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Physicochemical stability and antioxidant activity of peel-off and carbomer gels containing ginger and bamboo extracts

Estabilidade físico-química e atividade antioxidante de géis peel-off e de carbômero contendo extratos de gengibre e bambu

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RESUMO

A crescente demanda por cosméticos naturais tem incentivado pesquisas sobre ingredientes ativos botânicos com propriedades antioxidantes. Os extratos de gengibre *(Zingiber officinale)* e bambu *(Bambusa vulgaris)* são candidatos promissores para aplicações cosméticas; no entanto, sua incorporação em formulações requer avaliação adequada da estabilidade e do desempenho funcional. Este estudo teve como objetivo desenvolver e caracterizar géis cosméticos contendo esses extratos vegetais. Os extratos foram incorporados, isolada ou combinadamente, em géis peel-off (à base de PVA) e géis à base de carbômero, os quais foram avaliados quanto à estabilidade físico-química (características organolépticas e pH) e à atividade antioxidante (ensaio de DPPH) no tempo inicial e após 30 dias de armazenamento a 4 °C, 25 °C e 40 °C. Os extratos de gengibre e bambu apresentaram atividades antioxidantes de 4,80 e 6,42 µmol de equivalentes de ácido gálico/g de extrato, respectivamente, determinadas pelo ensaio de DPPH. As formulações de gel peel-off e de gel à base de carbômero preparadas com os extratos apresentaram características organolépticas adequadas. No entanto, apenas os géis à base de carbômero contendo extrato de gengibre, isolado ou combinado com extrato de bambu, apresentaram atividade antioxidante significativa. Em contraste, os géis peel-off à base de PVA não apresentaram atividade antioxidante detectável, sugerindo possível interferência desse veículo polimérico na resposta antioxidante. Embora as formulações tenham demonstrado, de modo geral, estabilidade física adequada, a formulação à base de carbômero contendo os extratos combinados apresentou a maior estabilidade físico-química entre as formulações avaliadas, permanecendo estável por 30 dias em todas as condições de armazenamento (4 °C, 25 °C e 40 °C) embora, diferentemente do gengibre isolado (F6), tenha sido a única formulação que manteve atividade antioxidante detectável nas três condições de armazenamento avaliadas; inclusive a 25 °C, condição em que o F6 não apresentou atividade detectável após 30 dias. De modo geral, esses achados atendem ao objetivo proposto de avaliar o efeito da incorporação dos extratos, isolados ou combinados, em diferentes veículos, e destacam a importância da seleção do excipiente na preservação da estabilidade e do desempenho funcional (antioxidante) das formulações.

Palavras-chave: Antioxidantes; Extratos Vegetais; Fitoterapia; Estabilidade de Medicamentos; Cosméticos

ABSTRACT

The growing demand for natural cosmetics has encouraged research into botanical active ingredients with antioxidant properties. Ginger *(Zingiber officinale)* and bamboo *(Bambusa vulgaris)* extracts are promising candidates for cosmetic

applications; however, their incorporation into formulations requires adequate assessment of stability and functional performance. This study aimed to develop and characterize cosmetic gels containing these plant extracts. The extracts were incorporated, individually or in combination, into peel-off (PVA-based) and carbomer-based gel formulations, which were evaluated for physicochemical stability (organoleptic characteristics and pH) and antioxidant activity (DPPH assay) at baseline and after 30 days of storage at 4 °C, 25 °C, and 40 °C. Ginger and bamboo extracts showed antioxidant activities of 4.80 and 6.42 µmol gallic acid equivalents/g extract, respectively, as determined by the DPPH assay. Peel-off and carbomer-based gel formulations prepared with the extracts exhibited suitable organoleptic characteristics. However, only the carbomer-based gels containing ginger extract, alone or combined with bamboo extract, showed significant antioxidant activity. In contrast, the PVA-based peel-off gels showed no detectable antioxidant activity, suggesting possible interference of this polymeric vehicle with the antioxidant response. Although the formulations generally demonstrated adequate physical stability, the carbomer-based formulation containing the combined extracts showed the greatest physicochemical stability among the formulations evaluated, remaining stable for 30 days under all storage conditions (4 °C, 25 °C, and 40 °C). Unlike the ginger-only formulation (F6), it was the only formulation that retained detectable antioxidant activity under all three storage conditions tested, including 25 °C, where F6 showed no detectable activity after 30 days. Overall, these findings meet the proposed objective of evaluating the effect of incorporating the extracts, individually or in combination, into different vehicles, and highlight the importance of excipient selection in preserving the stability and functional (antioxidant) performance of the formulations.

Keywords: Antioxidants; Plant Extracts; Zingiber officinale; Bambusa; Drug Stability.

INTRODUCTION

Currently, the cosmetics and aesthetics sector occupies a prominent position in the global market, driven by the increasing appreciation of physical appearance and the strengthening of the concept of well-aging. The pursuit of firm, radiant skin with minimal signs of aging is closely associated with perceptions of health, well-being, and self-esteem. In this context, healthy aging involves not only maintaining balanced lifestyle habits but also adopting a consistent skincare routine (Silva; Lima; Siqueira, 2023).

The field of phytocosmetics has increasingly focused on the development of formulations containing plant extracts and their derivatives, particularly because of their potential antioxidant effects. These ingredients may help minimize oxidative damage caused by free radicals, thereby contributing to the prevention of premature expression lines, dark spots, and other skin changes associated with aging. In parallel, consumer interest in products of natural origin has grown significantly for both aesthetic and therapeutic-related applications. This demand has encouraged the development of safer, more effective cosmetic products containing botanical ingredients, aligned with current market trends (Michalak, 2022).

