



(REVIEW ARTICLE)



Phytochemical constituents and bioactivities of *Hippeastrum puniceum*: A review

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International Journal of Science and Research Archive, 2024, 13(02), 1314–1321

Publication history: Received on 14 October 2024; revised on 21 November 2024; accepted on 23 November 2024

Article DOI: <https://doi.org/10.30574/ijrsra.2024.13.2.2279>

Abstract

Hippeastrum puniceum, a plant native to tropical Africa, including Nigeria, has garnered increasing attention due to its rich phytochemical profile and diverse bioactivities. This review highlights the key phytochemical constituents—alkaloids, flavonoids, saponins, terpenoids, tannins, and starch—found in *Hippeastrum puniceum*. These compounds contribute to the plant's significant antioxidant, antimicrobial, and anti-inflammatory properties, positioning it as a valuable resource for various industrial applications. Flavonoids and alkaloids primarily contribute to the antioxidant activity, which helps mitigate oxidative stress and potentially prevent chronic diseases like cancer and cardiovascular disorders. Its antimicrobial effects, driven by alkaloids and flavonoids, offer promising natural alternatives to combat antibiotic-resistant pathogens. Additionally, the plant's anti-inflammatory properties suggest potential therapeutic applications in treating inflammatory conditions like arthritis and asthma. The review also explores the potential applications of *Hippeastrum puniceum* across different industries. In the pharmaceutical industry, it holds promise for developing novel drugs targeting oxidative stress, microbial infections, and inflammation. The food industry can leverage its antioxidant and antimicrobial properties as natural preservatives and functional food additives. In the cosmetic industry, its bioactive compounds could be used in anti-ageing and skincare products. Despite these promising findings, further research is needed to isolate and characterise specific compounds, conduct clinical trials, and assess the pharmacokinetics and toxicity of *Hippeastrum puniceum*. This comprehensive review underscores the importance of continued exploration of *Hippeastrum puniceum*, emphasising its potential to contribute to advancements in phytochemistry, pharmacology, and various industrial applications.

Keywords: Phytochemicals; Bioactivities; *Hippeastrum puniceum*; Phytochemistry; Pharmacology

1. Introduction

Hippeastrum puniceum, commonly known as Barbados Lily or Amaryllis, belongs to the family Amaryllidaceae. It is known for its attractive trumpet-shaped flowers in vibrant shades of red, orange and pink. It is native to tropical and subtropical regions of South America and the Caribbean. This perennial plant... This herbaceous plant has spread to different parts of the world due to its beauty and adaptability to different climates (Meerow et al., 2000). Generally, this plant grows from a bulb with long strap-like leaves. Strong, hollow stems and... large, beautiful flowers. Typically, each flowering sequence produces two to four flowers. This has contributed to its popularity in the horticultural sector (Dutilh, 2014). In addition to its aesthetic value, *H. puniceum* also has cultural significance in traditional medicine. Indigenous communities have used various parts. It is used in wound healing respiratory conditions and skin infections (Elgorashi & Van Staden, 2004). Phytochemically, *Hippeastrum* species are a rich source of alkaloids. especially of the family Amaryllidaceae. Demonstrating broad biological activity (Berkov et al., 2011), these scaffolds have been studied for their potential in treating neurological disorders, cancer, and microbial infections. The presence of bioactive compounds such as lycorine and galantamine in related *Hippeastrum* species indicates that *H. puniceum* is an important source of bioactive compounds.

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Phytochemical studies play an important role in the scientific investigation of medicinal plants. It provides insights into the natural compounds that influence healing effects (Etinagbedia 2022). Medicinal plants such as *Hippeastrum puniceum* contain a wide range of phytochemicals such as alkaloids, flavonoids, saponins, phenolic compounds, etc. Identification of these compounds helps to understand the structure. Mechanism of action and possible applications, for example, alkaloids in the family Amaryllidaceae plants such as galanthamine have been used to treat neurological disorders such as Alzheimer's disease (Nair et al., 2012). This underscores the importance of phytochemical research in discovering compounds with pharmaceutical potential. Many plants used in traditional medicine lack rigorous scientific investigation. Phytochemical studies help bridge this gap by providing empirical evidence on the efficacy and safety of these plants. For example, the traditional use of *Hippeastrum puniceum* to treat wounds and infections can be substantiated by the identification of antimicrobial compounds or anti-inflammatory compounds contained in plants (Elgorashi & Van Staden, 2004). This certification not only enhances the credibility of traditional medicine. But it also promotes integration into modern health care systems. Natural products remain an important source of drug discovery.

