Development of cosmetic formulations containing pequi oil: rheological behavior, physical-mechanical and sensorial properties

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ABSTRACT

Background: The search for natural cosmetics has increased over the years, in this context Brazilian biodiversity has the potential for application in the development of innovative products. The oil extracted from *Caryocar brasiliense* Cambess, (pequi oil) native to the Cerrado is known as an antioxidant due to its rich composition of secondary and primary metabolites. Thus, the study aims to develop a formulation containing 5% pequi oil and evaluate the physical-mechanical and sensory properties. **Methods:** A gel-cream added or not (vehicle-F1) of the pequi oil (F2) was developed and the rheological behavior, texture and spreadability was analyzed in terms of flow index, consistency, viscosity, firmness, cohesiveness, and work of shear. The sensorial properties were evaluated with 16 participants, who answered a questionnaire about their perception after the application. **Results:** The formulations presented thixotropic and pseudoplastic rheological behavior and the rheograms did not showed alterations after 28-days. The results of texture profile showed that the F2 significantly ($p<0.05$) reduces the texture parameters. However, the work of shear did not change between the formulations. In the sensorial analysis the F2 presented a good spreadability and increased the sensation of hydration, with no white residue or stickiness touch. **Conclusion:** This study contributes to the development of a formulation using a natural ingredient from Brazilian biodiversity and to the prediction of sensorial properties using physical-mechanical instruments, being an innovative approach in the cosmetic area. Thus, pequi oil is a natural emollient to be applied in cosmetic products, as it can bring important benefits to skin care, like improving sensorial properties and skin hydration.

Keywords: pequi oil, cosmetic formulations, physical-mechanical properties, sensory analysis.

Introduction

The search of consumers for cosmetics based on natural raw materials has increased over the years, as well as the investment to prospect new ingredients and the development of sustainable formulations [1]. In this context, the use of vegetable oils has significant economic importance, especially for the cosmetic industry [1,2]. Oils extracted from plant sources are widely used in cosmetic products, as they classically act as emollients, and have secondary benefits that improve the sensory and texture properties of formulations [3] and clinical benefits, like antioxidant activity [4].

In this scenario, Brazilian biodiversity has potential for application in the development of innovative cosmetic products. The oil extracted from the *Caryocar brasiliense* Cambess, also known as pequi oil, native to the Brazilian Cerrado is well known for its antioxidant and anti-inflammatory due to its rich composition of secondary metabolites like polyphenols and carotenoids and primary ones like oleic and palmitic acid [5].

Thus, it has potential for application in the development of cosmetics formulations for skin and hair care. The incorporation of this natural oil in cosmetic formulations could bring benefits for skin, such as the increase of the hydration, protection of skin barrier function and antioxidant effects [6].

The addition of oils can change the texture profile and rheological behavior of formulations by altering the skin surface characteristics [6]. Thus, this analysis is very important to understanding the role of a single ingredient in a complex formulation. These ingredients, like emollients, can induce considerable changes in the physicochemical parameters of the skin [7,8]. This way, during the development of cosmetic products, the evaluation of stability, texture profile and sensory properties are very important to obtain a stable formulation suitable for cosmetic purposes.

In addition, the analysis of the parameters related to the texture and spreadability of a formulation by means of a system of analysis of the physical-mechanical properties is fundamental to complement the rheological study once this analysis allows evaluate the behavior of the product on the skin [9].

In this context, the proposal of this study was to develop a minimalist cosmetic formulation containing the pequi oil and to evaluate the rheological behavior, texture profile and sensory properties.

Material and methods

Studied Formulations

A gel-cream formulation added or not (vehicle) to 5% of pequi oil was developed. The formulation was based on polymer, glycerin, preservatives, emulsifier, aqua and humectant and was developed in a minimalistic way, which means that the minimum amount of raw materials was used without losing its stability and sensory properties.

The vehicle formulation was named F1 and the formulation added with 5% of the oil extracted from the pulp of the pequi was named F2.

The studied formulations were submitted to preliminary stability tests, rheological behavior, and texture analysis.

Preliminary stability test

The preliminary stability tests of the formulations were evaluated in terms of centrifugation, pH and analysis of organoleptic characteristics. For this, the formulations were stored in glass containers at room temperature (25°C) and were submitted by thermal stress at 37°C and 45°C under controlled humidity (70% RH). The centrifugation test was carried out using 3g of each formulation submitted in 3 cycles of 30 minutes at 3000 rpm. pH and organoleptic alterations of the formulations were evaluated after 24 hours,14 and 28 days after the preparation [10].

