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# Development and evaluation of emulsifying systems of the material grease from Brazilian flora

[Desarrollo y evaluación de sistemas emulsionantes a partir de grasas de la flora brasileña]

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## Abstract

*Context:* Oils and butter of seed from Brazilian biodiversity are extending the range of innovative products for cosmetics development. They have a fat potential similar to skin composition, leading to the improved performance of these product.

*Aims*: Improve the emulsions spreadability through prior screening of grease composition and studying the viscosity, and the emulsions accelerated stability.

*Methods*: Emulsions were formulated using oils from semiarid plants from Bahia: *Syagrus coronate, Pachira retusa*, and *Pachira aquatica*, so as to compare them with oils already standard in the production of cosmetics. Spreadability and stability tests were made comparing the results. The same criteria were used with Amazon seed butter: *Virola surinamensis*, *Butyrospermum parkii*, *Astrocaryum murumuru*, *Theobroma cacao* and *Theobroma grandiflorum*. For the emulsions screening and performance, a system was developed for oil/ butter, following tests of accelerated stability, viscosity, and spreadability.

*Results:* The combined system of spreadability was optimized using screening. Emollients containing oleic and palmitic acids, and light chain fatty acids obtained good spreadability. The oil emulsion containing *Pachira retusa* and *Virola surinamensis* butter had a higher viscosity.

*Conclusions*: With high content of fatty acids such as oleic, palmitic or the light chain fatty acids obtain an appropriated appearance, texture, and spreadability for cosmetic use. Thus, oils with a low fatty acid content may be combined with butter that have a high fatty acid content and vice-versa. Analyzing and strategically combining grease composition, one can optimize the performance of cosmetic formulations.

**Keywords:** Raw material grease; screening; spreadability; viscosity.

## Resumen

*Contexto:* Los aceites y mantecas de semillas de la biodiversidad brasileña están ampliando la gama de productos innovadores para el desarrollo de los cosméticos. Estos tienen una grasa potencial similar a la composición de la piel, dando lugar a la mejora del rendimiento de estos productos.

*Objetivos:* Mejorar la capacidad de extensión de las emulsiones mediante el cribado previo de la composición de grasa y el estudio de la viscosidad y la estabilidad acelerada de las emulsiones.

*Métodos:* Las emulsiones se formularon utilizando aceites de plantas semiáridas de Bahía: *Syagrus coronata*; *Pachira retusa; Pachira aquatica* y mantecas de semillas de la Amazona: *Virola surinamensis, Butyrospermum parkii, Astrocaryum murumuru, Theobroma cacao* y *Theobroma grandiflorum*. Para el cribado y el rendimiento de las emulsiones se desarrolló un sistema aceite/manteca, seguido de pruebas de estabilidad acelerada, viscosidad, y extensibilidad.

*Resultados:* Los emolientes que contenían ácidos oleico y palmítico, y ácidos grasos de cadena ligera obtuvieron buena extensibilidad. La emulsión de aceite de *Pachira retusa* y manteca de *Virola surinamensis* tuvo una viscosidad más alta.

*Conclusiones:* Con un alto contenido de ácidos grasos oleico, palmítico o los ácidos grasos de cadena ligera se obtienen apariencia, textura y extensibilidad adecuadas para uso cosmético. Por lo tanto, los aceites (contenido bajo de ácidos grasos) se pueden combinar con la manteca (alto contenido de ácidos grasos) y viceversa. Analizando y combinando estratégicamente la composición de grasa se puede optimizar el rendimiento de las formulaciones cosméticas.

**Palabras Clave:** Cribado; extensibilidad; materia prima grasa; viscosidad.

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## INTRODUCTION

Innovative research in the cosmetic industry has been growing, as consumers become more demanding, concomitantly seeking the continuous improvement of the products on offer to meet their needs.

The replacement of synthetic emollients by emollients derived from natural sources such as fixed oils and butter was a vast improvement for the qualities of cosmetic products. These emollients can positively influence sensory performance, as well as creating greater spreadability, wetting, and long-term stability, and a high replacement of fatty acids in the skin. It becomes evident how the emulsion's oil phase characteristics are due to cosmetic properties such as low viscosity, and good penetration (Morais, 2006). Kim et al. (2008) reported that oils containing palmitic and oleic fatty acids result in better permeation and spreading.

In the Brazilian Northeast there are many species of vegetation known to be natural producers of emollients, such as *Pachira retusa* (Chestnuts Chapada), and occurs in areas of the Cerrado and Caatinga (semi-arid). Its chestnuts produce a fixed oil yield of 55.6% (Pereira et al., 2013). *Syagrus coronata* (Licuri) is another oilseed species from Bahia, belonging to the *Arecaceae* family, which has 115 genera and 1550 species (Noblick, 1986). The 24.93% of fixed oil was extracted from its seeds through cooking (Trevizam et al., 2014). *Pachira aquatica* (Maranhão Chestnut) is another species known in that region; it occurs in many areas from Mexico to the Brazilian North (Silva et al., 2010). Further, there are other areas in Brazil where *Pachira retusa* can be found, as reported by Matos et al. (2010). It has been corroborated through mapping the species of vegetation existent in Aracaju, the main city in the Northeastern state of Sergipe. The historical process of reforestation of Brazil can explain this fact. According to Lorenzi (1992), the French landscaper Glaziou, cultivated *Pachira aquatica* because it is a species, which adapts well in reforestation projects. Oilseeds such as those cited above can give formulations, qualities desirable to consumers. Combining these oils with Amazonian vegetable butter it is possible to optimize the performance of the parameters of cosmetic formulations such as viscosity and spreadability. Finally, prior knowledge through screening of the raw grease material to be able to constitute strategic combinations of these oil/vegetable butter emulsifier systems is necessary.