Among promising active ingredients, ginger (*Zingiber officinale*) stands out for its cosmetic potential due to the presence of bioactive compounds with antioxidant and anti-inflammatory properties, which may contribute to protecting the skin against damage associated with oxidative stress and skin aging (Ayustaningwarno et al., 2024). Similarly, bamboo (*Bambusa vulgaris*) is notable for its phenolic compounds and flavonoids, which are associated with recognized antioxidant activity and may help protect the skin against oxidative damage, contributing to a healthier and more revitalized appearance (Gu et al., 2022; Nirmala et al., 2018). In this context, the combination of two or more plant extracts in cosmetic formulations represents a promising strategy, as their bioactive compounds may act in a complementary or synergistic manner, supporting antioxidant activity, collagen synthesis, cell renewal, and the maintenance of skin health (Michalak, 2023)

The development of cosmetic formulations with

antioxidant activity requires robust methodologies to ensure the stability, safety, and skin compatibility of the final product (Desai; Mhaskar, 2019; Hoang; Moon; Lee, 2021) Therefore, the selection of botanical active ingredients with well-established properties, as well as suitable vehicles that preserve their functional performance, is essential. Ginger extract, for example, has documented activity in topical products, including emulgels and hydrogels aimed at pain control, inflammation reduction, and wound healing, reinforcing its potential as a source of natural antioxidants for cosmetic applications (Desai; Mhaskar, 2019).

Although the individual benefits of these extracts are well described, the investigation of the potential synergy between *Zingiber officinale* and *Bambusa vulgaris* in specific gelled systems remains underexplored, representing a relevant opportunity for innovation in cosmetic formulation. Thus, this study aimed to evaluate the effect of incorporating these extracts, either individually or in combination, into two distinct vehicles: a carbomer-based gel, formulated with a crosslinked anionic acrylic polymer widely used in dermocosmetics because of its rheological properties and ability to deliver active ingredients; and a peel-off gel formulated with carbomer and polyvinyl alcohol (PVA), a water-soluble synthetic polymer capable of forming a film after drying (Nishikawa et al., 2007; Ozon et al., 2025). Specifically, although the antioxidant potential of ginger and bamboo extracts has been reported individually, no previous study, to our knowledge, has directly compared their incorporation—alone or combined—into both a peel-off and a carbomer-based vehicle within the same experimental design, which is the specific gap this study addresses.

It should be emphasized from the outset that antioxidant activity in this study was assessed exclusively through the DPPH chemical assay, which measures in vitro free-radical-scavenging capacity; these results do not, by themselves, demonstrate biological antioxidant efficacy in skin, nor anti-aging, photoprotective, or anti-inflammatory effects, which would require cell-based or in vivo evaluation.

METHODS

Preparation of the formulations

Dry ginger and bamboo extracts, purchased from Florien Fitoativos (Piracicaba, São Paulo, Brazil), were incorporated, either individually or in combination, into peel-off gel and carbomer-based gel formulations (Table 1). To prepare the formulations, the extracts were first levigated with glycerin and subsequently added to the previously prepared gel bases. The formulations were then homogenized until complete dispersion and uniform distribution of the active ingredients.

The initial stability of the formulations was evaluated by centrifugation and thermal stress testing. For the centrifugation assay, the samples were centrifuged at 3,000 rpm for 30 min. For the thermal stress assay, the temperature was gradually increased from 40 °C to 80 °C, with each temperature maintained for 30 min, in order to assess the preliminary stability and viability of the formulations (ANVISA, 2004).

Table 1 – Qualitative and quantitative composition of the formulations

INCI* ingredient	Formulation							
	F1	F2	F3	F4	F5	F6	F7	F8
Disodium EDTA	0.1							
Carbomer	0.8							
Aqua qsp	100							
Methylparaben	0.15							
Aminomethylpropanol	qs pH 5.0 - 6.0							
Polyvinyl Alcohol	7.0	7.0	7.0	7.0	-	-	-	-
Zingiber officinale extract	-	2.0	-	2.0	-	2.0	-	2.0
Bambusa vulgaris extract	-	-	5.0	5.0	-	-	5.0	5.0

*International Nomenclature of Cosmetic Ingredients. All values are expressed as % (w/w) of the final formulation, except where indicated (e.g., 'qs pH 5.0-6.0' for the pH-adjusting agent, and 'qsp 100' for water, added to complete the formulation to 100% w/w).

Legend: F1–F4, peel-off gels; F5–F8, Carbopol® 940 gels; (-), absence of the ingredient.

Preliminary stability assessment

The formulations were subjected to a preliminary stability study by storing the samples under different temperature conditions: 4.0 ± 2.0 °C, 25.0 ± 2.0 °C, and 40.0 ± 2.0 °C, for 30 days. Physical instability, assessed by changes in organoleptic characteristics; chemical instability, assessed by pH variation; and functional instability, assessed by antioxidant activity, were evaluated comparatively at the initial time point (T_0) and after 30 days (T_{30}), according to methodologies described in the literature (ANVISA, 2004).

pH determination

The pH of the samples was determined by potentiometry after dispersion in distilled water at 10% w/v under magnetic stirring for 15 min. A pH range of 4.5 to 6.2 was adopted as the stability criterion. This range is consistent with the natural skin surface pH, which in healthy skin averages below 5 (approximately 4.5–5.9) (Lambers et al., 2006), and follows the stability-monitoring framework described in the Anvisa Cosmetic Stability Guide (ANVISA, 2004).

Antioxidant activity assessment

The antioxidant activity of ginger and bamboo extracts, as well as that of the formulations, was evaluated using the DPPH assay (2,2-diphenyl-1-picrylhydrazyl).

For the formulations, 1.0 g of each sample was dispersed in 5.0 mL of absolute ethanol using a vortex mixer. The suspensions were then subjected to an ultrasonic bath for 10 min to ensure complete dispersion and subsequently centrifuged at 3,000 rpm for 15 min. After centrifugation, 2.5 mL of the

supernatant was transferred to a 10 mL volumetric flask, and the volume was made up to volume with absolute ethanol. Aliquots of 0.5 mL of these solutions were mixed with 2.5 mL of ethanolic DPPH solution (100 µM). After 30 min of incubation in the dark, absorbance was measured at 517 nm, using absolute ethanol as the blank. The negative controls were prepared from the base formulations, peel-off gel (F1) and carbomer-based gel (F5), following the same procedure described above, and mixed with DPPH solution (100 µM) at the same proportion.

