Evaluation of moisturizing, film-forming and sensory properties of cosmetic formulations containing tara gum and Brazilian berry extract

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ABSTRACT

Background: The application of natural extracts in cosmetic products, such as the Brazilian Berry (*Plinia cauliflora*), has potential for application in cosmetic products. Thus, the aim of the study was to develop and evaluate the physical-mechanical, film forming and sensorial properties of a cosmetic formulation containing Brazilian berry and Tara gum. **Methods:** A gel based on polyacrylate polymer and *Caesalpinia spinosa* gum was developed and added to *Plinia cauliflora* extract and evaluated in terms of the texture profile and sensorial properties and its effects in the skin hydration and microrelief, transepidermal water loss (TEWL) and skin morphological characteristics by Reflectance Confocal Microscopy – RCM. **Results:** The addition of Brazilian Berry to the studied formulation showed that texture parameters and work of shear parameter significantly decreased, which can be correlated to the improvement of spreadability described in the sensory analysis. The clinical study showed an improvement of the skin microrelief and hydration after 2 hours of application of the formulation added to Brazilian Berry and a reduction of TEWL when compared to baseline values.

The RCM imaging analysis showed the visible film forming property due to the increase of brightness on the skin surface and a significant increase in the interkeratinocites reflectance in the stratum granulosum after 2 hours of application of the formulation under study, which suggest a hydration effect in the deeper skin layers. **Conclusion:** The Brazilian berry extract can be suggested for application in multifunctional cosmetics with film-forming property for the skin protection and hydration evaluated by innovative methods.

Keywords: Imaging analysis, clinical study, texture profile, Brazilian berry

Introduction

The growing interest in natural products and their benefits for health has also been a trend in the cosmetic sector, and novel botanical ingredients have been searched to reduce consumer exposure to synthetic substances. The composition of cosmetic products consists of active ingredients with protective properties against skin changes resulting from the exposome. These products improve the overall appearance, providing the necessary nutrients for healthy skin. Cosmetics can standardize skin tone, texture and shine while reducing wrinkles, representing the fastest-growing segment of the personal care industry [1].

Natural ingredients have been used for centuries for skin care purposes. Currently, they are becoming more prevalent in cosmetic formulations due to consumer concerns regarding synthetic ingredients/chemicals. The main benefits reported for botanical extracts used in skin care include antioxidant and antimicrobial activities and tyrosinase inhibitory effect and moisturizing properties [2].

A careful choice of raw materials used during the development of cosmetic products is crucial since it determines how the final product will present itself. For botanical extracts, it is essential to define the part of the plant used, the extraction method and the standardization of major compounds according to the proposed biological activities.

The selection of botanical ingredients is usually based on preliminary experimental studies and information reported in the technical literature about the physicochemical and microbiological characteristics, concentrations for use and incompatibilities of each ingredient. This information contributes to reaching the desired objective of the developmental phase [1,3]. In addition, it is important to define the part of the plant used, the extraction method, appropriate solvents, and the standardization of the major compounds according to the purposes proposed for the extract.

Among the natural extracts, the Brazilian berry or jabuticaba berry (*Plinia cauliflora*) is a fruit native to Brazil that deserves special attention for its application as a raw material of botanical origin. Its fruits are also widely used in the preparation of syrups, jams, fermented beverages, homemade liquor, vinegar and ice cream [3-5]. In addition, due to a rich composition of the fruit in polyphenols (tannins and anthocyanins), polysaccharides, proteins, minerals, vitamins, this extract has potential for application in cosmetic formulations for skin care.

Brazilian berry is one of the richest tropical fruits in relation to phenolic compounds, showing an accentuated antioxidant activity when compared to similar fruits, mainly when using extracts obtained from its peels. However, few studies on its chemical constituents can be found in the literature, especially regarding the cosmetic properties of Brazilian berry by-products [3,6].

Considering that, the development of cosmetic formulations with moisturizing and film-forming properties has been very important to help the keep skin physiology and protection, the

application of Brazilian berry in cosmetic products can improve the efficacy of the products in the improvement of skin hydration and protection against skin changes resulting from the exposome.

In addition, the Tara gum, also known as Peruvian carob, is a natural gum obtained by grinding the endosperm of *Caesalpinia spinosa* seeds, that present film-forming properties and can promote an improvement in the skin barrier function, as well as preventing the contact of external agents with the skin.