## MATERIAL AND METHODS

### Materials

Prior screening of raw grease material was determined by literature profiles of the fatty oils and vegetable butter used (Pinto, 1963; Noblick, 1986; Instituto de Estudos Amazônicos e Ambientais, 1993; Amazon Oil, 2005; Pereira, 2008; Polizelli et al., 2008; Neto et al., 2009; Silva et al., 2010; Pereira et al., 2013; Silva et al., 2014). Screening was used to make combinations of grease materials (butter and vegetable oils), with prior knowledge of their compounds and state of saturation, for proper planning of the formulation.

The vegetable butter and *Macadamia integrifolia* oil were obtained through a sustainable cooperative in the Caatinga region, COOPES (Cooperative Production in Piemonte of the Diamantina region, Brazil). The *Pachira retusa* oil was obtained by extraction using a Soxhlet device (Pereira et al., 2013). Other oils used were provided by a sustainable cooperative COOPFITOS (cooperative producers of medicinal plants, phytotherapics, and phytocosmetics of Manaquiri, Brazil).

### Development of formulations

Simple emulsions were formulated O/A containing only semi-arid oils: (1) *Pachira retusa* (Mart.) Fern.Alonso (*Malvaceae*), (2) *Pachira aquatica* Aubl. (*Malvaceae*), (3) *Syagrus coronate* (Mart.) Becc. (*Arecaceae)*, and oils already in use in the industry: (1) *Caryocar brasiliense* A. St.-Hil. (*Caryocaraceae*), (2) *Macadamia integrifolia* Maiden & Betche (*Proteaceae*), (3) *Orbignya speciosa* (Mart.) Barb.Rodr. (*Arecaceae*) and (4) *Astrocaryum tucuma* Mart. (*Arecaceae*). The formulations containing vegetable butters: (1) *Virola surinamensis* (Rol. ex Rottb.) Warb. (*Myristicaceae*), (2) *Butyrospermum parkii* (G.Don) Kotschy (*Sa-*

*potaceae*), (3) *Theobroma grandiflorum* (Willd. ex Spreng.) K.Schum. (*Malvaceae*), (4) *Theobroma cacao* L. (*Malvaceae*), and (5) *Astrocaryum murumuru* Mart. (*Arecaceae*) were tested as emollients, emulsion. A control emulsion also was used (see F1 in Table 1). Table 1 below lists the formulations that were used in this study.

For their preparation, the phase inversion method (EIP) by Santos et al. (2005) was used. Both phases were heated to 75°C. The aqueous phase was poured into the oily one with continuous stirring. Each formulation was made in triplicate.

## Stability tests

Accelerated stability studies were performed in triplicate for the parameters: organoleptic characteristics, pH, centrifugation, vibe, and freeze/thaw cycle (Brasil, 2004).

### *Organoleptic features*

Aspects of coloring, odor, and coalescence of emulsions were observed in a post preparation timeframe of, 30, 60, and 90 days.

### *pH determination*

The pH determination was based on the method proposed by Borghetti and Knorst (2006), using samples diluted in distilled water (1:10 w/v), homogenized and submitted to reading. A temperature of 25 ± 1°C on the pH meter was calibrated beforehand, (Model. pH 300, ALPAX, Brazil) with pH 7.0 and 4.0 solutions. Regarding the timeframe, the test was performed 30, 60, and 90 days after the preparation of the emulsions. After 90 days, they were submitted to a freeze-defrost cycle.

### *Spin and vibration tested*

A small proportion of the emulsions were subjected to centrifugation at 3000 rpm for 30 minutes (centrifuge, Excelsa Baby model 208 N, Brazil) and then to vibe with a vortex, Mod. Lab Dander Bay (IKA, Brazil) as per the specifications of ANVISA (Brasil, 2004).

### *Temperature test*

The freeze-defrost cycle to room temperature (25°C) was performed in triplicate at 30, 60 and 90 days as per ANVISA specifications (Brasil, 2004).

## Check the spreadability profile of emulsions

The emulsions were subjected to *in vitro* spreading to achieve maximum spreadability, appropriately superimposing weights calcula-ted using the formula (Knorst 1991; Milan et al., 2007):

$Ei = d^2 \times \pi/4$

Where:

Ei = sample spreadability for weight i (mm),

d=average diameter ($mm^2$).

It was correlated by screening the oil and butter grease composition to demonstrate its influence on spreadability. For the vegetable oils and butter that performed best, simple emulsifying systems were formulated using oil/vegetable oil separately for comparison with emulsions containing emollients. All formulated emulsions were subjected to the spreadability test after preliminary confirmation of stability.

## Viscosity

From a pharmaco-technical viewpoint, developing rheological parameter studies (viscosity, plasticity and elasticity) are important, so as to ensure the adequate system flow required for therapeutic efficacy or adequate functioning of cosmetic products (Woolfson, 2000). Viscosity is a fundamental parameter, which describes the properties of the fluid flow. It can be defined as the internal friction of the fluid between its layers, or the resistance that it requires to achieve flow (Braseq, 2010).

The emulsion's viscosity can be measured by a viscometer, or using a rheometer with a rotational viscometer (Loch et al., 2011).

From the previous test, emulsions that had the best profiles were analyzed by the rheometer (Brookfield Digital Rheometer, model DV-III, Brazil). This analysis allowed the establishment of correlations between the spreadability profile and the saturation of fatty material and viscosity.