For ginger and bamboo extracts, 0.2 g of each extract was added to 5.0 mL of absolute ethanol, following the same dispersion protocol used for the formulations. The reaction negative control consisted of 0.5 mL of absolute ethanol added to 2.5 mL of DPPH solution.

The percentage of DPPH radical inhibition was calculated according to Equation 1, and antioxidant activity was expressed as gallic acid equivalents per gram of formulation or per gram of extract. For this purpose, an analytical curve was constructed using gallic acid as the reference standard, at concentrations ranging from 2 to 12 µg/mL in absolute ethanol, after reaction with DPPH solution (100 µM), following the methodology described above (Figure 1). From this curve, a linear equation correlating gallic acid concentration with the percentage of DPPH radical inhibition was obtained ($y = 0.9027x + 3.9398$, where y represents the percentage of free radical scavenging and x represents the gallic acid concentration (µM); $R^2 = 0.9909$) (Brand-Williams; Cuvelier; Berset, 1995). Antioxidant activity was determined in triplicate at the initial time point (T_0) and after 30 days of storage (T_{30}). It should be noted that expressing DPPH radical-scavenging activity as gallic acid equivalents provides a comparative measure of antioxidant capacity relative to a reference standard, and should not be interpreted as a direct quantification of the total phenolic content of the extracts or formulations, which would require a dedicated assay (e.g., Folin-Ciocalteu).

$$\text{DPPH radical inhibition (\%)} = [(\text{AbsA} - \text{AbsAm}) / \text{AbsA}] \times 100 \qquad (1)$$

Legend: AbsA is the absorbance of the negative control and AbsAm is the absorbance of the sample.

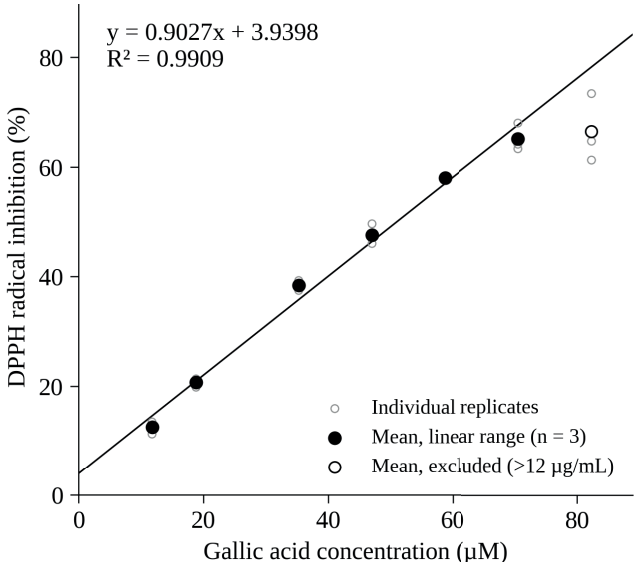


Figure 1. Analytical curve for gallic acid, correlating standard concentration (µM) with DPPH radical inhibition (%). Filled circles: mean values (n = 3) within the linear range (2-12 µg/mL) used for the regression ($y = 0.9027x + 3.9398$; $R^2 = 0.9909$); open circles: individual replicates; unfilled circle: mean at 14 µg/mL, outside the linear range and excluded from the fit.

Statistical analysis

Data were expressed as mean ± standard deviation from three independent determinations. Statistical comparisons were performed using one-way analysis of variance (ANOVA), followed by Tukey's post hoc test when applicable. Differences were considered statistically significant at $p \leq 0.05$. The three determinations per formulation/condition corresponded to independent preparations of each formulation, not analytical replicates of a single preparation. In addition to the per-condition one-way ANOVA described above, a two-way ANOVA (formulation × storage condition, with interaction) was performed on the pooled T0/T30 dataset for the carbomer-based gels (F6, F7, F8) to test whether the effect of formulation on antioxidant activity depended on the storage condition.

RESULTS

The carbomer-based gel containing ginger and bamboo extracts, either individually or in combination, was characterized as a low-viscosity, homogeneous formulation with a translucent to slightly yellowish appearance, depending on the incorporated extract. The formulations were odorless and showed pH values ranging from 5.0 to 6.2.

The peel-off gel, formulated with carbomer and polyvinyl alcohol and containing the same extracts, either individually or in combination, showed a viscous texture and adequate homogeneity. The formulation exhibited a cloudy appearance, an intrinsic feature of the developed system, and its color ranged from whitish to yellowish, depending on the incorporated extract. It remained odorless and showed an approximate pH of 5.0. Film formation occurred within approximately 20 to 25 min. After application, a continuous and removable film was formed.

After centrifugation, the peel-off and carbomer-based gel formulations containing ginger and bamboo extracts, either individually or in combination, remained physically stable, with no evidence of phase separation, color change, or precipitate formation. Similarly, during the thermal stress assay, in which the samples were exposed to temperatures ranging from 40 °C to 80 °C, no macroscopic changes were observed after exposure to the evaluated conditions, including lump formation, color or odor changes, precipitate formation, or phase separation.

After 30 days of evaluation, the formulations showed no signs of physical instability, such as changes in appearance, color, or odor (Figure 2). The pH values ranged from 5.0 to 6.2, remaining within the skin-compatible pH range under all three storage conditions evaluated: 4.0 ± 2.0 °C (refrigeration), 25.0 ± 2.0 °C (room temperature), and 40.0 ± 2.0 °C (oven).

