

**NATURAL COSMETOLOGY: THERAPEUTIC POTENTIAL OF PLANTS BIOACTIVES
WITH EMPHASIS ON PUPUNHA (*Bactris gasipaes*), FOR AESTHETICS AND
WELL-BEING: COMPARATIVE REVIEW**

Cosmetologia natural: potencialidades terapêuticas dos bioativos vegetais com ênfase na pupunha (*Bactris gasipaes*), para estética e o bem estar: revisão comparativa

Cosmetología natural: potencial terapéutico de los bioactivos vegetales con énfasis en la pupunha (*Bactris gasipaes*), para la estética y el bienestar: revisión comparativa

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ABSTRACT

Natural cosmetology is emerging as an effective, safe and sustainable solution for aesthetic care and well-being. This article reviews the main natural active ingredients applied in cosmetics, exploring their therapeutic properties, mechanisms of action and relevance for facial and body aesthetics. The methodology used was based on a systematic literature review, analyzing publications between 2020 and 2024 in scientific databases such as PubMed, SciELO, Web of Science and Google Scholar. The findings indicate that bioactives from pupunha (*Bactris gasipaes*), açaí (*Euterpe oleracea*), buriti (*Mauritia flexuosa*) and coconut (*Cocos nucifera*) are rich in fatty acids, vitamins and antioxidants. This composition gives them high potential for moisturizing, rejuvenating, anti-inflammatory and skin regenerating formulations. The discussion addresses the biochemical basis of these ingredients and their dermatological safety. It is concluded that natural cosmetology not only offers significant dermatological benefits, but also values traditional knowledge and promotes the development of more ethical, conscious and biocompatible cosmetics.

Keywords: natural cosmetology, plant bioactives, aesthetics, pupunha, phytocosmetic.

RESUMO

A cosmetologia natural emerge como uma solução eficaz, segura e sustentável para cuidados estéticos e bem-estar. Este artigo revisa os principais ativos naturais aplicados na cosmética, explorando suas propriedades terapêuticas, mecanismos de ação e relevância para a estética facial e corporal. A metodologia empregada baseou-se em uma revisão sistemática da literatura, analisando publicações entre 2020 e 2024 em bases científicas como PubMed, SciELO, Web of Science e Google Scholar. Os achados indicam que bioativos provenientes da pupunha (*Bactris gasipaes*), açaí (*Euterpe oleracea*), buriti (*Mauritia flexuosa*) e coco (*Cocos nucifera*) são ricos em ácidos graxos, vitaminas e antioxidantes. Essa composição confere-lhes alto potencial para formulações hidratantes, rejuvenescedoras, anti-inflamatórias e regeneradoras cutâneas. A discussão aborda as bases bioquímicas desses ingredientes e sua segurança dermatológica. Conclui-se que a cosmetologia natural não só oferece benefícios dermatológicos significativos, mas também valoriza saberes tradicionais e impulsiona o desenvolvimento de uma cosmética mais ética, consciente e biocompatível.

Palavras-chave: cosmetologia natural, bioativos vegetais, estética, pupunha, fitocosmético.

RESUMEN

La cosmetología natural emerge como una solución eficaz, segura y sostenible para el cuidado estético y el bienestar. Este artículo revisa los principales ingredientes activos naturales aplicados en cosmética, explorando sus propiedades terapéuticas, mecanismos de acción y relevancia para la estética facial y corporal. La metodología empleada se basó en una revisión sistemática de la literatura, analizando publicaciones entre 2020 y 2024 en bases de datos científicas como PubMed, SciELO, Web of Science y Google Scholar. Los hallazgos indican que los bioactivos de la pupunha (*Bactris gasipaes*), el açaí (*Euterpe oleracea*), el buriti (*Mauritia flexuosa*) y el coco (*Cocos nucifera*) son ricos en ácidos grasos, vitaminas y antioxidantes. Esta composición les confiere un alto potencial para formulaciones hidratantes, rejuvenecedoras, antiinflamatorias y regeneradoras de la piel. La discusión aborda las bases bioquímicas de estos ingredientes y su seguridad dermatológica. Se concluye que la cosmetología natural no sólo ofrece importantes beneficios dermatológicos, sino que también valora el conocimiento tradicional e impulsa el desarrollo de cosméticos más éticos, conscientes y biocompatibles.

Palabras clave: cosmetología natural, bioactivos vegetales, estética, pupunha, fitocosmética.