**Table 1.** Composition of developed formulations (%, O/W).

| Ingredients | F1 | F2 | F3 | F4 |
|---|---|---|---|---|
| Lanette ® | 5.0 ± 0.5 | 5.0 ± 0.5 | 5.0 ± 0.5 | 5.0 ± 0.5 |
| Cetiol V | 5.0 ± 0.5 | 5.0 ± 0.5 | 5.0 ± 0.5 | 5.0 ± 0.5 |
| Vegetable oil | - | 5.0 ± 0.5 | - | 2.5 ± 0.5 |
| Vegetable butter | - | - | 5.0 ± 0.5 | 2.5 ± 0.5 |
| BHT | 0.0025 ± 0.0005 | 0.0025 ± 0.0005 | 0.0025 ± 0.0005 | 0.0025 ± 0.0005 |
| Nipazol | 0.0125 ± 0.0005 | 0.0125 ± 0.0005 | 0.0125 ± 0.0005 | 0.0125 ± 0.0005 |
| Nipagin | 0.0125 ± 0.0005 | 0.0125 ± 0.0005 | 0.0125 ± 0.0005 | 0.0125 ± 0.0005 |
| Glicerine | 3.75 ± 0.5 | 3.75 ± 0.5 | 3.75 ± 0.5 | 3.75 ± 0.5 |
| Distilled water | QS.50 | QS.50 | QS.50 | QS.50 |

Data represent the mean ± SD of at least n = 3.
**F1** (Control Formulation), **F2** (Vegetable oil formulation), **F3** (Vegetable butter formulation, **F4** (Vegetable oil/butter formulation).
**BHT**: butyl hydroxytoluene.

### Statistical analysis

Descriptive statistic was used analyzing the averages and standard deviations for fat profiles and oils, and the butter's physicochemical properties were ascertained. The data was processed through the Tukey test, 5% significance ($p < 0.05$) for an adequate comparison of the averages obtained. The Friedman nonparametric treatment was applied to confirm the emulsion's spreadability (Borges, 2003).

## RESULTS AND DISCUSSION

Using the literature, the grease composition of each emollient was established, which allowed the prior screening of vegetable oils and butter used (Tables 2 - 3).

It was observed that the *Virola surinamensis* and *Butyrospermum parkii* butter had a better result in the cosmetic performance screening when analyzing the scattering of these emulsions displayed with these butters (Table 4-A). Regarding the vegetable oils, the ones with the best scattering profiles were the semi-arid oils made with *Caryocar brasiliense*, *Syagrus coronata*, *Pachira retusa*, and *Pachira aquatica* (Table 4-B). According to the spreadability (Table 4A-C) and screening profile, it can be inferred that the lauric acid (C12:0), and short chain fatty acids present in the *Syagrus coronata* oil favored good spreading of the emulsions produced from it. The analysis also showed that oils composed of high levels of oleic acid (C18:1) and palmitic acid (C16:0), as well as *Virola surinamensis* butter in which myristic acid (C14:0) was dominant resulted in good stable emulsions in terms of scattering and fluidity. According to Kim et al. (2008), oil grease compositions containing oleic and palmitic acids tested in the screening of raw grease materials (Tables 6 and 7), show a good level of permeation for a cosmetic emulsion. Complementing this reference, it has been shown that lauric acid (C12: 0), and short chain fatty acids present in *Syagrus coronata* oil favored good spreading of the emulsions formulated from it, the average spreadability scores being 11.398 $mm^2$, followed by emulsifying systems containing oils: *Caryocar brasiliense*, *Pachira retusa* and *Pachira aquatica* (Table 4-B). These emulsions proved adequate against the freeze-defrost cycle. Regarding the organoleptic aspects, the emulsions presented characteristic odor, staining, and homogeneous phases. After centrifugation and vibration tests, a separation phase in the emulsion containing *Caryocar brasiliense* oil could be observed. The other emulsions remained stable, and as such were resubmitted to *in vitro* spreading, with variation occurring within the interval $p < 0.05$ as foreseen by the statistical

tests. The best vegetable oil and butter spreadability profiles were selected and previously planned by screening grease composition to examine the occurrence of cosmetic performance optimization and interaction between different levels of trans fatty acids present in each raw material. As such, simple emulsifying systems of combined oil/vegetable oil were formulated: (1*) Pachira retusa*/*Virola surinamensis*, (2) *Pachira retusa*/*Butyrospermum parkii*, (3) *Pachira aquatica*/*Virola surinamensis*, (4) *Pachira aquatica*/*Butyrospermum parkii*, (5) *Syagrus coronata*/*Virola surinamensis*, (6) *Syagrus coronata*/*Butyrospermum parkii* and all the tests applied to emulsions with separate natural emollients were applied. Table 4-C shows the spreadability profiles of emulsions compared to the combined emulsions with oils isolated.

**Table 2.** Viscosy of emulsions optimized at 25°C.

| **Emulsion** | **Medium viscosity(Cp)** |
|---|---|
| *Pachira aquatica/ Butyrospermum parkii* | 21.050 ± 210.33[a] |
| *Pachira aquatica/Virola surinamensis* | 21.063 ± 116.96[b] |
| *Pachira retusa/ Butyrospermum parkii* | 21.020 ± 171.78[b] |
| *Pachira retusa/Virola surinamensis* | 68.006 ± 205.34[c] |
| *Syagrus coronata/ Butyrospermum parkii* | 20.615 ± 150.47[b] |
| *Syagrus coronata/Virola surinamensis* | 23.890 ± 270.82[a] |
| Control emulsion | 15.500 ± 50.12[c] |

Different letters symbolize significant differences ($p < 0.05$) by mean of the Tukey test.
Data represent the mean ± SD of at least n=3. Control emulsion composition appears in Table 1 (F1).

**Table 3.** Comparison of rates of saturation and maximum spreadability.

| **Emulsions** | **Satured Oil (%)** | **Unsatured Oil (%)** | **Satured butter (%)** | **Unsatured butter (%)** | **Maximum spreadabiliy ($mm^2$)** |
|---|---|---|---|---|---|
| *P. aquatica/V. surinamensis* | 48.0 ± 0.28[c] | 51.1 ± 0.32[b] | 98.2 ± 0.22[a] | 1.9 ± 0.05[d] | 9 585.1 ± 74[e] |
| *P. retusa/V. surinamensis* | 63.5 ± 0.23[b] | 29.3 ± 0.41[d] | 98.2 ± 0.22[a] | 1.9 ± 0.05[d] | 9 371.6 ± 36[c] |
| *P.aquatica/B. parkii* | 48.0 ± 0.28[c] | 51.1 ± 0.32[b] | 44.0 ± 0.15[c] | 56.0 ± 0.22[b] | 7 584.6 ± 36[f] |
| *P.retusa/B. parkii* | 63.5 ± 0.23[b] | 29.3 ± 0.41[d] | 44.0 ± 0.15[c] | 556.0 ± 0.22[b] | 8 987.5 ± 41[c] |
| *S.coronata/B. parkii* | 97.0 ± 0.31[a] | 4.5 ± 0.05[d] | 44.0 ± 0.15[c] | 56.0 ± 0.22[b] | 8 237.2 ± 56[c] |
| *S.coronata/V. surinamensis* | 97.0 ± 0.31[a] | 4.5 ± 0.05[d] | 98.0 ± 0.22[a] | 1.9 ± 0.05[d] | 8 737.2 ± 110[d] |
| Control emulsion | - | - | - | - | 7 500.0 ± 100[d] |