In this context, the application of ripe fruits of Plinia cauliflora (jabuticabeira), from Brazilian biodiversity, in the development of cosmetic formulations as well as the evaluation of sensorial properties, texture profile and clinical efficacy of these formulations by instrumental measures is very important.

Thus, the aim of the study was to develop and evaluate the physical-mechanical, film forming and sensorial properties of a cosmetic formulation containing Brazilian berry and Tara gum.

Material and methods

Studied formulations

A gel formulation added or not (vehicle) to 2% of Brazilian berry glycolic extract was developed. The formulation was based on natural polymer, glycerin, preservatives, water and humectants and was developed in a minimalistic way. The vehicle formulation - F1 and the formulation added to 2% of Brazilian berry glycolic extract - F2 were submitted to rheological behavior and texture analysis. The formulations were submitted to a preliminary stability study by determining the pH for 28 days.

Texture profile and spreadability analysis

The texture analysis and spreadability test were performed after 24 hours of the preparation of the formulations using the TA XT Plus® physical-mechanical properties analysis system, coupled with the Exponent® software [7, 8]. The texture test was performed with the A/BE 40 mm extrusion probe, with return distance of 100 mm and speed of 20mm/sec, and the parameters under study were consistency, firmness, cohesiveness, and index of viscosity. The spreadability analysis was performed with the TTC HDP/SR probe, with return distance of 25 mm and return speed of 20mm/sec and the work of shear was evaluated [9].

Sensorial properties

Sensorial properties analysis was carried out as one of the stages in the development of the gel formulations under study; 20 female/male participants applied a standardized amount (32 µL) of the formulations in distinct regions in the lower middle portion of the forearms. This study was

carried out by comparing the vehicle and the gel added with the Brazilian berry extract. Participants received a questionnaire, which question they assigned scores according to the parameters of spreadability and touch sensation, and after 5 minutes: hydration, stickiness and residue formation.

Clinical study

The clinical efficacy study was conducted according to the guidelines of the Declaration of Helsinki and after approval by the Ethics Committee for Clinical Research of the School of Pharmaceutical Sciences of Ribeirão Preto (CEP/FCFRP - CAAE: 32200720.6.0000.5403). 10 participants (female and male), aged between 20 and 40 years, Fitzpatrick Phototype II and III were recruited for the clinical efficacy in short-term.

The measurements were perfomed before and after 2 hours of application of the formulations in the volar forearm regions of the participants. The amount of formulation applied was 2 µL/cm^2, in a 4x4 cm quadrant, totaling 32 µL of each formulation. The formulations were spread in the delimited area with 10 rotations, using the index finger. The clinical study was performed by biophysical and skin imaging techniques and the stratum corneum water content, transepidermal water loss, skin microrelief and morphologigal characteristics of the skin were evaluated.

Stratum corneum water content

The stratum corneum water content was determined with Corneometer®, based on the principle of electrical capacitance measurement, i.e., on the variation of the dielectric constant of water. Results are given in arbitrary units (AU). With 1 AU being estimated to correspond to 0.2-0.9 mg of water per gram of stratum corneum. Five measurements were obtained, and the average of the values obtained was calculated [10].

Transepidermal water loss (TEWL)

Tewameter® TM 210 device, coupled to a MPA software, was used to measure TEWL , based on the Fick's law of diffusion. The values are given in g.m^2.h^{-1}. The probe remained for 30 seconds on the skin and the mean value of the three measurements obtained was used in the subsequent calculations [10].

Skin microrelief

The Visioscan® VC98 (Courage & Khazaka Electronic GmbH, Köln, Germany) was used to provides qualitative and quantitative information on the skin surface under physiological conditions, through optical profilometry techniques. The following parameters related to the skin

surface (SELS - Surface Evaluation of Living Skin) were evaluated: Sesm, Ser, Sesc and Sew [10].

Morphological characteristcs of the skin - Reflectance Confocal Microscopy (RCM)

The morphological and structural characteristics of different skin layers was performed by RCM (VivaScope^{TM} 1500), which uses a laser source (830nm) and an immersion objective capable of detecting twenty images per second. The microscopic images were taken using by Vivastack, which represents multiple deep images at a pre determinate location in the tissue, 3 by 3 µm images until 150 µm. The images were interpreted according to recent literature and with the help of the Image J® software [11-13].