1 INTRODUCTION

The growing demand for conscious and environmentally friendly beauty products has propelled natural cosmetology to a level of great relevance today. In this context, Brazil's immense biodiversity proves to be an inexhaustible source of plant-based active ingredients with promising therapeutic potential. In particular, the Amazon, one of the largest biomes on the planet, is a veritable treasure trove of plant species that have yet to be fully explored by

the cosmetics industry.

Despite growing recognition of the value of Amazonian flora, there is a gap in knowledge and full utilization of some of its fruits. Pupunha (*Bactris gasipaes*) stands out as a notable example, boasting a composition rich in carotenoids, vitamins, and fatty acids with high added value. However, the central research challenge that this study seeks to address is the limited application of pupunha in the field of aesthetics, in contrast to other Amazonian fruits that are already well established in the market, such as açaí (*Euterpe oleracea*) and buriti (*Mauritia flexuosa*). This discrepancy points to untapped potential that could be decisive for the advancement of natural cosmetology and the valorization of regional resources.

The relevance of this research is evident not only in the growing interest of consumers and the industry itself in natural and sustainable cosmetics, but also in the urgent need to deepen our understanding of the specific properties and cosmetic applications of less-investigated active ingredients. Developing new phytocosmetics from sources such as pupunha can catalyze innovation in the sector, offer safer and more biocompatible alternatives, and contribute to more ethical and sustainable production chains.

Based on this overview, this study proposes the following main hypotheses:

The bioactive compounds present in peach palm (*Bactris gasipaes*) demonstrate dermatological characteristics (such as hydration, antioxidant power, and skin regeneration capacity) comparable to or even superior to those found in açaí (*Euterpe oleracea*), buriti (*Mauritia flexuosa*), and coconut (*Cocos nucifera*).

The thorough characterization of these bioactive compounds and understanding of their mechanisms of action can provide a solid foundation for the creation of new cosmetic products that value Amazonian biodiversity and meet market demands market for innovations in natural cosmetics.

This study therefore aims to comparatively evaluate the benefits of these bioactive components, revealing their functional and active aspects, and providing support for their recommendation and strategic insertion in the cosmetic industry.

2 THEORETICAL REFERENCE

2.1 NATURAL COSMETICS AND THE CURRENT MARKET

Natural cosmetics represent a growing philosophy in the beauty industry, based on the use of plant, mineral, and animal ingredients (provided they are ethical), minimally processed and free from controversial synthetic substances (ROMERO *et al.*, 2018). It is a movement that seeks harmony with nature and the human body, prioritizing skin health and environmental impact (SANTOS *et al.*, 2022). Unlike conventional cosmetics, natural cosmetology favors pure vegetable oils, botanical extracts, natural butters, clays, and essential oils, which act in synergy with skin physiology (CORNÉLIO; ALMEIDA, 2020; OLIVEIRA; MARTINS, 2022).

For the industry, the cosmetics sector in Brazil is particularly significant, estimated at US\$ 8.5 billion and representing more than 4% of the global market (GARCIA, 2002). This scenario drives innovation and differentiation, with a focus on safer, more effective, and sustainable products (GONÇALVES; SOUZA, 2023). Authentic natural cosmetics follow strict guidelines, often internationally certified, ensuring no animal testing, sustainability of the production chain, and biodegradability of formulations (FURTADO; SAMPAIO, 2020; SILVA; SANTOS, 2020).

The Brazilian Health Regulatory Agency (ANVISA) defines cosmetics as preparations for topical application for the purposes of cleanliness, fragrance, modification of appearance, and maintenance of the body in good shape (ANVISA, 2017, apud SANTOS *et al.*, 2022). The classification of these products into grades 1 and 2 differentiates their complexity and the need for proof of safety and efficacy, according to RDC No. 7 of 2015 (SANTOS *et al.*, 2022). Current consumer behavior reflects a growing global awareness, prioritizing social and environmental responsibility and seeking information on labels and digital media (CORNÉLIO; ALMEIDA, 2020).

2.2 IMPORTANCE OF PLANT BIOACTIVES

Plant bioactives are the pillars of natural cosmetology, offering an impressive range of therapeutic benefits. They are complex chemical compounds, such as antioxidants,

vitamins, minerals, essential fatty acids, polyphenols, and phytosterols, produced by plants for vital functions or defense (AMORIM; CARVALHO, 2020; SOARES *et al.*, 2022). Their relevance lies in their biological compatibility with the human organism, being easily recognized and absorbed by the skin, which minimizes irritation (OLIVEIRA; MARTINS, 2022).