Rheological behavior

The rheological behavior was evaluated each 14 days for 28 days at room temperature, using a digital rheometer, cone and plate type Brookfield model RVDV3T-CPT (Brookfield, USA) with CP-52 spindle and coupled with Rheocalct® software. For this analysis, 0.50 g of each formulation was weighed on the plate and the rotation speed was progressively increased from 0 to 100 rpm with an interval of 5 seconds between each speed, forming an ascending curve composed of the axes "shear rate" versus "shear stress", and then an inverse curve was generated with the decrease of the velocity [9].

Texture profile analysis and spreadability test

The texture analysis and spreadability test were performed after 24 hours of the preparation of the formulations. The tests consist in the insert of a probe with standardized height and constant speed. For this, both tests were performed using the TA XT Plus® physical-mechanical properties analysis system, coupled with the Exponent® software

[11,12]. 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 [9]. The spreadability analysis was performed with the TTC HDP/SR probe, with return distance of 25 mm and return speed of 20mm/sec, the work of shear parameter was evaluated [9].

Sensorial analysis

After the approval of the Ethics Committee in Clinical Research at FCFRP/USP (CAAE nº CAAE: 45620321.2.0000.5403) 16 health participants, men and women, aged 20 to 29 years were recruited. The participants had their forearm delimited in a region of 4x5 cm² and they spread 40µm of each formulation with twenty circular movements. After that, they answered a questionnaire about their perception immediately after the application of these two formulations, regarding the spreadability and smoothness sensation, and after 5 minutes application they evaluated the hydration sensation, stickiness touch and white residue.

Results

The formulations remained stable in the preliminary stability tests. The rheological behavior remained the same throughout the analysis period (Figure 1). There was no significant difference ($p>0.05$) between the times T0, T7 and T28 in relation to the rheological parameters of flow index, consistency index and area of hysteresis.

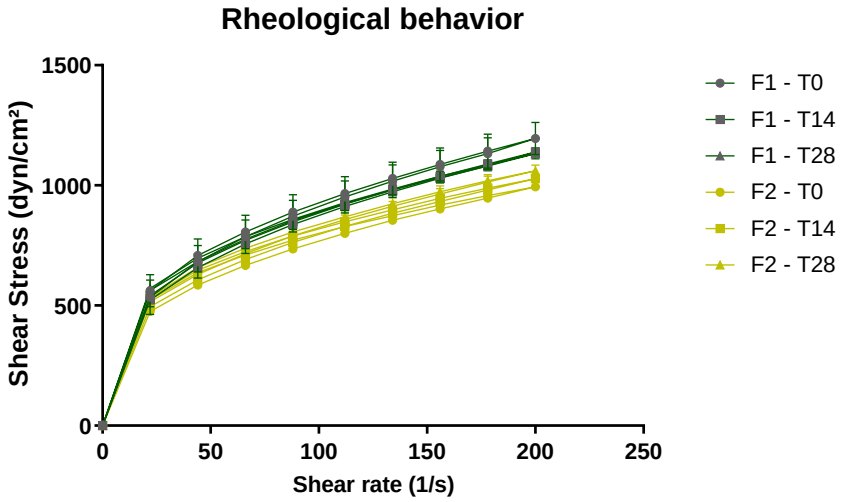

Figure 1. Rheograms of F1 (vehicle) and F2 (vehicle added with 5% of pequi oil) after 24 hours (T0), 14 (T14) and 28 (T28) days of preparation

The texture profile analysis showed that the addition of pequi oil in the formulation promoted a significant decrease ($p<0.05$) in the texture and spreadability parameters (Figure 2). However, there was no difference in the work of shear parameter ($p>0.05$). In addition, in the study of sensory properties, the F2 formulation has better accepted by the participants for promoting hydration and smooth touch sensation.