Statistical analysis

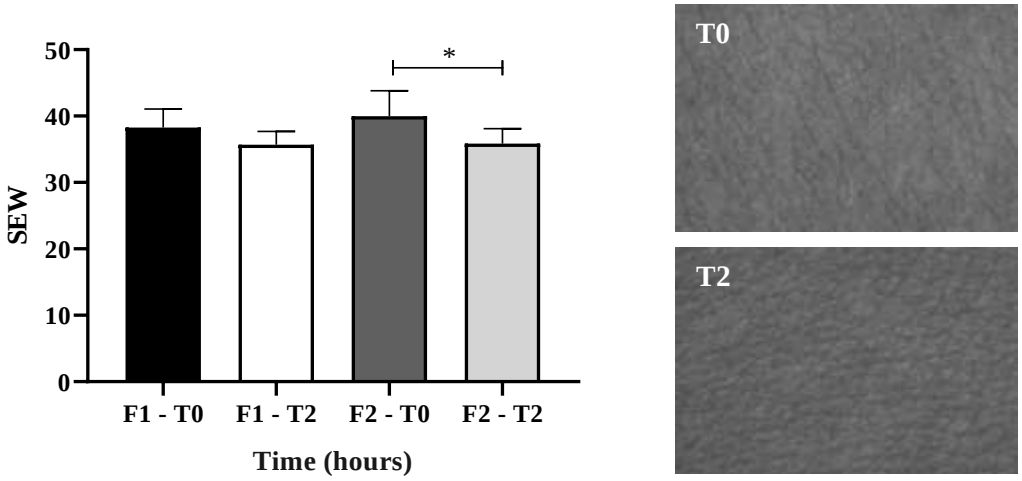
Statistical analysis was performed using the software Graph Pad Prism 8.0. The data were considered normal by the Shapiro-Wilk test of normality and correlated using the Two-way ANOVA test to compare the two groups at the basal and after treatments measurements [12,14].

Results and discussion

The formulations were submitted to a preliminary stability study by determining the pH, which remained around 5.5 ± 0.3 for the vehicle gel formulation (F1) and 5.1 ± 0.2 for the Brazilian berry gel formulation (F2), with no change in the pH value after 28 days of preparation.

The addition of Brazilian Berry extract to the studied formulation showed that texture parameters, such as firmness and cohesiveness, decreased while consistency and viscosity indices did not alternated. In addition, the work of shear parameter significantly decreased ($p<0.05$) when Brazilian Berry extract was added to the formulation, which can be correlated to the improvement of spreadability and touch sensation described in the sensory analysis [9].

The clinical study showed effects in the improvement of skin microrelief due to the reduction of Sew parameter, which represents the number and width of wrinkles, after 2 hours of application of the formulation added to Brazilian Berry extract (Figure 1). In addition, both formulations significantly reduced the TEWL and increased skin hydration when compared to baseline values.



(a) **(b)**

Figure 1. Skin microrelief - (a) Sew parameter (number and width of wrinkles) before (T0) and after 2 hours (T2) of application of F1 - vehicle formulation and F2 - Brazilian berry formulation ($p<0.05$) and (b) representative skin images on the volar forearm region, before (T0) and after 2 hours (T2) of application of F2.

The RCM imaging analysis showed that the Tara gum presented visible film-forming properties due to the increase of brightness on the skin surface and a significant increase in hyperreflective pixels in the stratum corneum [12] (Figure 2). In addition, a significant increase in the interkeratinocites reflectance in the stratum granulosum were observed in the RCM images after 2 hours of application of the formulation containing Brazilian Berry extract and Tara gum, which suggest a hydration effect that is not limited to the upper skin layers but is also present in the deeper ones [13]. (Figure 2).

A significant increase of the stratum corneum brightness ($p<0.01$) on the skin of forearm region before (T0) and after 2 hours (T2) of application of the gel formulation containing Brazilian berry extract (F2) was observed when compared to baseline values and for vehicle treatment.

The Figure 3 shows the RCM images analysis of the interkeratinocytes reflectance of granulosum layer before (T0) and after (T2) the application of gel formulation containing Brazilian berry extract (F2) and gel vehicle (F1). In addition, an improvement in the honeycomb pattern and an increase in interkerationocyte brightness after 2 hours of application of formulation containing Brazilian berry extract were observed.

