, natural antimicrobials have been shown to be effective against some strains of bacteria that are resistant to the synthetic antibiotics [21].

4- The Use of Natural Antimicrobials in Food Preservation

Natural antimicrobials are used in food preservation to prevent the growth of microorganisms that can cause food spoilage or foodborne illness [22].

They can be used in a variety of ways, such as:

(1) Adding natural antimicrobials to food directly, such as adding essential oils to fruits and vegetables,

(2) Using natural antimicrobials as a coating on food, such as using plant extracts to coat meat or cheese, and

(3) Using natural antimicrobials in food packaging, such as using essential oils in food wraps [23].

5- The Use of Natural Antimicrobials in Health Products

(1) Natural antimicrobials are also used in health products, such as cosmetics and personal care products.

(2) They can be used to kill microorganisms that can cause skin infections, such as acne and athlete's foot.

(3) Natural antimicrobials can also be used to prevent the growth of microorganisms in wound dressings and other medical devices [24].

6- The Antimicrobial Effects of Justicia secunda

Justicia secunda is a plant that is native to Africa and Asia. It has been used for centuries in traditional medicine to treat a variety of conditions, including infections [25].

Numerous studies have investigated the antimicrobial effects of compounds found in *Justicia secunda* extracts. Research has highlighted the ability of these compounds to inhibit the growth of various pathogenic microorganisms, including bacteria, fungi, and potentially harmful parasites [4, 16].

The presence of bioactive compounds in *Justicia secunda*, such as alkaloids and phenolic compounds, has been associated with these antimicrobial properties [7].

Understanding the specific mechanisms of action and the range of microorganisms affected by these compounds is crucial in harnessing their potential for natural antimicrobial applications. The antimicrobial properties of *Justicia secunda* are thought to be due to the presence of various bioactive compounds, such as alkaloids and phenolic compounds.

These compounds have been shown to have various antimicrobial mechanisms of action, including disrupting the cell membrane, inhibiting protein synthesis, and interfering with DNA replication [26].

7- Potential Applications of Justicia secunda Extracts in the Development of Natural Antimicrobial Products

Formulating Natural Preservatives for Food Products

Justicia secunda extracts hold significant potential in the realm of natural food preservation. With their antimicrobial properties, these extracts could emerge as crucial components in formulating natural preservatives for food products. By employing *Justicia secunda* compounds, it becomes possible to prevent spoilage, prolong shelf life, and ensure the safety of perishable food items [17]. Adopting a sustainable and health-conscious approach, this utilization of *Justicia secunda* compounds can be achieved by incorporating them into food packaging materials or directly into food formulations. This innovative approach offers a viable means of enhancing food preservation while reducing reliance on synthetic preservatives.

Development of Natural Antimicrobial Agents for Personal Care Products

The use of natural antimicrobial agents in personal care products is a growing trend, as consumers become more aware of the potential risks of synthetic chemicals. Natural antimicrobials are derived from plants, minerals, or other natural sources and are generally considered to be safer and more sustainable than synthetic alternatives. One plant that has shown promise as a natural antimicrobial agent is *Justicia secunda*. *Justicia secunda* is a shrub that is native to Africa and Asia. It has been used for centuries in traditional medicine to treat various conditions, including infections. Recent studies have shown that *Justicia secunda* extracts have strong antimicrobial activity [16].

They have been shown to inhibit the growth of a variety of microorganisms, including bacteria, fungi, and parasites. The antimicrobial properties of *Justicia secunda* are thought to be due to the presence of various bioactive compounds, such as alkaloids and phenolic compounds [16]. These compounds have been shown to have various antimicrobial mechanisms of action, including disrupting the cell membrane, inhibiting protein synthesis, and interfering with DNA replication. In addition to their applicability in food preservation, *Justicia secunda* compounds show

promise as natural antimicrobial agents for personal care products. Given their inherent antimicrobial properties, these compounds possess the potential for integration into various personal care items, including soaps, shampoos, creams, and more. Incorporating natural antimicrobial agents derived from plants, such as *Justicia secunda*, into these formulations enables the maintenance of proper hygiene and microbial balance without exposing the skin and body to potentially harmful synthetic chemicals [27]. This development emphasizes the importance of exploring natural alternatives in personal care, aligning with the growing consumer demand for safer, more sustainable options.

The development of natural antimicrobial agents for personal care products is a promising area of research. These agents offer a safer and more sustainable alternative to synthetic chemicals. They can also help to reduce the risk of exposure to harmful chemicals and protect the environment. Through their antimicrobial qualities, *Justicia secunda* extracts prove to be valuable across multiple domains, including food preservation and personal care. Harnessing the potential of these natural compounds opens up avenues for formulating safer, more sustainable products in both industries, contributing to the overall well-being of consumers.