More than 50% of today's medicines are derived from or inspired by natural compounds (Newman & Cragg, 2020). Studying the phytochemical components of plants such as *H. puniceum* may lead to the discovery of new therapeutic agents that have a unique mechanism of action. This is especially true in areas such as cancer therapy, antimicrobial resistance and chronic disease management. Studying the entire phytochemical history of a plant provides insight into how different compounds are affected. How does it react to create biological activity? This understanding may lead to the development of more effective multi-compound treatments compared to single-molecule drugs (Wink, 2015). Sustainable use of medicinal plants can stimulate local economies. Especially in biodiverse areas such as South America and Africa. Phytochemical research can promote conservation efforts by highlighting the value of conserving plant species with medicinal potential (Cunningham et al., 2017). Additionally, identification of bioactive compounds in plants reduces reliance on synthetic chemicals and promotes the development of environmentally friendly medicines. The increasing prevalence of drug-resistant pathogens and chronic diseases necessitates the discovery of new bioactive compounds. Plants such as *Hippeastrum puniceum* may have untapped potential to address these challenges through antimicrobial agents, antioxidants or anti-inflammatory compounds (Berkov et al., 2011). The goal of this review is to take an in-depth look at all the phytochemicals found in *Hippeastrum puniceum*, focusing on the bioactive compounds and how they work in the body. Other research Learn more about the treatment of *H. puniceum*.

2. Phytochemical Constituents of *Hippeastrum puniceum*

Hippeastrum puniceum is known for its rich phytochemical profile, containing several bioactive compounds that contribute to its medicinal properties. The primary phytochemicals identified in this plant include alkaloids, flavonoids, and tannins, each playing distinct roles in its therapeutic potential.

Alkaloids: In the family Amaryllidaceae, *H.* these nitrogen-containing compounds are known for their wide range of pharmacological effects. *H. puniceum* is especially known for the presence of a type of alkaloid. Amaryllidaceae species include lycorine, galantamine, and crinine (Berkov et al., 2011). Lycorine is known for its anticancer, antiviral, and anti-inflammatory properties. Lycorine has shown the ability to inhibit cancer cell proliferation and induce apoptosis in several forms of cancer (Nair et al., 2012). Extensive role in treating neurological diseases Galantamine acts as an acetylcholinesterase inhibitor, which improves cognitive function in Alzheimer's patients (Wink, 2015; Soprani et al., 2021). Crinine and other isoquinoline alkaloids It has antimicrobial and antifungal properties, making *H. puniceum* therapeutic in treating infections. The existence of these bases underscores the plant's potential to develop treatments for neurological diseases, cancer and infectious diseases.

Flavonoids: Flavonoids are a class of polyphenolic compounds known for their antioxidant and anti-inflammatory properties. It is necessary to destroy free radicals. Reduce oxidative stress and prevent cell damage (Pandey & Rizvi, 2009). Flavonoids play a pharmacological role in *H. puniceum*. Flavonoids such as quercetin and kaempferol Help reduce oxidative stress, which is linked to cancer and other chronic diseases and cardiovascular disorders (Middleton et al., 2000). Flavonoids also inhibit mediators that promote inflammation. This supports the traditional use of the plant for treating inflammation... (Sawandarajan and Kim, 2016). Additionally, flavonoids exhibit broad-spectrum antimicrobial activity. It complements the role of traditional medicine in treating wounds and infections (Cushnie & Lamb, 2011).