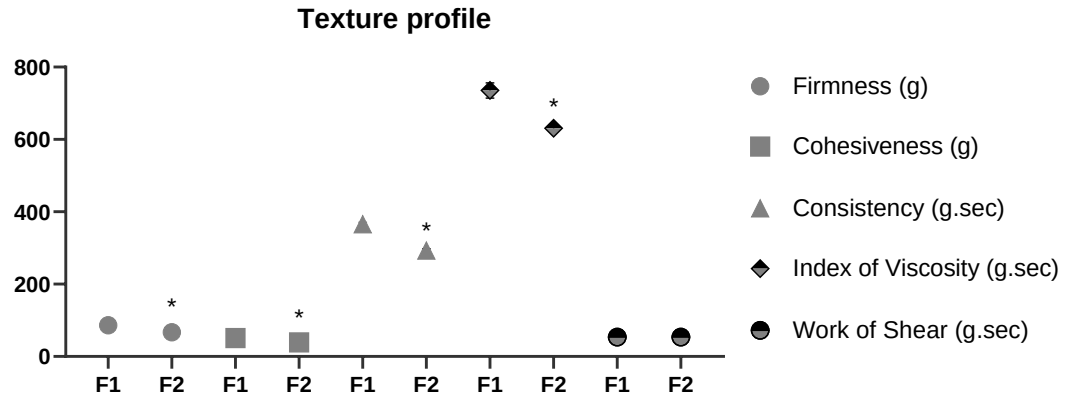

Figure 2. Texture profile of F1 (vehicle) and F2 (vehicle added with 5% of pequi oil) after 24 hours of preparation

*Significant difference compared to vehicle formulation ($p<0.05$)

Discussion

The formulations did not show phase separation in the centrifugation test and, also, there was no change in color, odor, and homogeneity, showing stability in the organoleptic characteristics. In addition, the formulations presented pH in the range of 5 to 5.5 after the 28 days of study even when submitted to the thermal stress, being compatible with the pH of the skin.

All the rheograms showed a non-Newtonian behavior of the pseudoplastic flow presenting flow index lower than 1. F2 presented significant ($p<0.05$) lager hysteresis area, which means that the viscosity recovers slowly after the shear than F1 [3]. The hysteresis area is resulting from the thixotropy phenomenon, the area between the ascending and descending curves indicates that the material needs more time to reorganize and return to the initial structure after the shear rate is removed [3,13]. This way, the F2 formulation suggests a better performance on the skin, once the larger thixotropy, the permeation of the pequi oil is higher [9].

Besides, the rheograms showed a reproductible rheological behavior, with no alterations or picks formations after 28 days of study at room temperature.

The sensorial properties analysis showed that the F2 presented a good spreadability and increased the sensation of hydration, with no white residue or stickiness touch after 5 minutes. This result is quite promising, since the presence of oils in the composition of cosmetic products usually are known for the oily sensation that the formulations leave on the skin. However, the addition of 5% of the pequi oil did not compromise the oiliness perception for the participants.

The results of the texture profile and spreadability analysis showed that the F2 formulation presented better performance, since the addition of the pequi oil significantly ($p<0.05$) reduces the parameters of consistency, firmness, cohesiveness, and index of viscosity (Figure 2), which corroborates with the results in the sensorial analysis. These reductions are due the action of the oil as an emollient, which interacts with the microstructure of the formulation, making the formulation less consistent [3]. This means that these values make the formulation easy to apply and spread but was also not thick and sticky not compromising the sensorial perception of the formulations.

However, the work of shear parameter did not change between the vehicle and the formulation added with the pequi oil, which suggests that the presence of the oil did not compromise the spreadability of the formulation.

Thus, the formulation F2 was the most accepted for the participants and the one that was considered more hydrated. So, the use of this natural ingredient can promote the increase of the sensorial properties, promoting a soft touch and smoothness sensation during the formulation application.

Conclusion

The formulation added with 5% of the pequi oil showed stability after 28 days of analysis. The rheograms showed a thixotropic and pseudoplastic rheological behavior. Besides, the parameters obtained of the texture profile were significant lower when compared to the vehicle, showing that the oil interacts with the microstructure of the formulation. However, the parameter work of shear from the spreadability test showed that the presence of pequi oil did not influence in this parameter, which reflects directly in the sensorial performance. In addition, the formulation added with pequi oil did not change sensorial properties, showing a good spreadability, no oily or white residue and the study participants perceived the moisturizing effect. Thus, the pequi oil is an effective

natural ingredient from Brazilian biodiversity to be applied in the cosmetic products since it can bring important benefits for a skin care formulation, such as an improvement of sensorial properties and skin hydration.

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SisGen

The activity of accessing the Genetic Heritage / CTA, in the terms summarized below, was registered at SisGen - registration number: A15D96E for the use of pequi oil extracted from the species *Caryocar brasiliense* Cambess, in accordance with the provisions of Law 13,123 / 2015 and its regulations.

Conflict of Interest Statement

The authors declare no conflict of interest

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