Different letters symbolize significant differences ($p < 0.05$) by mean of the nonparametric (Friedman) and Tukey test.
Data represent the mean ± SD of at least n = 3.

**Table 4.** Spreadability (Ei) of vegetable butters and/or oils by methodology of Knorst (1991). **(A)** Spreadability of vegetable butters. **(B)** Spredability of vegetable oils. **(C)** Spreadability of emulsions combined oil butters.

| Plants | Mass (kg) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0.44 | 0.87 | 1.30 | 1.75 | 2.34 | 3.10 | 4.02 |
| **A) Spreadability of vegetable butters ($mm^2$)** | | | | | | | |
| *A. murumuru* | 3 422 ± 47.8$^{a}$ | 5 605 ± 59.2$^{a}$ | 6 359 ± 32.7$^{c}$ | 6 936 ± 40.8$^{c}$ | 7 235 ± 31.3$^{d}$ | 7 772 ±49.6$^{c}$ | 8 328 ± 56.2$^{a}$ |
| *B. parkii* | 4 299 ± 75.4$^{a}$ | 5 874 ± 36.7$^{c}$ | 6 863 ± 56.3$^{c}$ | 7 462 ± 37.3$^{d}$ | 8 409 ± 28.6$^{a}$ | 8 987 ± 69.1$^{a}$ | 9 935 ± 36.3$^{d}$ |
| *T. cacao* | 4 475 ± 61.1$^{a}$ | 5 806 ± 50.5$^{a}$ | 6 573 ± 55.0$^{f}$ | 6 936 ± 25.0$^{c}$ | 7 694 ± 64.4$^{a}$ | 8 167 ± 57.0$^{a}$ | 8 737 ± 20.4$^{a}$ |
| *T. grandiflorum* | 4 416 ± 47.0$^{a}$ | 5 605 ± 7.6$^{d}$ | 6 717 ± 64.5$^{f}$ | 7 159 ± 29.5$^{c}$ | 7 850 ± 10.0$^{c}$ | 8 328 ± 21.2$^{a}$ | 8 820 ± 25.2$^{a}$ |
| *V. surinamensis* | 4 534 ± 49.7$^{a}$ | 7 085 ± 117.1$^{a}$ | 7 772 ± 70.2$^{a}$ | 8 491 ± 70.9$^{a}$ | 8 987 ± 66.7$^{a}$ | 9 499 ± 64.6$^{d}$ | 10 024 ± 39.2$^{c}$ |
| Control | 1 287 ± 28.1$^{b}$ | 1 884 ± 106.6$^{e}$ | 2 289 ± 36.6$^{a}$ | 2 595 ± 51.1$^{a}$ | 2 873 ± 31.3$^{a}$ | 3 018 ± 65.4$^{a}$ | 3 066 ± 50.9$^{a}$ |
| **B) Spredability of vegetable oils ($mm^2$)** | | | | | | | |
| *A. tucuma* | 1 288 ± 91.6$^{a}$ | 1 885 ± 61.2$^{b}$ | 2 826 ± 56.8$^{c}$ | 3 472 ± 100.5$^{b}$ | 3 847 ± 75.4$^{b}$ | 4 241 ± 58.9$^{d}$ | 4 534 ± 110.7$^{e}$ |
| *C. brasiliense* | 3 902 ± 75.4$^{c}$ | 6 429 ± 58.9$^{e}$ | 7 462 ± 120.7$^{c}$ | 8 409 ± 73.6$^{e}$ | 8 987 ± 44.8$^{e}$ | 9 585 ± 66.9$^{f}$ | 10 024 ± 41.3$^{e}$ |
| *M. integrifolia* | 3 018 ± 28.2$^{b}$ | 4 475 ± 106.6$^{e}$ | 5 087 ± 36.6$^{d}$ | 5 343 ± 51.1$^{d}$ | 5 974 ± 31.3$^{d}$ | 6 429 ± 65.4$^{d}$ | 7 235 ± 50.9$^{e}$ |
| *O. speciosa* | 3 847 ± 47.8$^{c}$ | 4 961 ± 59.2$^{d}$ | 5 473 ± 32.7$^{d}$ | 5 874 ± 40.8$^{d}$ | 6 359 ± 31.3$^{d}$ | 6 789 ± 49.6$^{d}$ | 7 085 ± 56.2$^{e}$ |