Tannin: Tannins are polyphenolic compounds known for their astringent properties and role in the plant's immune system. Tannins in *H. puniceum* are thought to be responsible for several healing properties. Tannins promote wound healing by creating a protective layer on tissue. Reduce infection and enhance tissue regeneration (Okuda et al., 2011). Like flavonoids, they inhibit the growth of bacteria and fungi by precipitating proteins and destroying microbial membranes (Scalbert, 1991). Tannins also act as antioxidants. Protects cells from oxidative damage and reduce the risk

of chronic disease (Hagerman et al., 1998). The presence of tannins supports the use of *H. puniceum* in traditional treatments for skin infections and gastrointestinal problems.

Terpenoids: Terpenoids are also known as isoprenoids. It is one of the largest and most diverse groups of naturally occurring phytochemicals. They are derived from five isoprene carbon units and play an important role in plant physiology, protection mechanism and interaction with the environment. The terpenoids in *Hippeastrum puniceum* are responsible for their pharmacological potential. Terpenoids have important anti-inflammatory effects by inhibiting key enzymes such as cyclooxygenase (COX) and lipoxygenase, which are involved in inflammatory processes. This property supports the traditional use of *H. puniceum* in treating inflammatory conditions (Siddiqui et al., 2011). - Many terpenoids have potent antibacterial, antifungal, and antiviral activities. They disturb the cell membranes of microorganisms and disrupt enzyme systems. This makes them effective against a wide range of pathogens. (Cox-Georgian et al., 2019) Terpenoids help scavenge free radicals. Reduce oxidative stress and protect cells from damage. This antioxidant effect is important in preventing chronic diseases such as cancer and cardiovascular disease (Lobo et al., 2010). Some terpenoids, especially triterpenoids and diterpenoids, are shown to be toxic to cancer cells. They induce cell death. It induces tumor cell death (programmed cell death) and inhibits the spread of tumor cells. This indicates their potential as chemotherapeutic agents (Yu et al., 2017). Some terpenoids have neuroprotective effects. This helps prevent Alzheimer's disease and other neurological diseases. They protect nerve cells from oxidative damage and inflammation, which is an important factor in neurodegeneration (Wink, 2015)

Saponins: Saponins are a class of glycosidic compounds characterized by outstanding foaming properties when dissolved in water. It consists of hydrophilic sugars associated with a hydrophobic aglycone (sapogenin) structure, which can be a steroid or a triterpenoid. The various biological activities of saponins in *Hippeastrum puniceum* are important contributors to their pharmacological and therapeutic potential. Saponins show strong antimicrobial properties. Including activity against bacteria, fungi and viruses, they interact with the cell membranes of microorganisms. This causes disruption of cell membranes and leakage of intracellular contents, ultimately leading to cell death (Mert-Türk, 2006). Saponins have important antioxidant effects. Helps eliminate free radicals and reduce oxidative stress. This property is important in protecting cells from damage associated with chronic diseases such as cancer and cardiovascular disorders (Saha & Ghosh, 2012). Saponins modulate the inflammatory response by inhibiting pro-inflammatory cytokines and enzymes such as cyclooxygenase-2 (COX-2) and nitric oxide synthase (NOS), making it effective in managing inflammatory conditions (Man et al., 2010). Saponins can stimulate the immune system by stimulating immune cell proliferation and antibody production. This immunostimulating effect has potential for application in vaccine adjuvants and immunotherapy (Francis et al., 2002). Saponins show toxicity against a variety of cancer cells. They induce cell death. Saponins induce saponins (programmed cell death) and inhibit cancer cell proliferation by disrupting the mitochondrial membrane potential and activating the caspase pathway (Podolak et al., 2010). Some species show hypoglycemic effects by increasing insulin secretion.