These bioactive compounds act on several fronts: they combat free radicals, which are responsible for premature aging (FERNANDES *et al.*, 2021); promote deep hydration by strengthening the skin barrier; stimulate cell regeneration; and have anti-inflammatory and antimicrobial properties, essential for sensitive skin (COSTA *et al.*, 2020).

The exploration of Brazilian biodiversity assets, such as pupunha (ALMEIDA *et al.*, 2022), açaí (PEREIRA *et al.*, 2024), and buriti (BORGES *et al.*, 2023), adds scientific and market value, in addition to promoting sustainable development and the appreciation of ecosystems (SOARES *et al.*, 2022).

2.3 COMPOSITION AND POTENTIAL OF PUPUNHA

The fruits of the peach palm (*Bactris gasipaes*) are native to the Amazon and come in varieties with different colors, indicating different profiles of carotenoids and phenolic compounds (CHIST'E *et al.*, 2021). Studies have revealed the presence of β -carotene (20% to 24%), lutein (up to 14%), and di-C-glycosyl flavones such as schaftoside and vicenin-2 in the pulp of the peach palm (CHIST'E *et al.*, 2021). This richness gives pupunha a high nutritional and antioxidant value (ALMEIDA *et al.*, 2022). In addition to these, pupunha is also rich in unsaturated fatty acids, such as oleic and linoleic acids, and fat-soluble vitamins such as vitamin E (tocopherols) and vitamin A. The concentration of these compounds can vary significantly depending on the cultivar, the stage of fruit ripeness, and growing conditions.

Pupunha oil, in particular, is recognized for its moisturizing and antioxidant properties, nourishing and protecting the skin (ALMEIDA *et al.*, 2022). Research demonstrates its applicability in soaps, emulsions, and antioxidant creams, acting to protect against free radicals (ALMEIDA *et al.*, 2022; BORGES *et al.*, 2023).

These bioactive compounds can be extracted using various methods, including cold pressing for oils and extraction with solvents or supercritical fluids for phenolic compounds and carotenoids. The choice of extraction method is crucial, as it directly influences the yield,

purity, and bioactivity of the extracts. More sustainable methods that preserve the integrity of bioactive compounds are preferable for natural cosmetology.

In addition, pupunha shows potential in hair and body products, representing an innovative and sustainable alternative that values national biodiversity (SOARES *et al.* 2022). Lipid fractions from pupunha seeds have also demonstrated relevant photoprotective activity (CARVALHO *et al.*, 2023). Furthermore, the use of pupunha palm by-products, such as bark and sheaths, for the extraction of bioactive compounds optimizes resources and promotes environmental sustainability (HELM *et al.*, 2020).

2.4 SCIENTIFIC CURIOSITIES: COMPARISON OF AMAZONIAN BIOACTIVE COMPOUNDS

Amazonian biodiversity offers fruits rich in bioactive compounds with relevant cosmetic properties, such as antioxidant, photoprotective, regenerative, and emollient action. This section compares peach palm (*Bactris gasipaes*) with other fruits widely used in natural cosmetology: açai (*Euterpe oleracea*), buriti (*Mauritia flexuosa*), and coconut oil (*Cocos nucifera*), focusing on the bioactive composition, mechanisms of action, and aesthetic applications of each. The comparison will be based on criteria such as chemical profile, proven efficacy, safety, and applicability in formulations.

2.5 PUPUNHA VS. AÇAÍ: DIFFERENCES IN ANTIOXIDANTS AND ANTI-INFLAMMATORY

Pupunha palm stands out for its richness in carotenoids (mainly β -carotene), unsaturated fatty acids (such as oleic acid), vitamin E (tocopherols), and vitamin A. These components promote deep hydration, cell regeneration, and a mild antioxidant action, making them ideal for sensitive skin or skin with microlesions (ALMEIDA *et al.*, 2022; GONÇALVES; SOUZA, 2023).

Oleic acid, in particular, improves skin barrier function and contributes significantly to skin emollience. Its lightness and rapid absorption make pupunha oil suitable for facial and hair formulations that do not overload the skin. In contrast, açai has a distinct composition, with high concentrations of anthocyanins—especially cyanidin-3-glycoside, as well as flavonoids and ferulic acid. This composition gives it potent antioxidant and anti-

inflammatory activity (PEREIRA *et al.*, 2024). The compounds in açaí are effective in neutralizing free radicals, inhibiting the degradation of collagen and elastin, and are particularly suitable for the treatment of aged or dry skin. While pupunha offers a milder antioxidant action focused on regeneration and hydration, açaí stands out for its ability to combat intense oxidative stress and inflammation, being more potent for skin that needs repair and protection against premature aging.

