Scientific Electronic Archives
Issue ID: Sci. Elec. Arch. Vol. 12 (6)
December 2019
DOI: http://dx.doi.org/10.36560/1262019998
Article link
http://www.seasinop.com.br/revista/index.php?journal=SEA&page=article&op=view&path%5B%5D=998&path%5B%5D=pdf
Included in DOAJ, AGRIS, Latindex, Journal TOCs, CORE, Discoursio Open Science, Science Gate, GFAR, CIARDRING, Academic Journals Database and NTHRYS Technologies, Portal de Periódicos CAPES.

ISSN 2316-9281

Development and stability study of products containing cupuaçu butter

R. V. F. Esprendor; A. L. Raiser; M. P. R. Torres; E. B. Ribeiro; R. M. Nogueira; C. R. Andrighetti; D. M. S. Valladão.

Federal University of Mato Grosso - Campus Sinop

Author for correspondence: deniavalladao@gmail.com

Abstract: The Amazon region is responsible for much of Brazil's native fruit biodiversity. In this context, stands out the cupuaçu (*Theobroma grandiflorum (*Wild. Ex Spreng.) K. Schum.), a fruit tree whose fruit has a seed with high fat content and nutritional value, besides antioxidant and moisturizing activities. The present research aimed to use the cupuaçu butter in the development of shampoo and emulsion formulations, evaluating their stability and the antioxidant activity of the emulsion. The butter was extracted from cupuaçu pulping byproducts by the ultrasound assisted extraction method, and was used to formulate four shampoos (I, II, III and IV) and emulsions containing 3% and 5% of cupuaçu butter. All formulations had their organoleptic characteristics (color, odor and appearance) and physicochemical parameters (pH determination, viscosity, conductivity and centrifugation) analyzed, as well as the evaluation of shampoo density, foam persistence and refractive index and spreadability and potencial antioxidant activity of the emulsion. The stability of the formulations was evaluated by monitoring the organoleptic and physicochemical characteristics by the preliminary and accelerated stability tests. Shampoo formulations I and II showed lower than expected viscosity during the preliminary stability test and were discarded. After accelerated stability, formulation IV had a change in its appearance while formulation III was satisfactory in the other parameters, only presenting a decrease in the viscosity values, allowing the addition of a new thickening agent. Emulsions showed values within the standards in all evaluations and were stable during stability tests. The spreadability of the butter-containing emulsions was higher than the control emulsion, implying that the addition of the butter provides ease of application. Emulsions showed low antioxidant activity as they are produced with processing byproducts, but allowing the addition of smaller amounts of synthetic antioxidants to the formulation. Thus, the use of cupuaçu butter obtained from pulping byproducts has been shown to be applicable in the development of different formulations of commercial interest such as shampoos and emulsions.

Keywords: Cupuaçu butter, emulsions, shampoo, quality control.

Introduction

Due to the richness of its flora, the Amazon biome is considered the cradle of native fruits, but many have not been evaluated for their nutritional and health properties. Popular medicine suggests that most of these fruits have functional properties, yet they are not profoundly explored in the scientific field.(Abadio Finco et al., 2012). The diversity of fruits with different flavors and scents contributes for the economics and appreciation of the region (Braga et al., 2010).

One of the most common trees in the Amazon forest is the cupuaçuzeiro (*Theobroma grandiflorum*), that produces the fruit cupuaçu, which concentrates its production in the states of Maranhão and Pará (Azevedo, Kopcak & Mohamed, 2003; Teixeira, 2014). The cupuaçu fruit measures from 12 to 15 cm of length and from 10 to 12 cm of width, weighing around 1kg (Teixeira, 2014). The pulp, which makes up to 30% of the fruit, is used as ingredient for a diverse range of products, like juices, ice cream, jams, liqueurs, due to its creaminess and exotic flavor (Azevedo, Kopcak & Mohamed, 2003). It has botanical and chemical similarity with cocoa, since they belong to the same genus *Theobroma*, however, cupuaçu almonds have higher biological value than cocoa's (Teixeira, 2014; Lopes, 2000). Although the seed represents only about 20% of the fruit and is mostly discarded as waste, it has a high fat content (62%) and a high nutritional value (Teixeira, 2014; Azevedo, Kopcak & Mohamed, 2003; Carvalho, 2004).