| *P. aquatica* | 4 241 ± 75.4$^{d}$ | 5 214 ± 36.7$^{e}$ | 5 874 ± 56.3$^{e}$ | 6 359 ± 37.3$^{d}$ | 7 159 ± 28.7$^{e}$ | 7 462 ± 69.1$^{e}$ | 7 850 ± 36.3$^{e}$ |
| *P. retusa* | 4 013 ± 55.6$^{d}$ | 5 739 ± 70.8$^{e}$ | 6 429 ± 55.2$^{e}$ | 6 936 ± 91.6$^{d}$ | 7 462 ± 61.2$^{e}$ | 8 167 ± 56.8$^{e}$ | 8 820 ± 100.5$^{e}$ |
| *S. coronata* | 5 214 ± 64.2$^{e}$ | 7 310 ± 63.8$^{d}$ | 8 491 ± 55.6$^{f}$ | 9 241 ± 89.5$^{g}$ | 9 935 ± 33.4$^{f}$ | 10 746 ± 62.1$^{f}$ | 11 398 ± 74.6$^{g}$ |
| Control | 1 287 ± 64.2$^{b}$ | 1 884 ± 63.8$^{b}$ | 2 289 ± 55.6$^{a}$ | 2 595 ± 89.5$^{a}$ | 2 873 ± 75.4$^{b}$ | 3 018 ± 36.7$^{c}$ | 3 066 ± 56.3$^{c}$ |
| **C) Spreadability of emulsions combined oil/butters ($mm^2$)** | | | | | | | |
| *P. aquatica (Oil)* | 4 241 ± 88.2$^{a}$ | 5 214 ± 92.3$^{b}$ | 5 874 ± 36.6$^{b}$ | 6 359 ± 51.1$^{d}$ | 7 159 ± 31.3$^{e}$ | 7 462 ± 65.4$^{e}$ | 7 850 ± 50.9$^{e}$ |
| *P. aquatica/ B. parkii* | 3 737 ± 75.4$^{a}$ | 4 715 ± 36.7$^{a}$ | 5 214 ± 56.3$^{b}$ | 5 874 ± 37.3$^{b}$ | 6 359 ± 28.7$^{d}$ | 6 917 ± 69.1$^{d}$ | 7 585 ± 36.3$^{e}$ |
| *P. aquatica/ V. surinamensis* | 4 654 ± 51.3$^{a}$ | 5 214 ± 66.7$^{b}$ | 6 359 ± 74.3$^{d}$ | 7 010 ± 34.9$^{e}$ | 7 850 ± 33.6$^{e}$ | 8 655 ± 60.5$^{f}$ | 9 585 ± 74.8$^{g}$ |
| *P. retusa (Oil)* | 4 013 ± 63.6$^{a}$ | 5 739 ± 26.9$^{b}$ | 6 429 ± 58.3$^{d}$ | 6 936 ± 75.9$^{d}$ | 7 462 ± 88.2$^{e}$ | 8 167 ± 54.4$^{f}$ | 8 820 ± 94.7$^{f}$ |
| *P. retusa/ B. parkii* | 5 087 ± 73.4$^{b}$ | 6 501 ± 63.5$^{d}$ | 7 159 ± 86.1$^{e}$ | 7 772 ± 89.6$^{e}$ | 8 087 ± 32.5$^{f}$ | 8 328 ± 41.6$^{f}$ | 8 988 ± 41.3$^{f}$ |
| *P. retusa/ V. surinamensis* | 4 475 ± 75.4$^{a}$ | 6 079 ± 56.7$^{d}$ | 6 936 ± 56.3$^{d}$ | 7 616 ± 37.3$^{e}$ | 8 167 ± 28.7$^{f}$ | 8 491 ± 69.1$^{f}$ | 9 072 ± 36.3$^{g}$ |
| *S. coronasta (Oil)* | 5 214 ± 28.2$^{b}$ | 7 310 ± 106.6$^{e}$ | 8 491 ± 36.6$^{f}$ | 9 241 ± 51.1$^{g}$ | 9 935 ± 31.3$^{g}$ | 10 746 ± 65.4$^{g}$ | 11 398 ± 50.9$^{h}$ |
| *S. coronasta/ B. parkii* | 3 137 ± 64.2$^{a}$ | 4 550 ± 63.8$^{a}$ | 6 118 ± 55.6$^{d}$ | 6 290 ± 89.5$^{d}$ | 6 862 ± 75.4$^{d}$ | 7 600 ± 36.7$^{e}$ | 8 237 ± 56.3$^{f}$ |
| *S. coronasta/ V. surinamensis* | 3 737 ± 91.6$^{a}$ | 5 150 ± 61.2$^{b}$ | 6 218 ± 56.8$^{d}$ | 6 790 ± 100.5$^{d}$ | 7 462 ± 75.4$^{e}$ | 8 087 ± 58.9$^{f}$ | 8 737 ± 110.7$^{f}$ |
| Control | 1 287 ± 55.6$^{c}$ | 1 884 ± 70.8$^{c}$ | 2 289 ± 55.2$^{b}$ | 2 595 ± 91.6$^{b}$ | 2 873 ± 61.2$^{b}$ | 3 018 ± 56.8$^{a}$ | 3 066 ± 100.5$^{a}$ |