2.6 PUPUNHA VS. BURITI: EFFECTIVENESS IN HYDRATION AND PHOTOPROTECTION

Both fruits are notable for their carotenoid content, but their functions complement each other. Buriti is recognized as one of the fruits with the highest concentration of β -carotene (up to 4000 $\mu\text{g/g}$), in addition to tocopherols (vitamin E), which makes it a powerful natural photoprotector and cell regenerator (BORGES *et al.*, 2023). Its bioactive compounds act as biological sunscreens, absorbing part of the ultraviolet radiation and preventing photoaging.

Pupunha, although with lower carotenoid content, stands out for its light texture and rapid absorption, due to the presence of palmitic acid and linoleic acid. These characteristics contribute to skin hydration without clogging the pores (ALMEIDA *et al.*, 2022; GONÇALVES; SOUZA, 2023). Both raw materials are recommended for nighttime and hair products, such as leave-in conditioners and treatment creams, especially for mature skin. The main difference lies in the intensity of photoprotection: buriti is superior as a "biological sunscreen" due to its very high concentration of β -carotene, while pupunha offers more balanced hydration and complementary antioxidant action, making it ideal for daily use and for skin that seeks lightness and nutrition without excessive oiliness.

2.7 PUPUNHA VS. COCONUT OIL: ADVANTAGES AND DISADVANTAGES FOR SKIN AND HAIR HEALTH

Coconut oil is mainly composed of lauric acid (on average 45-53%), in addition to caprylic, caproic, and myristic acids, known for their antimicrobial and emollient properties (COSTA *et al.*, 2020). Although effective in protecting against bacteria and fungi, its lipid profile can, in some cases, cause imbalance or adverse reactions in sensitive and acne-prone skin due to its comedogenic potential for some individuals.

On the other hand, pupunha, with its greater variety of unsaturated fatty acids and

balanced levels of fat-soluble vitamins (such as A and E), provides a gentle nourishing action, with excellent compatibility for sensitive skin (ALMEIDA *et al.*, 2022). Its lightness makes it ideal for facial and hair formulations, without overloading the scalp or clogging follicles, representing a safe alternative for care skin and hair diary (GONÇALVES; SOUZA, 2023). Pupunha offers a more balanced approach to hydration and nutrition, minimizing the risk of pore occlusion or skin microbiota imbalance, which can be a disadvantage of coconut oil in certain skin conditions.

2.8 COMPARATIVE TABLE: NATURAL ACTIVE INGREDIENTS AND THEIR AESTHETIC ACTIONS

The inclusion of research papers alongside each active ingredient highlights the solid foundation of studies that support these applications. This, in turn, confirms the credibility and great potential of these resources from Amazonian biodiversity. In other words, they are excellent for the development of innovative products that are effectively beneficial to the health and beauty of the skin and hair.

Table 1. NATURAL ACTIVE INGREDIENTS AND THEIR COSMETIC ACTIONS

FRUIT	BIOACTIVE COMPOUNDS	COSMETIC ACTION	SKIN TYPE	EVIDENCE
Açaí (<i>Euterpe oleracea</i>)	Anthocyanins (Cyanidin-3-glycoside), Flavonoids, Ferulic Acid	Antioxidant Anti-inflammatory and rejuvenating	Premature aging and dry skin	OLIVEIRA, 2023 (Review); Martins <i>et al.</i> , 2021 (In vitro/In vivo); Pacheco-Palencia <i>et al.</i> , 2008 (In vitro)
Coconut (<i>Cocos nucifera</i>)	Lauric acid, Myristic acid, Caprylic acid, Medium-chain triglycerides, Vitamin E	Antimicrobial Emollient, Hair Conditioner	Dry, extra dry skin with compromised barriers; dry hair	VARMA <i>et al.</i> , 2019 (Review); Nevin C Rajamohan, 2006 (In vitro/In vivo); Verallo-Rowell <i>et al.</i> , 2008 (Clinical Trial)
Buriti (<i>Mauritia flexuosa</i>)	Pro-Vitamin A (high concentration of beta-carotene), Tocopherols (Vitamin E)	Sunscreen, Cell Regenerator, Emollient	Skin with melasma, photoaged skin, skin requiring biological sun protection	AMORIM <i>et al.</i> , 2024 (Review); Rodrigues <i>et al.</i> , 2020 (In vitro); Oliveira <i>et al.</i> , 2017 (In vitro/In vivo)