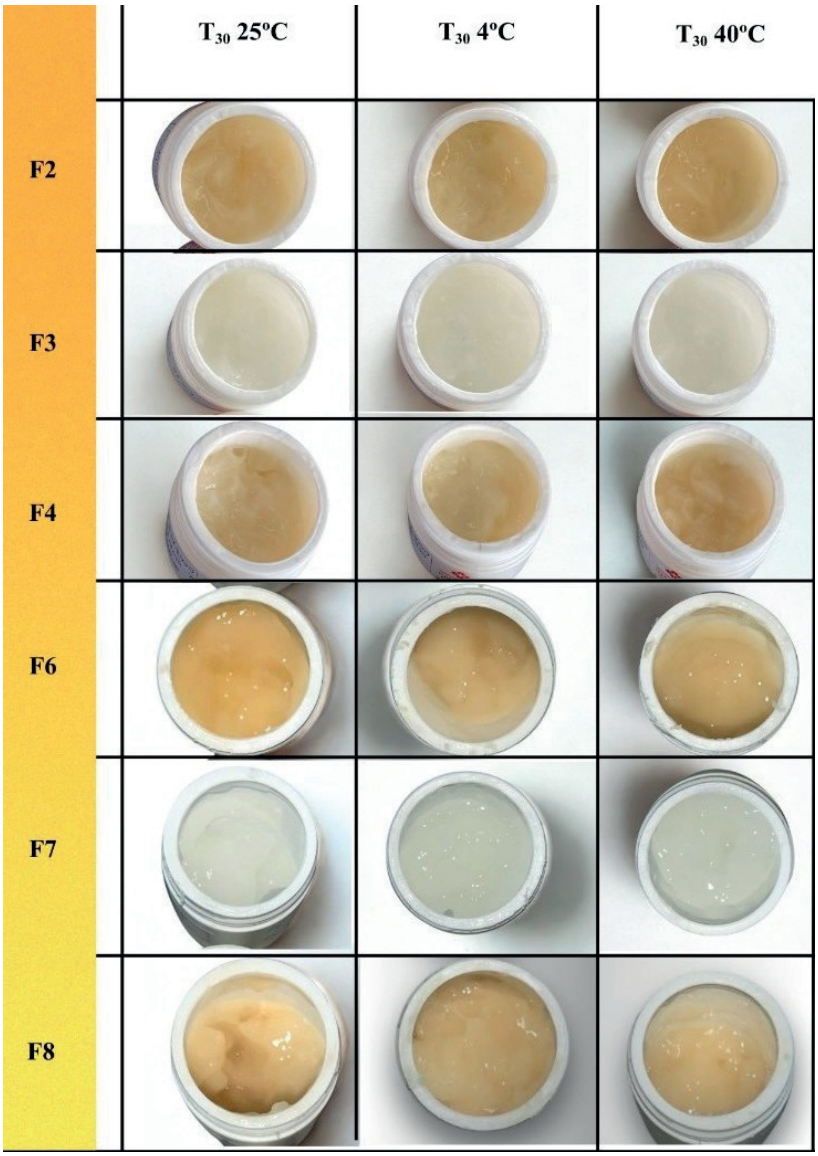


Figure 2. Appearance of the formulations after 30 days of preliminary stability testing under different storage conditions.

Legend: F2: peel-off gel containing ginger extract; F3: peel-off gel containing bamboo extract; F4: peel-off gel containing ginger and bamboo extracts; F6: Carbomer-based gel containing ginger extract; F7: Carbomer-based gel containing bamboo extract; F8: Carbomer-based gel containing ginger and bamboo extracts.

The DPPH assay showed that ginger extract exhibited antioxidant activity of 4.80 µmol gallic acid equivalents/g of extract, whereas bamboo extract showed a higher value of 6.42 µmol gallic acid equivalents/g of extract.

At the initial time point (T_0), the highest antioxidant activity was observed in the carbomer-based gel formulations containing ginger extract (F6) and the combination of ginger and bamboo extracts (F8) (F6 = 13.96 ± 7.37; F8 = 22.13 ± 5.18 µmol gallic acid equivalents/g formulation), both with statistically significant results ($p \leq 0.05$). The formulation containing only bamboo extract (F7) did not show measurable antioxidant activity (F7 = -2.26 ± 2.73 µmol gallic acid equivalents/g formulation, a mean statistically indistinguishable from zero), as shown in Figure 3.

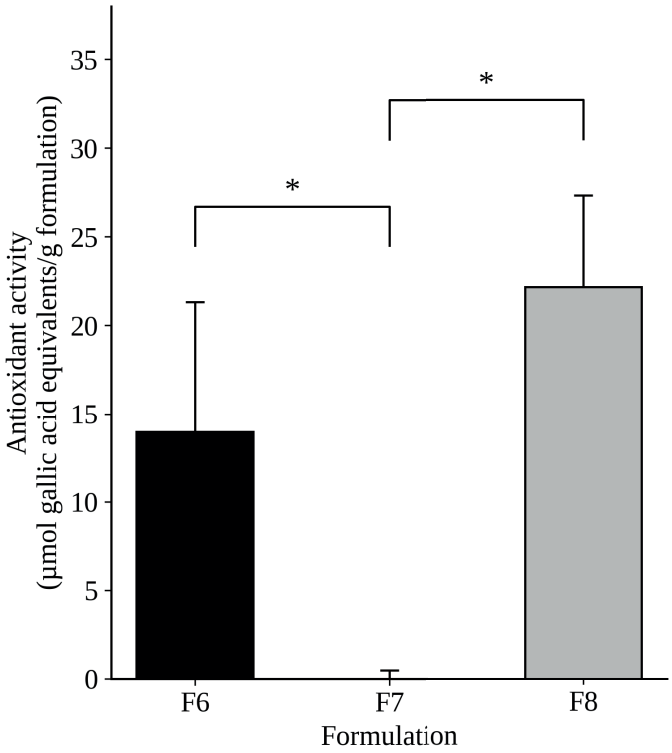


Figure 3. Initial antioxidant activity (T_0) of the carbomer-based gel formulations.