Different letters symbolize significant differences ($p < 0.05$) respect to the Control in non parametric (Friedman) test. Data represent the mean ± SD of at least n =3.

**Table 5.** pH of emulsions with butter and/or oils until 90 days and cycle freeze/defrost (G/D). **(A)** pH of emulsions with oils. **(B)** pH of emulsion with butters. **(C)** pH of emulsions combined oil/butter.

| Plants | Days | | | | | G/D |
|---|---|---|---|---|---|---|
| | 1 | 15 | 30 | 60 | 90 | |
| *A. murumuru* | 5.8 ± 0.19$^{a}$ | 5.6 ±0.19 $^{a}$ | 5.4 ± 0.23$^{c}$ | 5.3 ± 0.31$^{e}$ | 5.3 ± 0.15$^{a}$ | 5.3 ± 0.09$^{a}$ |
| *B. parkii* | 5.5 ± 0.15$^{a}$ | 5.4 ± 0.08$^{e}$ | 5.4 ± 0.25$^{c}$ | 5.4 ± 0.27$^{b}$ | 5.3 ± 0.15$^{a}$ | 5.4 ± 0.12$^{a}$ |
| *T. cacao* | 6.1 ± 0.10$^{b}$ | 5.8 ± 0.20$^{b}$ | 5.7 ± 0.12$^{a}$ | 5.7 ± 0.25$^{c}$ | 5.5 ± 0.20$^{b}$ | 5.7 ± 0.10$^{a}$ |
| *T. grandiflorum* | 5.8 ± 0.25$^{c}$ | 5.6 ± 0.16$^{a}$ | 5.5 ± 0.15$^{a}$ | 5.4 ± 0.22$^{b}$ | 5.5 ± 0.20$^{b}$ | 5.6 ± 0.28$^{b}$ |
| *V. surinamensis* | 6.0 ± 0.25$^{c}$ | 5.8 ± 0.18$^{b}$ | 5.6 ±0.10 $^{a}$ | 5.4 ± 0.20$^{b}$ | 5.5 ± 0.20$^{b}$ | 5.6 ±0.23 $^{b}$ |
| Control | 6.0 ± 0.25$^{c}$ | 5.6 ± 0.13$^{a}$ | 5.7 ± 0.12$^{a}$ | 5.8 ± 0.17$^{a}$ | 5.9 ± 0.14$^{a}$ | 5.9 ± 0.13$^{a}$ |
| *A. tucuma* | 5.5 ± 0.17$^{a}$ | 5.4 ±0.11 $^{a}$ | 5.2 ± 0.12$^{a}$ | 5.5 ± 0.23$^{b}$ | 5.4 ± 0.15$^{a}$ | 5.3 ± 0.20$^{b}$ |
| *O. speciosa* | 5.9 ± 0.11$^{b}$ | 5.8 ± 0.15$^{a}$ | 6.0 ± 0.20$^{b}$ | 6.2 ± 0.25$^{b}$ | 6.0 ± 0.12$^{d}$ | 5.9 ± 0.25$^{b}$ |
| *P. aquatica* | 5.9 ± 0.21$^{b}$ | 5.8 ± 0.2$^{b}$ | 5.7 ±0.13 $^{a}$ | 5.5 ± 0.25$^{c}$ | 5.6 ± 0.14$^{a}$ | 5.7 ± 0.23$^{b}$ |
| *P. retusa* | 6.4 ± 0.18$^{d}$ | 6.3 ± 0.25$^{d}$ | 6.1 ± 0.08$^{d}$ | 6.2 ± 0.20$^{b}$ | 6.0 ± 0.10$^{b}$ | 6.4 ± 0.20$^{b}$ |
| *S. coronata* | 6.5 ± 0.15$^{d}$ | 6.2 ±0.13 $^{d}$ | 6.1 ± 0.11$^{d}$ | 6.2 ± 0.21$^{b}$ | 6.4 ± 0.12$^{b}$ | 6.2 ± 0.21$^{b}$ |
| Control | 6.0 ± 0.16$^{d}$ | 5.6 ± 0.11$^{a}$ | 5.7 ± 0.16$^{a}$ | 5.8 ± 0.12$^{a}$ | 5.9 ± 0.11$^{a}$ | 5.9 ± 0.21$^{b}$ |
| *P. aquatica/B. parkii* | 5.8 ± 0.20$^{b}$ | 5.6 ±0.16 $^{a}$ | 5.4 ±0.17 $^{a}$ | 5.3 ± 0.13$^{a}$ | 5.3 ±0.12 $^{a}$ | 5.3 ± 0.23$^{b}$ |
| *P. aquatica/ V. surinamensis* | 6.1 ± 0.19$^{b}$ | 5.8 ± 0.25$^{b}$ | 5.7 ± 0.13$^{a}$ | 5.7 ± 0.18$^{a}$ | 5.5 ± 0.11$^{a}$ | 5.7 ± 0.11$^{a}$ |
| *P. retusa/B. parkii* | 5.5 ±0.15 $^{a}$ | 5.4 ±0.20$^{b}$ | 5.4 ± 0.30$^{e}$ | 5.4 ± 0.20$^{a}$ | 5.3 ± 0.15$^{a}$ | 5.4 ± 0.14$^{a}$ |
| *P. retusa/ V. surinamensis* | 6.0 ± 0.16$^{b}$ | 5.8 ± 0.20$^{b}$ | 5.6 ± 0.27$^{b}$ | 5.4 ± 0.15$^{a}$ | 5.5 ± 0.21$^{b}$ | 5.6 ± 0.22$^{b}$ |
| *S. coronata/B. parkii* | 5.5 ± 0.15$^{a}$ | 5.3 ± 0.17$^{a}$ | 5.6 ± 0.18$^{a}$ | 5.3 ± 0.15$^{a}$ | 5.4 ± 0.23$^{b}$ | 5.5 ± 0.22$^{b}$ |
| *S. coronata/ V. surinamensis* | 5.8 ± 0.11$^{a}$ | 5.6 ±0.12 $^{a}$ | 5.5 ± 0.12$^{a}$ | 5.4 ± 0.15$^{a}$ | 5.5 ± 0.25$^{b}$ | 5.6 ± 0.25$^{b}$ |
| Control | 6.0 ± 0.17$^{b}$ | 5.6 ±0.24 $^{b}$ | 5.7 ± 0.12$^{a}$ | 5.8 ±0.10$^{b}$ | 5.9 ± 0.10$^{a}$ | 5.9 ± 0.16$^{a}$ |

Different letters symbolize significant differences ($p < 0.05$) by mean of the Tukey test. Data represent the mean ± SD of at least n =3.