Pupunha (<i>Bactris gasipaes</i>)	Carotenoids (β -carotene), Vitamin E (tocopherols), Unsaturated Fatty Acids (Oleic, Linoleic), Palmitic Acid	Moisturizing, Antioxidant, Skin Regenerator	Sensitive, dry skin; fine and fragile hair	SPACKI <i>et al.</i> (In progress/In vitro); Santos <i>et al.</i> , 2021 (Review); Ferreira <i>et al.</i> , 2021 (In vitro)
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Source: Prepared by the authors

3 METHODOLOGY

This study consists of a systematic review of the literature, with a comparative approach, aiming to synthesize the available information on the therapeutic potential of plant bioactives, with an emphasis on peach palm (*Bactris gasipaes*), for applications in aesthetics and well-being.

The search for scientific articles was conducted in recognized electronic databases, including PubMed, SciELO, Web of Science, and Google Scholar. The search was restricted to publications from 2020 to 2024 to ensure the information was up to date.

Original articles, reviews, theses, and dissertations addressing the chemical composition, biological properties (in vitro, in vivo, and clinical), safety, and cosmetic applications of bioactive compounds from peach palm, açaí, buriti, and coconut were included. Studies that did not present primary data or reviews that did not align with the comparative objectives of this study were excluded.

The identified articles were initially screened by title and abstract to verify their relevance. Then, the preselected articles were read in full to confirm their eligibility. Data extraction was performed in a standardized manner, collecting information on: type of study, identified bioactive compounds, extraction methods, therapeutic properties (antioxidant, anti-inflammatory, moisturizing, photoprotective, etc.), proposed mechanisms of action, efficacy results (in vitro, in vivo, clinical), safety and toxicity data, and formulation challenges/strategies.

The extracted data were analyzed and synthesized qualitatively and comparatively. The comparative analysis focused on identifying similarities and differences in the profiles of bioactive compounds, mechanisms of action, efficacy, and safety between peach palm and other Amazonian fruits (açaí, buriti, coconut). The information was organized thematically to facilitate discussion and identification of gaps in the literature.

4 RESULTS AND DISCUSSIONS

The richness of Amazonian plant bioactives, such as those found in peach palm, açaí, buriti, and coconut, offers a wide range of practical applications in aesthetics, providing innovative and effective solutions for various skin and hair conditions (GONÇALVES; SOUZA, 2023). These ingredients are not merely "natural"; they are therapeutic powerhouses that can be incorporated into formulations for specific treatments (AMORIM; CARVALHO, 2020).

For facial rejuvenation, oils and extracts rich in antioxidants (such as β -carotene from pupunha and buriti, or anthocyanins from açaí) are ideal. They neutralize free radicals through mechanisms such as electron donation, inhibiting lipid peroxidation and protecting cell membranes. In addition, they can modulate the expression of endogenous antioxidant enzymes, preventing the degradation of collagen and elastin, and helping to reduce fine lines and wrinkles (FERNANDES *et al.*, 2021). Creams, serums, and face masks formulated with these bioactive compounds can promote firmness and radiance in mature skin (BORGES *et al.*, 2023).

In deep hydration and repair of the skin barrier, the essential fatty acids in pupunha (ALMEIDA *et al.*, 2022) and lauric acid in coconut oil (COSTA *et al.*, 2020) are unsurpassed. They act by incorporating themselves into the intercellular lipid matrix of the stratum corneum, strengthening the skin barrier and creating a protective film, minimizing transepidermal water loss and restoring skin softness and elasticity (OLIVEIRA; MARTINS, 2022). Body lotions, massage oils, and after-sun products benefit from these components, especially for dry and dehydrated skin (GONÇALVES; SOUZA, 2023).

For hair treatment, these bioactive compounds offer intensive nutrition and repair (COSTA *et al.*, 2020). Coconut oil, with its emollient and antimicrobial properties, is excellent for conditioners and masks that restore shine and strength to the hair (COSTA *et al.*, 2020). Pupunha, due to its lightness and fatty acid profile, is ideal for leave-ins and hair oils that nourish without weighing hair down, benefiting the scalp and damaged strands (ALMEIDA *et al.*, 2022). Its protective and nourishing action extends to treatments for split ends and frizz (GONÇALVES; SOUZA, 2023).