Legend. Ginger extract (F6), bamboo extract (F7), and the combination of ginger + bamboo extracts (F8). Values are expressed as gallic acid equivalents (µmol/g of formulation) ± standard deviation. *p ≤ 0.05.

After 30 days of storage at room temperature, under refrigeration, and in an oven, the formulations containing ginger and/or bamboo extracts were reassessed for antioxidant activity. Only the carbomer-based gel containing the combined extracts (F8) maintained significant antioxidant activity ($p \leq 0.05$) under all three storage conditions evaluated. (F8 = 24.82 ± 9.19 at 4 °C; 24.30 ± 4.50 at 25 °C; 22.37 ± 10.17 at 40 °C, µmol gallic acid equivalents/g formulation). The formulation containing ginger alone (F6) retained significant activity at 4 °C and 40 °C but showed no detectable activity at 25 °C after 30 days. (F6 = 36.02 ± 6.52 at 4 °C; 22.98 ± 6.87 at 40 °C; -7.53 ± 2.45 at 25 °C, µmol gallic acid equivalents/g formulation, statistically indistinguishable from zero). A direct statistical comparison between T0 and T30 within each formulation was not performed in the present analysis; this should be considered in future statistical treatments to more directly support the claim that antioxidant activity was "maintained" after storage. Although the bamboo extract itself showed antioxidant activity, formulation F7 showed values statistically indistinguishable from zero (Figure 4). In contrast, the peel-off formulations containing the bioactive extracts did not exhibit detectable antioxidant activity, regardless of the extract incorporated or storage time. A two-way ANOVA (formulation × storage condition) performed on the pooled T0/T30 dataset for the carbomer-based gels confirmed a statistically significant formulation × condition interaction ($F(6, 24) = 9.16$, $p < 0.0001$), in addition to significant main effects of formulation ($F(2, 24) = 53.82$, $p < 0.0001$) and storage condition ($F(3, 24) = 10.95$, $p = 0.0001$), indicating that the effect of formulation on antioxidant activity was not uniform across storage conditions.

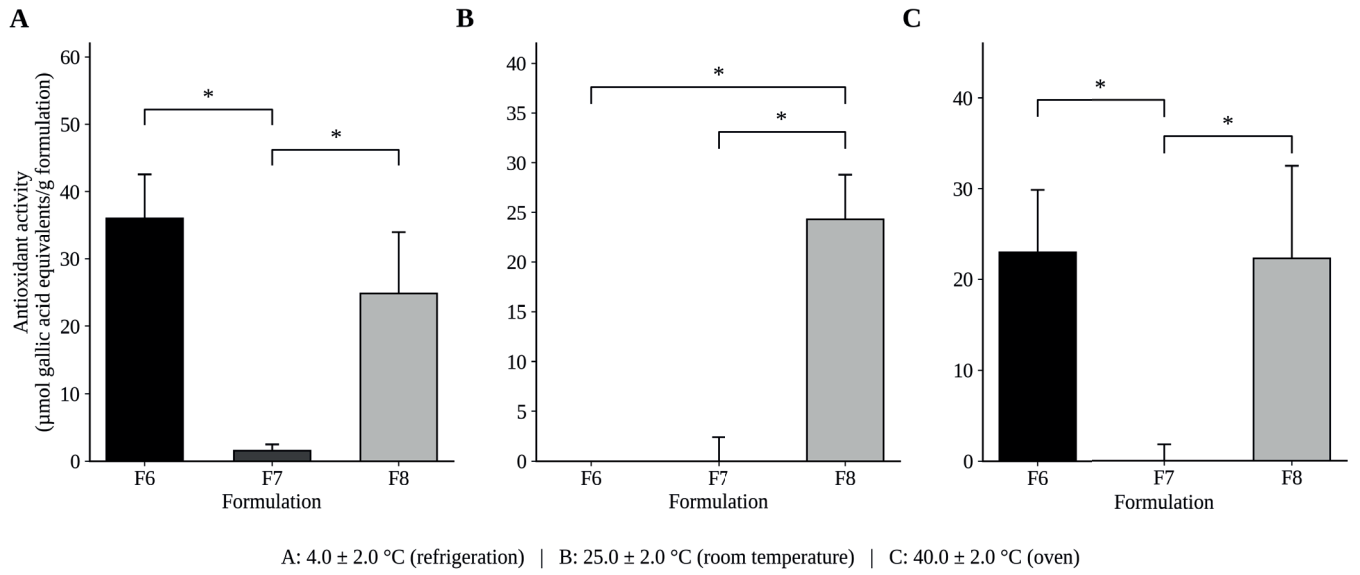


Figure 4. Antioxidant activity of carbomer-based gel formulations after 30 days of storage (T_{30}) at 4 °C (refrigeration), 25 °C (room temperature), and 40 °C (oven).

Legend. Formulations containing ginger extract (F6), bamboo extract (F7), and the combination of ginger and bamboo extracts (F8). Values are expressed as gallic acid equivalents (µmol/g of formulation) ± standard deviation. *p ≤ 0.05.

The peel-off gel formulations (F1-F4) were also evaluated at T0; unlike the carbomer-based gels, all peel-off formulations showed negative or near-zero DPPH values, indicating no detectable antioxidant activity regardless of the extract incorporated (F1 = -23.66 ± 18.29; F2 = -6.91 ± 8.25; F3 = -25.51 ± 4.74; F4 = -2.90 ± 9.12 µmol gallic acid equivalents/g formulation; one-way ANOVA, p = 0.088, no significant differences among peel-off formulations), as shown in Figure 5.