**Table 6.** Fatty acids composition (%) prior screening of vegetable oil.

| Fatty acid | *S. coronata* | *C. brasiliensis* | *P. retusa* | *M. integrifolia* | *P. aquatica* | *O. speciosa* | *A. tucuma* |
|---|---|---|---|---|---|---|---|
| Capric acid | 15.0 ± 0.25$^{d}$ | - | - | - | - | 5.5 ± 0.25$^{b}$ | - |
| Caproic acid | - | - | 0.2 ± 0.08$^{m}$ | 0.2 ± 0.02$^{a}$ | - | - | - |
| Caprylic acid | 27.3 ± 0.34$^{d}$ | - | - | - | - | 5.5 ± 0.16$^{b}$ | - |
| Lauric acid | 39.5 ± 0.65$^{d}$ | - | - | - | - | 43.0 ± 0.35$^{a}$ | - |
| Linolenic acid | - | - | 8.5 ± 0.21$^{c}$ | 2.6 ± 0.12$^{e}$ | 0.5 ± 0.34$^{f}$ | - | 3.8 ± 0.21$^{b}$ |
| Linoneic acid | - | 1.0 ± 0.36$^{e}$ | 1.6 ± 0.38$^{i}$ | 1.9 ± 0.4$^{e}$ | 11.3 ± 0.25$^{d}$ | 2.6 ± 0.38$^{b}$ | - |
| Myristic acid | 8.1 ± 0.46$^{c}$ | - | - | - | - | 16.0 ± 0.63$^{d}$ | - |
| Oleic acid | 4.5 ± 0.72$^{a}$ | 54.9 ± 0.52$^{a}$ | 19.2 ± 0.72$^{a}$ | 58.2 ± 0.24$^{f}$ | 39.3 ± 0.63$^{d}$ | 15.0 ± 0.51$^{d}$ | 56.4 ± 0.52$^{a}$ |
| Palmitic acid | 4.0 ± 0.61$^{b}$ | 40.5 ± 0.45$^{a}$ | 60.0 ± 0.61$^{c}$ | 8.9 ± 0.05$^{d}$ | 44.9 ± 0.41$^{a}$ | 9.0 ± 0.74$^{a}$ | 26.4 ± 0.61$^{d}$ |
| Palmitoleic acid | - | - | - | 23.0 ± 0.2$^{a}$ | - | - | 0.2 ± 0.03$^{a}$ |
| Stearic acid | 4.2 ± 0.40$^{a}$ | 1.9 ± 0.35$^{e}$ | 3.3 ± 0.40$^{b}$ | 4.3 ± 0.15$^{e}$ | 3.1 ± 0.05$^{d}$ | 13.5 ± 0.48$^{d}$ | 3.5 ± 0.37$^{e}$ |

Different letters symbolize significant differences ($p < 0.05$) by mean of the Tukey test. Data represent the mean ± SD of at least n = 3.

**Table 7.** Fatty acids composition (%) prior screening of vegetable butter.

| Fatty acid | *T. cacao* | *T. grandiflorum* | *A. murumuru* | *V. surinamensis* | *B. parkii* |
|---|---|---|---|---|---|
| Araquidic acid | 0.6 ± 0.15$^{b}$ | 7.9 ± 0.25$^{a}$ | 0.1 ± 0.05$^{b}$ | - | - |
| Beenic acid | 0.1 ± 0.02$^{d}$ | 0.7 ± 0.32$^{b}$ | - | - | - |
| Capric acid | - | - | 2.1 ± 0.05$^{a}$ | 1.0 ± 0.03$^{c}$ | - |
| Caproic acid | - | - | - | - | - |
| Caprylic acid | - | - | 2.7± 0.08$^{a}$ | - | - |
| Lauric acid | - | - | 51.6± 0.72$^{a}$ | 19.8 ± 0.25$^{a}$ | - |
| Linolenic acid | 0.1 ± 0.06$^{b}$ | 0.2 ± 0.02$^{d}$ | 0.1 ± 0.05$^{b}$ | - | 6.1 ± 0.34$^{a}$ |
| Linoneic acid | 1.8 ± 0.10$^{c}$ | 2.4 ± 0.26$^{b}$ | 3.1 ± 0.33$^{b}$ | - | - |
| Myristic acid | 0.1 ± 0.02$^{b}$ | 0.1 ± 0.01$^{d}$ | 25.8± 0.10$^{d}$ | 68.1 ± 0.31$^{e}$ | - |
| Oleic acid | 24.7 ± 0.32$^{a}$ | 38.8 ± 0.48$^{a}$ | 5.7 ± 0.23$^{a}$ | 0.9 ± 0.24$^{b}$ | 50.0 ± 0.53$^{e}$ |
| Palmitic acid | 38.3 ± 0.51$^{a}$ | 11.2 ± 0.28$^{a}$ | 6.0 ± 0.12$^{a}$ | 5.2 ± 0.15$^{a}$ | 4.1 ± 0.15$^{a}$ |
| Palmitoleic acid | 0.7 ± 0.11$^{b}$ | 0.4 ± 0.05$^{b}$ | - | - | - |
| Stearic acid | 33.5 ± 0.40$^{a}$ | 38.1 ± 0.45$^{a}$ | 2.9 ± 0.05$^{a}$ | 5.0 ± 0.10$^{a}$ | 40.1 ± 0.26$^{e}$ |

Different letters symbolize significant differences ($p < 0.05$) by mean of the Tukey test. Data represent the mean ± SD of at least n = 3

The pH values obtained showed a slightly acidic pH range about skin, with a composition of 4.5 to 6 according to Brooks and Idson (1991) and 4 to 7 by Taylor (1995). The batch was then measured in triplicate at 15, 30, 60, and 90 days at a room temperature of 25°C, after the pH of the emulsion preparation. After the 90-day cycle, the emulsions were subjected to low-temperature cycle freeze/defrosted, and the respective analyzed pHs (Table 5-A-B).

Even subject to combined emulsion systems, systems containing the semi-arid oils (*Syagrus coronata*, *Pachira retusa,* and *Pachira aquatica*), maintained a pH compatible with formulations for skin (Table 5-C).