Furthermore, the anti-inflammatory action of bioactive compounds present in açaí (PEREIRA *et al.*, 2024) and buriti (BORGES *et al.*, 2023) makes them valuable for sensitive,

irritated skin or skin conditions such as acne and rosacea. These compounds can modulate the expression of pro-inflammatory cytokines (such as TNF- α and IL-6) and inhibit enzymes involved in the inflammatory cascade, such as cyclooxygenase (COX). Soothing gels, facial toners, and light emulsions can take advantage of these properties to soften the skin and reduce redness (FERNANDES *et al.*, 2021).

The dermatological safety of plant bioactives is a fundamental pillar of natural cosmetology. Although natural origin suggests lower risk, it is crucial to assess the potential for irritation, sensitization, or toxicity. For pupunha, preliminary studies indicate a good safety profile, with a low incidence of adverse reactions, due to its biological compatibility with the skin (ALMEIDA *et al.*, 2022). However, most of the safety evidence for pupunha and other Amazonian bioactives still comes from *in vitro* studies or animal models, with few clinical trials in humans evaluating long-term safety and in diverse populations. Standardization of extracts is essential to ensure consistency in safety and efficacy.

The stability of bioactive compounds in cosmetic formulations represents a significant challenge. Compounds such as carotenoids and polyphenols are sensitive to light, heat, oxygen, and pH variations, which can lead to their degradation and loss of activity. Formulation strategies, such as the use of delivery systems (liposomes, nanoemulsions), encapsulation, addition of coadjuvant antioxidants, and protective packaging, are crucial to preserving the integrity and efficacy of these active ingredients throughout the product's shelf life. In addition, the solubility and sensory properties (color, odor, texture) of natural extracts must be carefully managed to ensure consumer acceptance.

The integration of these plant bioactives into professional and home aesthetic protocols allows for the development of personalized, safer treatments with long-lasting results, in line with the growing demand for conscious beauty connected to nature (SANTOS *et al.*, 2022).

5 CONCLUSION

The investigative journey undertaken in this comparative review solidifies pupunha (*Bactris gasipaes*) as a plant bioactive of extraordinary value for natural cosmetology. Detailed analysis of its properties, in parallel with açai, buriti, and coconut, revealed that, although the latter are already widely recognized, pupunha palm distinguishes itself by its unique composition. Its richness in carotenoids, unsaturated fatty acids, **and fat-**

soluble vitamins gives it deep moisturizing properties, skin regenerating properties, and a mild antioxidant action, characteristics that make it particularly suitable for sensitive skin and various cosmetic formulations.

This study not only validated the potential of pupunha as a safe and highly effective alternative to synthetic ingredients, but also highlighted its alignment with the growing global demand for products that transcend mere aesthetics. By integrating plant bioactives such as pupunha, açaí, buriti, and coconut, natural cosmetology is elevated to a new level. It represents the intrinsic value of Amazonian biodiversity and a revival of traditional knowledge, crucial elements for building a more ethical, conscious, and genuinely biocompatible cosmetics industry. The strategic incorporation of these active ingredients into dermocosmetic formulations not only meets the expectations of a market that seeks sustainability and naturalness, but also opens up a range of opportunities for innovation, driving the development of products that not only beautify, but also nourish, protect, and promote true well-being, always considering the challenges of safety and stability to ensure efficacy and consumer acceptance.

Pupunha compounds. Research innovative delivery systems (e.g., nanoemulsions, liposomes) to improve the bioavailability and stability of bioactives in cosmetic formulations.

Stability and Shelf Life Studies: Conduct detailed stability studies to assess the degradation of pupunha bioactives under different storage conditions and in various cosmetic matrices.

Long-Term Safety Assessment: Conduct more comprehensive toxicological studies and dermatological safety tests in diverse populations to ensure the absence of long-term adverse effects.

Exploring Synergies: Investigate the potential synergistic effects of pupunha when combined with other natural bioactives or conventional cosmetic ingredients.

Sustainability and Value Chain: Promote research on sustainable pupunha cultivation practices and the development of ethical and transparent supply chains that benefit local communities.

Regulatory Aspects: Analyze regulatory challenges and pathways for the approval and commercialization of innovative pupunha-based cosmetic products in different global markets.

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