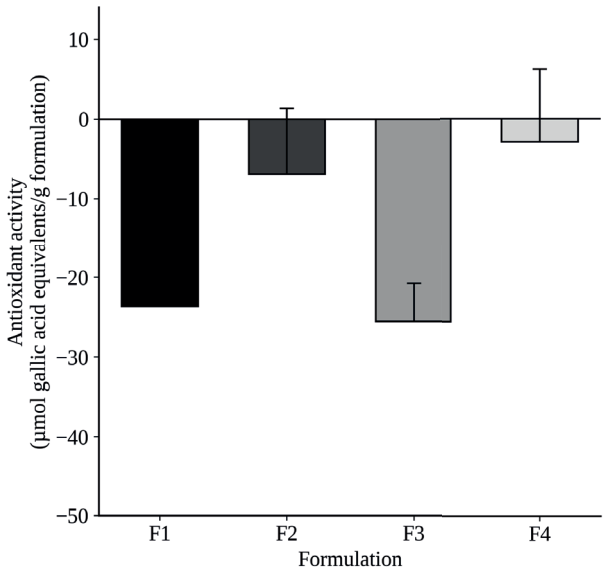


Figure 5. Antioxidant activity (T0) of the peel-off gel formulations.

Legend. F1: peel-off gel base (no extract); F2: peel-off gel containing ginger extract; F3: peel-off gel containing bamboo extract; F4: peel-off gel containing ginger and bamboo extracts. Values are expressed as gallic acid equivalents (µmol/g of formulation) ± standard deviation; negative values indicate no detectable radical-scavenging activity relative to the negative control. One-way ANOVA: p = 0.088 (no significant differences among formulations).

DISCUSSION

A key finding of this study was that vehicle selection influenced not only the incorporation of natural extracts, but also the preservation of their functional activity in cosmetic formulations. In this context, the carbomer-based gel was shown to be a suitable vehicle for ginger extract, as it maintained significant antioxidant activity after incorporation. This finding is consistent with Desai; Mhaskar (2019), who developed a carbomer-based emulgel containing *Zingiber officinale* and reported relevant antioxidant activity, attributed to the presence and stabilization of phenolic compounds, particularly gingerols and shogaols, within the polymeric system. The suitability of Carbopol® as a gelling agent for topical formulations containing botanical extracts has also been reported by Vispute; Yadav (2024), supporting its potential as a vehicle for bioactive compounds. The low-viscosity, homogeneous appearance observed for the carbomer-based gel in this study is consistent with other Carbopol-based formulations characterized in the literature (Ozon et al., 2025). The pH values recorded for both vehicles (5.0-6.2) are consistent with the expected physicochemical characteristics of anionic gel systems and remained compatible with the skin pH range throughout the 30-day evaluation, with no marked changes in pH observed under the storage conditions tested. This pattern was further confirmed by a two-way ANOVA on the carbomer-based gels, which detected a significant formulation × storage-condition interaction ($F(6, 24) = 9.16$, $p < 0.0001$), indicating that formulation identity and storage condition jointly, rather than independently, determined the antioxidant response — consistent with the condition-specific loss of activity observed for F6 at 25 °C and the comparatively stable performance of F8 across all conditions tested.

In contrast, the lack of detectable antioxidant activity in the formulation containing bamboo extract alone in the carbomer-based vehicle (F7) is noteworthy, especially considering the antioxidant activity observed for the pure extract. This result may be related to interactions between bamboo-derived polyphenols and components of the gel matrix, which could reduce the availability of antioxidant compounds in the ethanolic phase used for the DPPH assay. Given the anionic character and crosslinked structure of carbomer, interactions with phenolic constituents cannot be ruled out; however, this mechanism was not directly investigated in the present study. Therefore, this interpretation should be considered a hypothesis that requires further confirmation using complementary analytical approaches. This possibility is consistent with Nirmala et al. (2018), who highlighted the chemical complexity of bamboo polyphenols and indicated that their bioavailability and activity may be influenced by interactions with other matrix components.

One of the most relevant aspects of this study was the evaluation of the combined extracts in formulation F8. Contrary to the initial expectation of a synergistic or additive effect, the antioxidant activity of F8 was generally comparable to that of the formulation containing ginger alone (F6), and in some conditions, such as refrigerated storage, it was lower. Notably, at 25 °C, F6 showed no detectable antioxidant activity after 30 days of storage, whereas F8 retained significant activity under this same condition; this indicates that, although F8 did not exceed F6 in magnitude whenever F6 was active, F8 was the only formulation that preserved antioxidant activity consistently across all three storage temperatures evaluated. These results do not support the occurrence of a clear synergistic antioxidant effect between ginger and bamboo extracts under the experimental conditions evaluated. Instead, they suggest that interactions between the extracts or between the extracts and the formulation matrix may have influenced the antioxidant response. Although antagonistic interactions among phytochemical mixtures have been reported in the

literature (Kaur; Kaur; Sirhindi, 2017), the present data are not sufficient to define the mechanism involved. Therefore, the possibility of antagonism should be interpreted cautiously and investigated in future studies using complementary assays and chemical characterization of the extract mixtures.

Although formulation F8 did not show evidence of antioxidant synergy, its behavior under different storage conditions suggests that the combined system remained physicochemically stable. The antioxidant response observed for F8 appears to be mainly associated with the presence of ginger extract, since the formulation containing ginger alone also maintained significant activity. However, at 25 °C, only the combined formulation (F8) retained detectable antioxidant activity, while the ginger-only formulation (F6) did not; this suggests that the presence of bamboo extract may have contributed to stabilizing antioxidant performance under this specific storage condition, rather than acting merely as a neutral component. Further studies are needed to determine whether the components of ginger and bamboo interact with each other or with the carbomer-based matrix in a way that affects antioxidant availability.

The favorable performance of the carbomer-based vehicle is consistent with reports in the scientific literature. For instance, Akhter et al. (2024) showed that nanoemulsion gels formulated with Carbopol® 940 maintained high antioxidant activity and improved topical performance. Similarly, Ji et al. (2024), in a study evaluating the glycolic extract of *Mangifera indica* L. var. Tommy Atkins peel, reported that a carbomer-based gel preserved antioxidant activity more effectively than Estagel® gel and gel-cream formulations after storage under different thermal conditions. Taken together, these findings support the relevance of the excipient as an active formulation factor that may influence the stability and functional performance of botanical extracts.