Cupuaçu butter is a triacylglycerol compound of saturated and insaturated fatty acids, with a low melting point and the appearance of a soft solid (Teixeira, 2014). Essential nutrients, vitamins and antioxidants, which help to promote skin elasticity, anti-aging action as well as improve skin hydration and protection against the effects of UV-A and UV-B rays, are found in it (PEREIRA Et Al, 2015).

The cosmetic industry, with the new market trends, has been looking for options for naturally occurring compounds, rich in oils and with antioxidant, emollient and moisturizing properties. Examples of the most common products used in the cosmetic industry include emulsions and shampoos. According to Miguel et al. (2002), in compounding pharmacies in the state of Paraná, emulsions make up 18% of formulated products and shampoo represents 9%. In addition, according to ABIHPEC (2008), Brazil is the 4th country that consumes the most personal hygiene, perfumery and cosmetic products, being the 3rd largest market for hair care products and the 8th for skin care products.

Within this context, the present research had the objective of using the cupuaçu butter in the development of shampoo and emulsionated formulations. In addition, the stability of the developed products and the potencial antioxidant property of the emulsion were also studied.

Methods

Cupuaçu butter extraction

The cupuaçu seeds, from the cupuaçu fruit used for pulp production, were obtained from the company Yasai Alimentos, the seeds were ground in a knife mill and the fat extracted using ultrasound and hexane solvent. The seed/solvent mixture was prepared in a 1:5 ratio and underwent an ultrasonic bath for two hours, using a frequency of 45 kHz. Afterwards, the butter/solvent mixture was filtered and evaporated on a rotary evaporator at 50°C, obtaining the cupuaçu crude fat (SCHONS Et Al., 2017).

Shampoo

Four shampoo formulations were developed using the raw materials Triethanolamine Lauryl Ether Sulfate, Sodium Lauryl Ether Sulfate, Lauryl Polyglucoside, Cocoamidopropyl betaine, hydrolyzable Silicone, Lactic Acid, Methylparaben, Propylparaben, EDTA disodium, Pearly base, Coconut fatty acid diethanolamine, Sodium Chloride, Distilled water, ultrasound-extracted cupuaçu butter. The proportions of each constituent of the formulations are in Table 1.

Preparation Technique:

Formulation I and II

In a beaker, under constant manual stirring with a glass rod and heating from a water bath at 80 °C, the raw materials in the order 1 or 2, 3, 4, 6, 7, 8, 9, 10 and 11 were added. After the total cooling of the formulation, the remaining volume was filled with distilled water (14) and lactic acid (5) was added (Cunha; Silva & Chorilli, 2009; Silva & Silva, 2017).

Formulation III and IV

In a beaker, under constant manual stirring with a glass rod and heating from a water bath at 80 °C, the raw materials in the order 1 or 2, 3, 4, 6, 7, 8, 9, 10, 11 and 12 were added. After the total cooling of the formulation, the previously diluted, in distilled water, sodium chloride (13) was added, the remaining volume was filled with (14) and the lactic acid (5) was added (Cunha; Silva & Chorilli, 2009; Silva; Silva, 2017).

Emulsions

The emulsions were prepared according to Raiser et al. (2018) using the raw materials: Lanette N (Sintetica®) 5%, propyleneglycol (Sintetica®) 5%, Nipagin (Sintetica®) 0.015%, Nipazole (Sintetica®) 0.05%, EDTA (Sintetica®) 0.1%, and cupuaçu butter from 3% and 5%.

Physicochemical characterization

pH, viscosity, conductivity, centrifugation and stability studies were performed for shampoos and emulsions; foam persistence and density were performed only for shampoos and spreadability and potential antioxidant activity only for emulsions.