Starch: Starch is a complex carbohydrate made up of the polymers amylose and amylopectin. Acts as the primary energy storage polysaccharide in plants. *Hippeastrum puniceum* contains a lot of starch, especially in the head which acts as an energy store for plant growth and development. In *H. puniceum*, starch serves as a primary energy store. Starch stored during growth or flowering is hydrolyzed into glucose that provides energy for metabolic processes (Ball et al., 1996). In bulbous plants such as *H. puniceum*, starch accumulates in specialized storage tissues and they help plants survive in adverse environmental conditions such as drought or nutritional deficiencies (Smith et al., 2005). Starch breakdown products such as glucose and maltose act as precursors of other metabolic pathways including the synthesis of secondary metabolites such as alkaloids and flavonoids (Zeeman et al., 2007). Although the starch itself does not show any direct pharmacological effects, its presence in *H. puniceum* is vital for the production and accumulation of bioactive compounds. In addition, starch-based materials have also received interest in pharmaceutical applications, including drug and nutrient delivery systems. Starch nanoparticles and hydrogels are being investigated for controlled drug release due to their biocompatibility and biodegradability (Sun et al., 2015). Starch-rich extracts can be used in foods to health and may be used to treat *H. pylori* infection.

3. Bioactivities of *Hippeastrum puniceum*

Hippeastrum puniceum, known for its striking flowers and traditional medicinal uses, exhibits several bioactivities that contribute to its therapeutic potential. These bioactivities, including antioxidant, antimicrobial, and anti-inflammatory properties, have been widely studied and are believed to be largely attributed to the plant's diverse phytochemical constituents. Below, we discuss the main bioactivities associated with *H. puniceum*.

3.1. Antioxidant Properties

Antioxidants play an important role in neutralizing harmful free radicals that cause oxidative stress. Which leads to various chronic diseases such as cancer, heart disease and blood vessels. and neurodegenerative disorders (Basu et al., 2012). The antioxidant properties of *Hippeastrum puniceum* are mainly due to its rich flavonoid, alkaloid, and saponin content. which are known to have significant free radical scavenging abilities. Flavonoids in *H. puniceum* such as quercetin and kaempferol It is a powerful antioxidant that works by donating. electrons to neutralize reactive oxygen species (ROS), which protects cells from oxidative damage (Zhao et al., 2016). Alkaloids and saponins also contribute to antioxidant activity by reducing Fat oxidation occurs. which is a major cause of cell damage (Yadav et al., 2016) et al., 2015). Studies have found that *H. puniceum* extracts have strong antioxidant effects in vitro. For example, A. Thanol of the *H. punicem* bulb has a significant DPPH (1,1-diphenyl-2-picrylhydrazyl) free radical scavenging effect. and a noticeable decrease in the level malondialdehyde (MDA), a marker of oxidative damage (Sharma et al., 2014). - The plant's antioxidant activity supports its potential as a natural source of antioxidants for use in dietary supplements and pharmaceuticals.

3.2. Antimicrobial Properties

The antimicrobial properties of *Hippeastrum puniceum* make it a valuable plant in traditional medicine. This is especially true for treating infections caused by bacteria, fungi, and other germs. Bioactive plant compounds such as alkaloids, flavonoids, and terpenoids. It has an outstanding antimicrobial effect. Alkaloids from *H. puniceum* inhibit microbial growth by disrupting the microbial cell membrane. and disrupts the metabolism Flavonoids are known to have antimicrobial properties by inhibiting bacterial cell wall synthesis and cell division enzymes (Loizzo et al., 2013). Lipophilic can destroy the cell membranes of microorganisms. This leads to leakage of intracellular contents and cell death (Shin et al., 2010). The antimicrobial efficacy of *H. puniceum* has been proven by research in several studies. Plant extracts have an inhibitory effect on common pathogens such as *Staphylococcus aureus*, *Escherichia coli*, *Candida albicans*, *Aspergillus niger* (Ali et al., 2012).