In sharp contrast, formulation F4, corresponding to the peel-off gel, exhibited poor performance in the DPPH assay. The atypical results, including negative antioxidant activity values, suggest possible interference of the formulation matrix with the analytical response. This behavior may be associated with the presence of PVA and with the physical characteristics of the peel-off system, which may have affected extract dispersion or interfered with the interaction between antioxidant constituents and the DPPH radical. However, because matrix interference was not specifically investigated, this explanation should be interpreted as a hypothesis. These results indicate that the peel-off gel was not a suitable vehicle for preserving or detecting antioxidant activity under the experimental conditions used in this study. The viscous texture and adequate homogeneity observed for the peel-off gel are nonetheless consistent with previous reports on PVA-based polymeric systems for topical applications (Asthana et al., 2021).

Overall, the statistically significant differences observed among the formulations ($p \leq 0.05$) indicate that the antioxidant response depended on both the incorporated extract and the vehicle used. Although combinations of plant extracts may enhance antioxidant activity through synergistic interactions, as reported by Kaur et al. (2022), this effect was not clearly observed in the present study. Synergism in phytochemical mixtures is commonly attributed to complementary mechanisms involving different bioactive compounds acting on multiple oxidative pathways. Sonam; Guleria (2017) described antioxidant regeneration as one possible mechanism, in which one compound may restore the antioxidant capacity of another after radical neutralization. However, the occurrence of this mechanism in the formulations evaluated here remains hypothetical and should be investigated in future studies.

This study has some limitations. The proposed mechanisms explaining the reduced antioxidant

activity of bamboo extract within the carbomer matrix, as well as the atypical DPPH results observed for the peel-off gel (F4), were not directly investigated and remain hypotheses to be confirmed through complementary analytical approaches. In addition, statistical comparisons were performed among formulations at each time point, but not directly between T0 and T30 within the same formulation, which limits stronger conclusions regarding the maintenance of antioxidant activity over storage. Finally, antioxidant activity was assessed using a single in vitro assay (DPPH); complementary assays are recommended in future studies. Additionally, the formulations did not contain equal amounts of each botanical extract (2% ginger vs. 5% bamboo, w/w; Table 1), so the absolute antioxidant response of F6, F7, and F8 is not directly comparable on a per-unit-extract basis, and the concentrations were not systematically varied to establish a dose-response relationship. The botanical extracts were also used as supplied by the manufacturer, without in-house authentication, batch-specific marker-compound quantification, or characterization of the extraction method/solvent; such information, when available from the supplier, should be reported in a future revision. Likewise, the extraction procedure used before the DPPH assay (ethanol dispersion, sonication, centrifugation) was not validated for recovery, and formulation-matrix interference with absorbance readings at 517 nm was not directly investigated; this is particularly relevant for the peel-off (PVA-containing) formulations, for which the observed lack of activity may reflect true inactivation, incomplete extraction, or analytical interference, and cannot be distinguished with the present data. Finally, physicochemical characterization was limited to organoleptic appearance and pH; viscosity/rheological behavior and, for the peel-off system, film properties (thickness, flexibility, adhesion, residual moisture) were not measured and would strengthen the formulation characterization in future work.

These findings indicate that carbomer-based gel is a promising vehicle for incorporating natural extracts into antioxidant cosmetic formulations, particularly with respect to physicochemical stability. They also reinforce the role of the excipient as a functional component of the formulation, capable of modulating both the stability and the biological performance of active—ingredients. In the present study, the combined-extract formulation (F8) showed a distinct advantage over the ginger-only formulation (F6): it was the only formulation that retained significant antioxidant activity under all three storage conditions tested, including 25 °C, where F6 showed no detectable activity after 30 days — indicating that the incorporation of bamboo extract may contribute to a more consistent antioxidant performance across storage conditions, in addition to preserving physicochemical stability.

CONCLUSION

This study demonstrated that vehicle selection directly affects the stability and antioxidant performance of cosmetic formulations containing natural extracts. Among the formulations evaluated, the carbomer-based gel containing the combined extracts of *Zingiber officinale* and *Bambusa vulgaris* showed the best physicochemical performance and preserved antioxidant activity after 30 days of storage under different conditions. This advantage reflects both the physicochemical stability of the combined-extract formulation and its more consistent antioxidant performance across storage conditions: F8 was the only formulation that retained significant antioxidant activity at all three temperatures tested, including 25 °C, where the ginger-only formulation (F6) showed no detectable activity. Future studies should investigate the mechanisms underlying extract–vehicle interactions and the possible interactions among associated botanical compounds.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

DECLARATION OF USE OF ARTIFICIAL INTELLIGENCE

The authors declare that they used ChatGPT (OpenAI), to support language editing, academic writing improvement, and translation of sections of the manuscript during the preparation and textual revision stage of the work. After using the tool, all content was reviewed, checked, and validated by the authors, who assume full responsibility for the final version submitted to BJHP.

REFERENCES

AKHTER, A.; SHIRAZI, J. H.; SHOAIB KHAN, H. M.; HUSSAIN, M. D.; KAZI, M. Development and evaluation of nanoemulsion gel loaded with bioactive extract of Cucumis melo var. agrestis: A novel approach for enhanced skin permeability and antifungal activity. **Heliyon**, v. 10, n. 15, p. e35069, 2024. Disponível em: https://doi.org/10.1016/j.heliyon.2024.e35069

ANVISA. **Guia de Estabilidade de Produtos Cosméticos**. 1. ed. Brasília: ANVISA, 2004. *E-book*. Disponível em: https://www.gov.br/anvisa/pt-br/centraisdeconteudo/publicacoes/cosmeticos/manuais-e-guias/guia-de-estabilidade-de-cosmeticos.pdf. Acesso em: 26 maio. 2025.