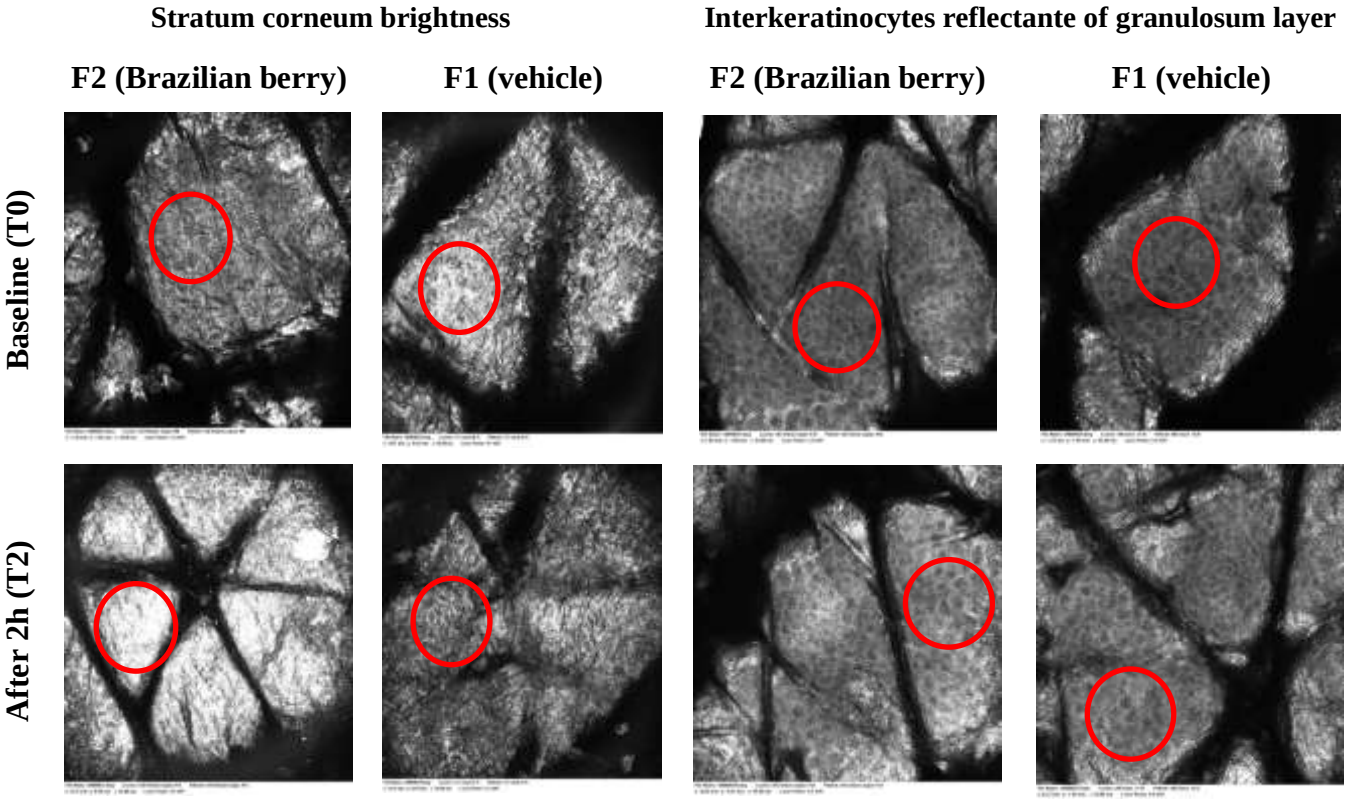


Figure 2. RCM images of brightness of *stratum corneum* and interkeratinocytes reflectance of granulosum layer before (T0) and after two hours (T2) of application of the gel containing Brazilian berry extract (F2) and gel vehicle (F1).