3.3. Anti-inflammatory Properties

Inflammation is a physiological response to injury or infection. But when chronic, it can lead to diseases such as arthritis, cardiovascular disease, and cancer (Libby, 2012). *Hippeastrum puniceum*'s anti-inflammatory properties are due to active compounds that link inflammatory pathways. Flavonoids and the saponins contained in *H. punisseum* can reduce inflammation by inhibiting the expression of pro-inflammatory cytokines and enzymes such as cyclooxygenase (COX-2) and cyclooxygenase (COX-2) and nitric oxide synthase (NOS). These enzymes play a key role in the inflammatory response and inhibiting them may help reduce chronic inflammation. (Gao et al., 2009) Moreover, flavonoids such as quercetin are known to inhibit the NF- κ B signaling pathway, which is involved in the formation of inflammatory mediators (Yang et al., 2015) and the anti-inflammatory potential of *H. puniceum* is supported by several studies. For example, a study by Sharma et al. (2014) showed that ethanol extract of *H. puniceum* reduces levels of inflammatory markers such as C-reactive Protein (CRP) and interleukins (IL-6, IL-1 β) in experimental animals significantly. This suggests that *H. puniceum* may be effective in managing arthritis and other inflammatory diseases.

4. Potential Applications

1. Pharmaceutical Industry: *Hippeastrum puniceum* offers great potential in the formulation of drugs targeting oxidative stress, microbial infections, and inflammation. The pharmaceutical potential of *Hippeastrum puniceum* lies in its rich phytochemical content, which exhibits a wide range of medicinal properties. The bioactive compounds present in *Hippeastrum puniceum*, such as flavonoids and alkaloids, make it a valuable ingredient in the cosmetic industry. These compounds exhibit potent antioxidant and anti-inflammatory properties, which are critical for protecting skin cells from oxidative damage and promoting skin repair. Extracts from the plant can be incorporated into anti-aging creams, moisturizers, and serums to reduce wrinkles and improve skin elasticity. Additionally, its potential for soothing irritated skin makes it suitable for sensitive skin formulations. The growing preference for natural and plant-based cosmetics further underscores its appeal in this sector (Chakraborty et al., 2022).

4.1. Nutraceuticals

Nutraceuticals are functional foods or dietary supplements that provide health benefits beyond basic nutrition. *Hippeastrum puniceum* holds promise in this area due to its rich phytochemical profile. The plant's antioxidants and anti-inflammatory agents may contribute to cardiovascular health, immune system support, and the prevention of chronic diseases. Its extracts could be used in the formulation of capsules, powders, or drinks aimed at enhancing overall well-being. These properties align with the increasing consumer interest in natural, health-promoting products (Singh & Verma, 2020).

4.2. Traditional Medicine Practices

In traditional medicine, *Hippeastrum puniceum* has been utilized for treating various ailments. Indigenous communities have used the plant for its analgesic and anti-inflammatory properties to alleviate pain and swelling. Additionally, the bulb of the plant is often applied in folk remedies for wounds, skin infections, and fever management. Its historical use highlights its potential for further exploration in modern herbal medicine and pharmacological studies (Rahman et al., 2019).

4.3. Food Industry

The food industry can greatly benefit from the bioactive properties of *Hippeastrum puniceum* due to its antioxidant, antimicrobial, and preservative qualities. The plant's extracts are promising for:

Natural preservatives: Due to the antioxidant properties of its flavonoids, *Hippeastrum puniceum* can be utilized in the food industry as a natural preservative to prevent the oxidation and spoilage of food products (Arroo et al., 2011).

Functional foods: The antioxidant and antimicrobial properties can be incorporated into functional food products aimed at improving health and preventing diseases. Such foods can benefit from the addition of plant extracts that provide bioactive compounds beneficial for boosting immune health and improving digestion (Rao et al., 2012).

Food fortification: *Hippeastrum puniceum* can also be used in fortifying foods, especially in regions where micronutrient deficiencies are prevalent. The bioactive compounds in the plant can enhance the nutritional value of foods, providing added health benefits (Saldanha et al., 2015). These applications open the door for *Hippeastrum puniceum* to contribute significantly to the food industry's focus on natural additives, functional foods, and health supplements.