Preparation Technique

Emulsions were prepared by heating the aqueous phase separately at 75°C and the oily phase at 70°C in a water bath. After complete solubilization of the components, the aqueous phase was slowly poured over the oily phase, under constant agitation with the aid of a pistil until completely cooled.

Organoleptic Characteristics

The shampoo and emulsion formulations were visually analyzed, observing changes in homogeneity, color and odor. The changes that can be found are: possible thickening, presence of precipitates, change in color, presence of lumps or non-dispersed particles (Cunha; Silva & Chorilli, 2009; Lourenço & Lyra, 2015).

PH determination was performed with digital pH meter (Del Lab®), by direct insertion of the electrode into the formulations (Ferreira, 2010; Lourenço & Lyra, 2015).

Viscosity determination was obtained using a compact rotational viscometer MYR® VR-3000. It was determined using spindle 3 at 20 RPM for shampoo (Cunha; Silva & Chorilli, 2009; Lourenço & Lyra, 2015), and spindle 4 for emulsion (Frange & Garcia, 2009).

Conductivity was assessed by direct insertion of the electrode into the formulations using the conductivity meter (Del Lab®)(Raiser et al., 2018a).

The samples were centrifuged at 25°C in a centrifuge (Quimis®) at 3000 RPM for 30 minutes (Raiser et al., 2018a).

The refractive index was determined using the Abbe refractometer (Polax WYA-2S), calibrating the equipment with distilled water (Raiser et al., 2018a).

Relative density for shampoo formulations was determined using the pycnometer method (Brasil, 2010), using the equation:

$$d = \frac{M_1 - M_0}{V}$$

Where d = density in gmL^{-1}; M_1 = Mass of the pycnometer with the sample; M_0 = Mass of the empty pycnometer; V = Volume of the pycnometer in mL. (Lourenço & Lyra, 2015).

Table 1. Formulation I, II, III and IV of shampoo containing cupuaçu oil.

Nº	Constituent	Function	Quantity (%)			
			I	II	III	IV
1	Triethanolamine Lauryl Ether Sulfate	Anionic surfactant	12	-	12	-
2	Sodium Lauryl Ether Sulfate	Anionic surfactant	-	12	-	12
3	Lauryl Polyglucoside	Nonionic surfactant	12	12	12	12
4	Cocoamidopropyl betaine	Amphoteric surfactant / thickener	5	5	9	9
5	Hydrolyzable silicone	Overfatener/ conditioner	0,4	0,4	0,4	0,4
6	Lactic Acid	pH corrector	q.s.p. 5,5-6,5	q.s.p. 5,5-6,5	q.s.p. 5,5-6,5	q.s.p. 5,5-6,5
7	Methylparaben	Preservative	0,1	0,1	0,1	0,1
8	Propylparaben	Preservative	0,1	0,1	0,1	0,1
9	EDTA disodium	Chelator / Antioxidant	0,1	0,1	0,1	0,1
10	Pearly base	Beading	2	2	6	6
11	Cupuaçu butter	Emolience / Nutrition / Moisturizer	0.3	0.3	0.3	0.3
12	Coconut fatty acid diethanolamine	Thickener	-	-	6	6
13	Sodium chloride	Thickener	-	-	2	2
14	Distilled water	Vehicle	q.s.p. 100 mL	q.s.p. 100 mL	q.s.p. 100 mL	q.s.p. 100 mL

Persistence of foam formed in shampoos

The persistence and quality of the foam formed in the shampoo formulations was analyzed by adding 40 mL of water in a 100 mL graduated cylinder and adding 1.0 g of the shampoo sample, capping the graduated cylinder and shaking vigorously for 1 minute until foaming. After this period, the beaker was kept at rest and protected from light until the foam disappeared, which was timed, thus establishing the foam persistence time (Ferreira, 2010).