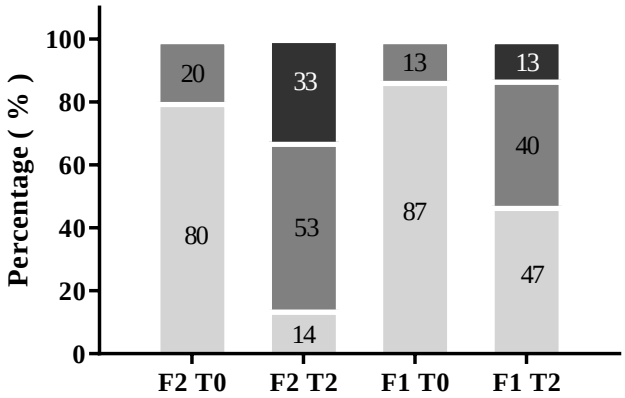


Figure 3. Interkeratinocytes reflectance of granulosum layer before (T0) and after (T2) of gel treatment containing Brazilian berry extract (F2) and vehicle (F1). ■ score 1 (low); ■ score 2 and ■ score 3 (high)

After the 2 hours of study, the participants were asked about their perception of efficacy of the formulations under study. Most part of the participants reported an improvement of skin

hydration, a good spreadability of the formulation and pleasant touch sensation after application of the formulation with Brazilian berry - preference of 84% of the participants (Figure 4).

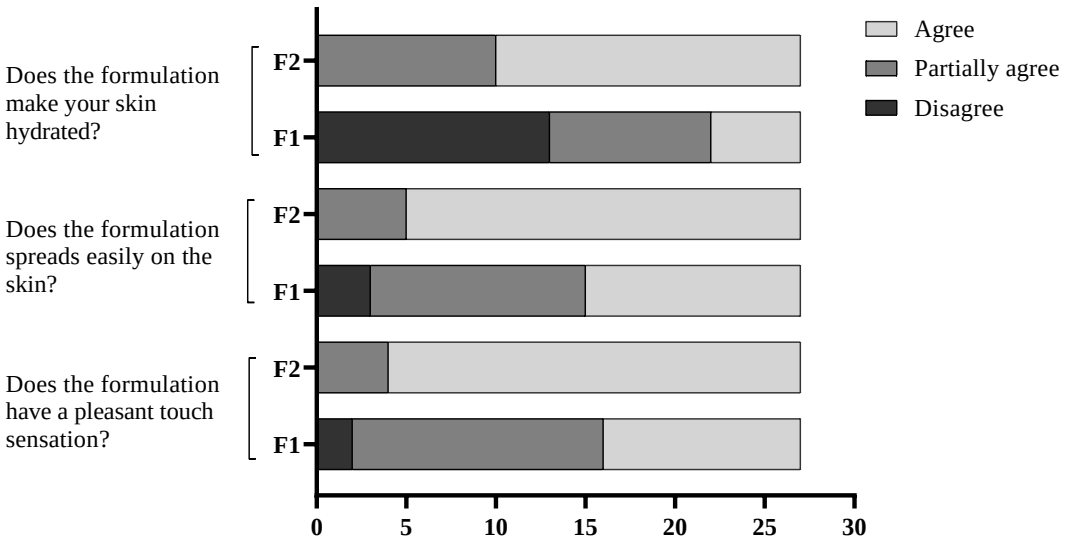


Figure 4. Perception of the efficacy of the formulations under study - gel containing Brazilian berry extract (F2) and gel vehicle (F1).

The sensorial properties showed that the addition of the Brazilian berry extract improved the spreadability and touch sensation, which corroborates with the spreadability test, where there was a significant ($p<0.05$) decrease in the parameter work of shear, correlated with spreadability of the formulations [9]. This result is relevant, since the participants reported that the vehicle formulation leaves a white residue on the skin, probably due to the Tara gum. This way, the extract under study improved the sensorial properties.

Conclusion

The use of ingredients obtained from natural sources to develop cosmetic formulations helps obtain more innovative and effective products with good texture and sensory properties. Thus, the Brazilian berry extract can be suggested for application in multifunctional cosmetics for skin care and can add value to the product. In addition, the use of advanced imaging techniques such as RCM is fundamental in order to scientifically prove the benefits of the cosmetics. Finally, the present study has an important contribution since it showed the benefits of a cosmetic product based on natural ingredients with film-forming properties for the skin protection and hydration using innovative evaluation methods.

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SisGen

The activity of accessing the Genetic Heritage/CTA, under the terms below, was registered at SisGen (registration number AE821C2 for the use of Brazilian berry extract - *Plinia cauliflora*), in accordance with the provisions of Law 13.123 / 2015 and its regulations.

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