3. Cosmetic Industry: In the cosmetic industry, *Hippeastrum puniceum* offers several promising applications due to its skin-protective, antimicrobial, and anti-inflammatory properties:

Anti-aging products: The antioxidant properties of flavonoids and saponins help protect skin cells from oxidative damage, thereby delaying signs of aging and promoting healthier skin. These bioactive compounds are often used in cosmetic formulations aimed at preventing wrinkles, fine lines, and skin aging (Liu et al., 2009).

Skin care treatments: The plant's anti-inflammatory and antimicrobial effects can be harnessed in skincare products designed to treat conditions such as acne, dermatitis, and eczema. Extracts of *Hippeastrum puniceum* can reduce inflammation and soothe irritated skin (Nair et al., 2013).

Hair care: Due to its antimicrobial properties, *Hippeastrum puniceum* can be used in hair care products such as shampoos and conditioners to maintain scalp health, prevent dandruff, and reduce hair loss (Saad et al., 2018). The plant's diverse bioactive properties provide a promising foundation for the development of innovative cosmetic products that address various skin and hair health concerns.

5. Conclusion and Future Research Directions

The review has shown that *Hippeastrum puniceum* possesses significant bioactive properties due to its rich phytochemical composition, which includes alkaloids, flavonoids, saponins, terpenoids, and starch. These bioactive compounds contribute to a variety of beneficial activities such as antioxidant, antimicrobial, and anti-inflammatory effects. The antioxidant properties, primarily attributed to flavonoids and alkaloids, help neutralize free radicals, preventing oxidative stress and cellular damage. The plant's antimicrobial effects, exhibited by flavonoids and alkaloids, make it a promising candidate for developing natural alternatives to synthetic antibiotics. Furthermore, the anti-inflammatory potential of *Hippeastrum puniceum*, driven by its flavonoid and saponin content, suggests its value in treating inflammatory conditions like arthritis and asthma. These review findings position *Hippeastrum puniceum* as a valuable source of bioactive compounds with potential therapeutic uses across various fields, including the pharmaceutical, food, and cosmetic industries. While the current body of research on *Hippeastrum puniceum* has highlighted its promising bioactivities, several areas require further investigation to fully unlock its potential:

- **Isolation and Characterization of Bioactive Compounds:** Further research is needed to isolate and identify specific bioactive compounds from *Hippeastrum puniceum* to better understand their mechanisms of action and therapeutic efficacy.

- Clinical Trials: Although preliminary studies suggest promising bioactivities, clinical trials are essential to confirm the safety and efficacy of *Hippeastrum puniceum* extracts or isolated compounds in human subjects.
- Pharmacokinetics and Toxicity Studies: To ensure the safe use of *Hippeastrum puniceum* in medicinal formulations, studies on its pharmacokinetics (absorption, distribution, metabolism, and excretion) and potential toxicity are needed.
- Synergistic Effects: Research could explore the synergistic effects of *Hippeastrum puniceum* compounds when used in combination with other plant-based bioactives, which could lead to more potent therapeutic products.
- Standardization and Commercialization: Future work should focus on developing standardized extracts and formulations for industrial use, ensuring consistency in potency and efficacy across various applications.

Implications for the Field of Photochemistry and Pharmacology

Research findings on *Hippeastrum puniceum* have important implications for phytochemistry and pharmacology. The diverse phytochemical properties of plants have enormous potential for the discovery of new therapeutic agents in phytochemistry. This underscores the importance of searching little-known plants for valuable bioactive compounds. This could lead to the development of new drugs. Especially in the context of increasing concerns about antibiotic resistance and chronic diseases related to oxidative stress...

Pharmacologically, *Hippeastrum puniceum* may provide a new avenue for drug development. This is especially true for the treatment of inflammatory diseases, infections, and disorders related to oxidative stress. This is because bioactive compounds may be a natural alternative to synthetic drugs, which has contributed to the increase in natural products - Basic Therapy In addition, its antioxidant and antimicrobial properties may provide important preventive health benefits. It contributes to the development of healthy foods and dietary supplements aimed at improving health and preventing disease...

In conclusion, *Hippeastrum puniceum* represents a promising candidate for future research and industrial applications. It has the potential to lead to advances in drug development, healthy food and cosmetic formulas

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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