Stability studies

Formulation stability and quality control trials were divided into preliminary and accelerated stability. For the preliminary stability study, the formulations went through alternating cycles of 45.0 ± 2.0 °C and in a refrigerator at 5.0 ± 2.0 °C every 24 hours for a period of 14 days (Brasil, 2004). PH, conductivity and viscosity were determined at the beginning and end of the cycles. In the accelerated stability, three distinct groups of samples were kept under different storage conditions: being a drying oven at 45.0 ± 2.0 °C, refrigerator at 5.0 ± 2.0 °C and 25.0 ± 2.0 °C room temperature for 60 days. On days 0, 30 and 60, the samples were taken out of the storage and kept in room temperature for evaluation of their physicochemical characteristics, pH, conductivity and viscosity (Lourenço & Lyra, 2015; Brasil, 2004).

Spreadability

The spreadability of the formulations was determined according to Raiser et al. (2018). Approximately 0.5 g of the sample was introduced into the plate opening and a glass plate with predetermined weight was placed on the sample. The mean diameter was calculated by measuring the diameter in two opposite positions. The spreadability at 25 °C was determined by the equation: $s = \pi \times d^2 / 4$, where s: spreadability of the sample by the weight x (mm^2), d: mean diameter (mm) (RAISER et al., 2018b; ZANIN et al., 2001)

Antioxidant activity

Potential antioxidant activity was determined by the DPPH radical scavenging method (2,2-diphenyl-1-pricylhydrazyl), according to Lange et al., 2009. For the calibration curve, solutions of the DPPH radical in the concentration range of 5.0 to 60.0 $mmolL^{-1}$ in methanol were prepared.

Samples were diluted in methanol at concentrations from 1.562 a 3.125 μgmL^{-1} and analyzed in reaction with DPPH in triplicate.

The percentage of remaining DPPH was calculated through the absorbance values, expressed as a percentage of DPPH inhibition, by the equation: % of DPPH inhibition = $[(A_0 - A_1) / A_0 x 100]$, where A_0 represents the absorbance of the control and A_1, the absorbance of the sample (LANGE et al., 2009).

Results and discussion

The yield of cupuaçu butter using ultrasound extraction was 27.0% considering the weight of the seeds used and the final amount of raw butter. Vasconcelos et al., (1975) obtained 59.2% of fat using hexane solvent, while Azevedo, Kopcak &

Mohamed, (2003) obtained 62.3 ± 2.00% of fat by Soxhlet extraction both in relation of the cupuaçu seeds. This difference can be related with climate factors and the regional variability of the plants used for the extraction (Raiser et al., 2018a). Furthermore, the seeds used were residue of the cupuaçu pulp processing. The use of these fruit residues, such as pomace, peel and seeds, have the advantage of reducing the waste that causes environmental pollution, besides adding to the added value of the product and providing nutritional value (Corrêa et al. 2019).

The produced shampoo formulations I, II, III and IV were homogeneous, colorless and with characteristic odor.

The data of the relative density determination are presented in Table 2 and the values ranged from 1.105 to 1.109 gmL^{-1}. Legislation does not establish a value to the density test, only instructs to the necessity of maintaining the homogeneity of this parameter between batches. The values measured during the stability tests didn't present significant variations, considering that variations above 20% may indicate instabilities.

When the samples were submitted to the centrifugation didn't present phase separation nor presence of precipitates. The centrifugation test is important to predict instability once it simulates the increase of gravitational force and consequently the particles mobility (Silva & Silva, 2017).

Table 2. Shampoo formulation densities.

Formulations	Density (gmL^{-1})
I	1.1064 ± 0,003
II	1.1057 ± 0,003
III	1.1068 ± 0,002
IV	1.1090 ± 0,003

In the preliminary stability tests the formulations I and II presented no alterations in the organoleptic characteristics after the temperature cycles, remaining stable throughout it.

The preliminary stability test involves important parameters to identify instability in the formulation's composition, besides possible chemical alterations or microbiological contaminations (Fujiwara et al., 2014). The centrifugation and preliminary stability results of formulations I and II can be seen in Table 3.

Table 3. Preliminary stability for formulations I and II.