ASTHANA, N.; PAL, K.; ALJABALI, A. A. A.; TAMBUWALA, M. M.; DE SOUZA, F. G.; PANDEY, K. Polyvinyl alcohol (PVA) mixed green–clay and aloe vera based polymeric membrane optimization: Peel-off mask formulation for skin care cosmeceuticals in green nanotechnology. **Journal of Molecular Structure**, v. 1229, p. 129592, 2021. Disponível em: https://doi.org/10.1016/j.molstruc.2020.129592

AYUSTANINGWARNO, F.; ANJANI, G.; AYU, A. M.; FOGLIANO, V. A critical review of Ginger's (Zingiber officinale) antioxidant, anti-inflammatory, and immunomodulatory activities. **Frontiers in Nutrition**, v. 11, 2024. Disponível em: https://doi.org/10.3389/fnut.2024.1364836

BRAND-WILLIAMS, W.; CUVELIER, M. E.; BERSET, C. Use of a free radical method to evaluate antioxidant activity. **LWT - Food Science and Technology**, v. 28, n. 1, p. 25–30, 1995. Disponível em: https://doi.org/10.1016/S0023-6438(95)80008-5

DESAI, P.; MHASKAR, G. M. Formulation and Evaluation of *Zingiber officinale* Emulgel. **Research Journal of Pharmacy and Technology**, v. 12, n. 3, p. 1294, 2019. Disponível em: https://doi.org/10.5958/0974-360X.2019.00217.8

GU, Y.; XUE, F.; XIAO, H.; CHEN, L.; ZHANG, Y. Bamboo Leaf Flavonoids Suppress Oxidative Stress-Induced Senescence of HaCaT Cells and UVB-Induced Photoaging of Mice through p38 MAPK and Autophagy Signaling. **Nutrients**, v. 14, n. 4, p. 793, 2022. Disponível em: https://doi.org/10.3390/nu14040793

HOANG, H. T.; MOON, J.-Y.; LEE, Y.-C. Natural Antioxidants from Plant Extracts in Skincare Cosmetics: Recent Applications, Challenges and Perspectives. **Cosmetics**, v. 8, n. 4, p. 106, 2021. Disponível em: https://doi.org/10.3390/cosmetics8040106

JI, S.; BALISTA, P. A.; DARIO, M. F.; GONÇALVES, F. S. Avaliação da estabilidade e atividade antioxidante de formulações com o extrato de Mangifera indica L. **O Mundo da Saúde**, v. 48, 2024. Disponível em: https://doi.org/10.15343/0104-7809.202448e15832024P

KAUR, G.; GAUTAM, S.; ARORA, P.; DHINGRA, N. Estimation of Synergistic Antioxidant Effect of Methanolic Extracts of Some Medicinal Herbs. **Research Journal of Pharmacy and Technology**, p. 1042–1046, 2022. Disponível em: https://doi.org/10.52711/0974-360X.2022.00174

KAUR, N.; KAUR, B.; SIRHINDI, G. Phytochemistry and Pharmacology of *Phyllanthus niruri* L.: A Review.

Phytotherapy Research, v. 31, n. 7, p. 980–1004, 2017. Disponível em: https://doi.org/10.1002/ptr.5825

LAMBERS, H.; PIESSENS, S.; BLOEM, A.; PRONK, H.; FINKEL, P. Natural skin surface pH is on average below 5, which is beneficial for its resident flora. **International Journal of Cosmetic Science**, v. 28, n. 5, p. 359–370, 2006. Disponível em: https://doi.org/10.1111/j.1467-2494.2006.00344.x

MICHALAK, M. Plant-Derived Antioxidants: Significance in Skin Health and the Ageing Process. **International Journal of Molecular Sciences**, v. 23, n. 2, p. 585, 2022. Disponível em: https://doi.org/10.3390/ijms23020585

MICHALAK, M. Plant Extracts as Skin Care and Therapeutic Agents. **International Journal of Molecular Sciences**, v. 24, n. 20, p. 15444, 2023. Disponível em: https://doi.org/10.3390/ijms242015444

NIRMALA, C.; BISHT, M. S.; BAJWA, H. K.; SANTOSH, O. Bamboo: A rich source of natural antioxidants and its applications in the food and pharmaceutical industry. **Trends in Food Science & Technology**, v. 77, p. 91–99, 2018. Disponível em: https://doi.org/10.1016/j.tifs.2018.05.003

NISHIKAWA, D.; ZAGUE, V.; PINTO, C.; VIEIRA, R.; KANEKO, T.; VELASCO, M.; BABY, A. Avaliação da estabilidade de máscaras faciais peel-off contendo rutina. **Revista de Ciências Farmacêuticas Básica e Aplicada**, v. 28, n. 2, p. 227–232, 2007.

OZON, E. A. et al. Formulation and Characterization of Carbopol-Based Porphyrin Gels for Targeted Dermato-Oncological Therapy: Physicochemical and Pharmacotechnical Insights. **International Journal of Molecular Sciences**, v. 26, n. 8, p. 3641, 2025. Disponível em: https://doi.org/10.3390/ijms26083641

SILVA, P. M. da; LIMA, S. H. P. de; SIQUEIRA, L. da P. O uso de fitocosméticos para o tratamento de melasma: uma revisão de literatura. **Research, Society and Development**, v. 12, n. 6, p. e12312642040, 2023. Disponível em: https://doi.org/10.33448/rsd-v12i6.42040

SONAM, K.; GULERIA, S. Synergistic Antioxidant Activity of Natural Products. **Annals of Pharmacology and Pharmaceutics**, v. 2, n. 8, 2017.

VISPUTE, Y.; YADAV, P. Formulation and evaluation of anti-oxidant herbal gel. **Journal of Advanced Multidisciplinary Research Studies and Development** , v. 3, n. 2, p. 1–12, 2024.