8- Synergistic Effects and Combinations

Literature reveals that *Justicia secunda* extracts comprise a diverse array of bioactive compounds, each possessing distinct properties. Recent investigations suggest the existence of potential synergistic interactions among these compounds, amplifying their individual effects and yielding a more robust collective impact. Notably, the interplay between flavonoids and phenolic compounds within *Justicia secunda* has been highlighted, indicating the likelihood of additive or synergistic outcomes, particularly in terms of antioxidant and antimicrobial activities [13]. Understanding the potential synergies between these compounds is crucial for maximizing the health benefits they can offer.

The synergistic effects observed in *Justicia secunda* compounds have significant implications for the development of functional foods and natural products [4]. By carefully formulating products to leverage these synergies, manufacturers can create items with enhanced health-promoting properties. For instance, combining *Justicia secunda* extracts with other bioactive-rich ingredients may result in products with amplified antioxidant capacities or improved antimicrobial action. This approach aligns with the growing consumer demand for natural, additive-free products with higher efficacy and safety profiles.

There are emerging examples of successful combinations involving *Justicia secunda* compounds and other natural ingredients. For instance, the incorporation of *Justicia secunda* extracts alongside certain herbal extracts known for their health benefits, such as green tea or turmeric, may create synergistic effects that amplify the overall therapeutic potential of a functional food or supplement [8]. In addition, pairing *Justicia secunda* compounds with specific carrier agents or natural stabilizers can improve the bioavailability and stability of these compounds, enhancing their usefulness in various product formulations [28].

9- Challenges and Considerations

Incorporating *Justicia secunda* extracts into products may pose certain challenges. Ensuring consistent quality and potency of the extracts is vital to maintain the desired health benefits. Variability in growing conditions, harvesting methods, and extraction processes can impact the composition of bioactive compounds. Moreover, the characteristic taste, aroma, or color of these extracts could influence consumer acceptance, necessitating careful formulation to balance health benefits with sensory attributes

[29]. The safety of functional foods and natural products containing *Justicia secunda* extracts must be rigorously evaluated. Regulatory agencies require comprehensive safety assessments, including toxicological studies, to ensure that the products are safe for human consumption. Furthermore, proper labeling is essential to inform consumers about the presence of *Justicia secunda* extracts, their intended effects, and potential allergens. Adhering to regulatory guidelines and transparently communicating the benefits and risks are crucial aspects of responsible product development [29]. While promising, the applications of *Justicia secunda* extracts in functional foods and natural products require further validation through rigorous research and clinical studies. Robust scientific evidence is necessary to substantiate the claimed health benefits, establish optimal dosages, and ensure the safety of prolonged consumption. Clinical trials can provide insights into the compounds' efficacy in real-world settings, potential interactions, and any adverse effects. This research is vital to build a solid foundation for the integration of *Justicia secunda* extracts into various products and to provide consumers with reliable health-enhancing options.

CONCLUSION

To sum up, this review has highlighted the significant potential of *Justicia secunda* extracts as a source of bioactive compounds with antioxidant and antimicrobial properties. The identification of key bioactive compounds, their synergistic effects, and their applications in functional foods and natural products showcase the versatility and promising nature of *Justicia secunda*. The evidence presented underscores the potential benefits that *Justicia secunda* extracts can bring to the development of functional foods and natural products. Their antioxidant and antimicrobial properties offer an avenue for creating safer, more sustainable, and health-enhancing products that align with the growing demand for natural alternatives. Leveraging the unique qualities of *Justicia secunda* compounds can lead to innovative solutions in the realms of food preservation and personal care, improving both health and environmental outcomes.

Table 1. Application of *Justicia secunda* Extracts

Application of *Justicia secunda* Extracts	**Description**
Herbal Teas and Infusions	*Justicia secunda* leaves are used for herbal teas in order to add blood to the body.
Antioxidant Supplements	Extracts have been incorporated for their antioxidant properties.
Anti-Inflammatory Agents	Used in products targeting inflammation reduction.
Traditional Medicine Formulations	Used or infused in traditional medicine products.
Cosmetics and Personal Care Products	Potential uses in skincare products.
Natural Flavorings and Colorants	As flavorings or colorants in food and beverages.
Functional Foods and Beverages	Enhanced nutritional value in various products.
Immune Support Products	Used in products supporting the immune system.

While this review provides valuable insights, there is still much to explore in the realm of *Justicia secunda* extracts and their applications. This review emphasizes the need for continued research to validate the efficacy and safety of these extracts, both through laboratory studies and well-designed clinical trials. This ongoing investigation is essential for building a solid scientific foundation, unlocking new possibilities, and ensuring that consumers can fully benefit from the potential health advantages that *Justicia secunda* offers.

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