The oils studied have in their fat composition unsaturated omega 3, 6 and 9 acids that allow proper skin hydration, and a high degree of spreadability. According to Rieger (1987), the epidermis presents an oil balance between saturated/unsaturated fats of 1.2. Among the certificate oils, the *Pachira retusa* oil (2.1) and *Pachira aquatica* oil (0.94) have the closest saturation band relationship to that of the epidermis. Despite having optimized the combined emulsifying systems, *Virola surinamensis* butter has a high content of the saturated/unsaturated relationship (51.36). However, *Butyrospermum parkii* butter presented 0.79% in the same relation. Analyzing these screening saturation profiles, the combination *Pachira retusa*/*Butyrospermum parkii* and *Pachira aquatica*/*Butyrospermum parkii* gives a desirable cosmetic performance, as already confirmed by experiment. *Butyrospermum parkii* butter has 56% unsaturated fatty acids compared with 44% saturated fatty acids in its composition. The *Pachira aquática* oil and that of the *Pachira retusa* present for saturated fatty acids 48 and 63%, and for unsaturated 51 and 29%, respectively. It is possible through screening, however, to calibrate an emollient with a greater saturated percentage, with one that contains a reduced percentage. The aim of this is to obtain a ratio close to 1.2 (saturation index/introduction of the skin).

Only the optimized emulsions were analyzed for viscosity (Table 2). It was observed that the emulsion containing *Pachira retusa* oil combined with *Virola surinamensis* butter showed a higher viscosity. One infers from this that the combination of palmitic and myristic fatty acids mainly is responsible for this character of the emulsion. Correlating this with the values of Table 3, there is not a direct relationship with spreadability. It was expected because the higher the viscosity, the less likely it is to spread. However, in terms of fatty acids, it appears that myristic acid as a constituent of *Virola surinamensis* butter interferes with the viscosity of emulsions. It occurred when high viscosity emulsions were combined with this vegetable butter. Regarding emulsion control, there were consistent results since the accretion of emollients directly influences the emulsion's viscosity.

If a screening of the saturation profile (Tables 8 and 9) is made, comparing it with spreadability (Table 4–A-C), it appears that the more saturated profiles contain vegetable oil as observed with the *Virola surinamensis* butter in all its combinations. Therefore spreadability will be greater, being differentiated by the interactions of oil emulsifier greases present in the same system. Regarding viscosity, it was noted that the *Pachira retusa* emulsion containing oil and *Virola surinamensis* butter has a high percentage of oil saturation/unsaturation butter 63.47/1.91, and even butter saturation/unsaturation oil 98.2/29.28 applying the same relation to the emulsion containing the *Syagrus coronasta* oil combined with butter of *Virola surinamensis*. However, the data can only be indicative. It is necessary to analyze the composition by screening of the grease content of each emollient and the interactions of these greases.

## CONCLUSIONS

Screening grease material can be a strategy used in the development of cosmetic formulations. Vegetable oils and butter that present a high saturated fatty acid content, with a low molecular weight, grant one an emulsion with good spreadability. The screening can also help in a preliminary study of viscosity since viscosity is not related to spreadability. The combination of vegetable oils, which have a high content of short chain fatty acids, with a vegetable butter rich in

oleic acid, and vice-versa, could be the adequate combination for the optimization of the spreadability of emulsions. However, the screening strategy allows one to directly formulate systems based in the analysis of fatty profiles, so as to minimize the time and cost for the research, development and innovation in large-scale production. Furthermore, the fixed oils existing in Brazilian oilseeds from Bahia, such as the *Pachira retusa*, *Pachira aquatica* and *Syagrus coronata* should be applied as raw materials valuable in the development of cosmetic emulsions.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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**Table 8.** Relationship between satured fatty acid/unsaturated fatty acid from vegetable butter.

| Butters | Saturated (%) | Unsaturated (%) | Saturated/Unsaturated (%) |
|---|---|---|---|
| *A. murumuru* | $91.2 \pm 0.31^{a}$ | $8.7 \pm 0.21^{d}$ | $10.5 \pm 0.52^{d}$ |
| *B. parkii* | $44.0 \pm 0.15^{c}$ | $56.0 \pm 0.22^{b}$ | $0.8 \pm 0.37^{f}$ |
| *T. grandiflorum* | $58.3 \pm 0.25^{b}$ | $40.6 \pm 0.41^{e}$ | $1.4 \pm 0.61^{f}$ |
| *T.cacao* | $72.7 \pm 0.35^{b}$ | $27.3 \pm 0.25^{e}$ | $2.7 \pm 0.60^{f}$ |
| *V. surinamensis* | $98.1 \pm 0.22^{a}$ | $1.9 \pm 0.05^{d}$ | $51.4 \pm 0.27^{b}$ |

Different letters symbolize significant differences ($p < 0.05$) by mean of the Tukey test.
Data represent the mean ± SD of at least n = 3.

**Table 9.** Relationship between satured fatty acid: unsaturated fatty acid from vegetable oil.

| Oils | Saturated (%) | Unsaturated (%) | Saturated/Unsaturated (%) |
|---|---|---|---|
| *A. tucuma* | $25.6 \pm 0.14^{e}$ | $74.4 \pm 0.22^{a}$ | $0.3 \pm 0.36^{g}$ |
| *C. brasiliensis* | $42.3 \pm 0.45^{b}$ | $54.9 \pm 0.25^{c}$ | $0.8 \pm 0.70^{g}$ |
| *M. integrifolia* | $13.1 \pm 0.37^{d}$ | $85.9 \pm 0.21^{a}$ | $0.2 \pm 0.58^{f}$ |
| *O. speciosa* | $82.5 \pm 0.25^{c}$ | $17.6 \pm 0.24^{b}$ | $4.7 \pm 0.49^{f}$ |
| *P. aquatica* | $48.0 \pm 0.28^{e}$ | $51.1 \pm 0.32^{c}$ | $0.9 \pm 0.60^{h}$ |
| *P. retusa* | $63.5 \pm 0.23^{c}$ | $29.3 \pm 0.41^{b}$ | $2.2 \pm 0.64^{f}$ |
| *S. coronata* | $97.0 \pm 0.31^{a}$ | $4.5 \pm 0.05^{b}$ | $21.6 \pm 0.36^{b}$ |

Different letters symbolize significant differences ($p < 0.05$) by mean of the Tukey test.
Data represent the mean ± SD of at least n = 3.

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