Formulation	Time (days)	Appearance, Color and Odor	pH	Conductivity (µScm^{-1})	Viscosity (cP)
I	0	N	5.763 ± 0.182	9.852 ± 0.211	50.00 ± 0.001
	14	N	6.110 ± 0.334	12.11 ± 0.764	124.5 ± 91.3
II	0	N	5.572 ± 0.856	8.370 ± 0.040	19.00 ± 0.001
	14	N	5.660 ± 0.693	9.690 ± 0.809	23.5 ± 13.770

Appearance, Color and Odor: N - Normal, M - Modified; pH - pH value

The formulations presented pH values that ranged from 6.11 ± 0.33 to 5.57 ± 0.85. According to Lourenço & Lyra (2015) and Ferreira (2010) the shampoos must have pH between 5.0 and 7.0. Thus, the formulations were ideal for use after the temperature cycle and preliminary stability.

For the conductivity test, values that ranged from 8.37 ± 0.04 to 12.11 ± 0.76 µScm^{-1} were obtained. No alterations compromising product stability were observed. The values are related not only to the water (biggest percentage in the formulation), but also due to anionic surfactants present in the formulation (Silva & Silva, 2017).

The viscosity, presented low values, being lower than the desired for the development of a shampoo, where the values obtained ranged from 19.00 ± 0.01 to 124.50 ± 91.33 cP. According to Vieira, Moreira & Frizzo (2017), the ideal is that a shampoo has a viscosity of 2000 cP. Commercial shampoos typically have viscosity in the range of 2000 to 5000 cP.

Due to the low viscosity of shampoo formulations I and II, modifications were made to the formulations, where new raw materials were added. The new formulations were designated III and IV.

For the composition of formulations III and IV (Table 1) a greater amount of the thickening agent, cocoamidopropyl betaine, was added, up to 9%, same amount used by Fujiwara et al. (2014) and obtained a viscosity of 3277.1 cP after stability studies. In addition, 6% coconut fatty acid diethanolamide and 2% sodium chloride were added to the formulations. Coconut fatty acid diethanolamide has in addition to thickening effect, an overfatener and a foam stabilizer action, providing the replacement of fatty acids to the yarn and better foam sensory characteristics, besides increasing viscosity (Lourenço &Lyra, 2015).

Sodium chloride is an electrolyte that provides the increase of viscosity in shampoos with anionic surfactants, when employed in up to 5% of the formulation (Ferreira, 2010). Lourenço & Lyra

(2015), when using the salt, obtained viscosity values that ranged from 5412.4 to 6705.8 cP, while Cunha; Silva & Chorilli (2009) obtained 1250 to 2600 cP. The use of sodium chloride in shampoos is controversial due to the dryness of the hair strands that this electrolyte may cause. However, the amount used in this hair product is not enough for such action, besides, when evaluated in vitro and in vivo, no statistical difference was observed in brushing the hair (Silva et al., 2011).

The shampoo formulations III and IV, prepared after modifications, were evaluated during 60 days in different temperatures (accelerated stability test) in which the results are presented in Table 4.

Adding the thickening agents to the formulations III and IV was effective only for formulation III. Formulation IV presented low viscosity and phase separation after the 50th day of storage, being discarded.

Formulation III did not present meaningful changes ($p < 0.005$) of pH, conductivity or organoleptic changes during all period.

Conductivity increased in relation to the values obtained in the preliminary stability due to the addition of the sodium chloride, that by forming ions helps in the conduction of the ions already present in the formulation. For the viscosity determination, a value of 2210 cP was initially observed, decaying by the end of the 60 days to 1066 cP in ambient temperature, and to 636.0 cP when stored in 5 and 45 °C. Fujiwara et al. (2014) also obtained decreasing viscosity in their samples after 30 days of study. Gama et al. (2014) observed in child shampoos, greater viscosity (above 2349.33 cP) when those presented in their composition a greater quantity of amphoteric and nonionic surfactants, besides other thickening agents like methyl glucose dioleate (PEG-120), of the polyethylene glycols class (PEGs), substances of high thickening power consisting of mixtures of polymeric compounds (Chiroli, Campos & Silva, 2013).

Foam persistence was evaluated only in formulation III, which presented foam of adequate appearance, with small round lasting bubbles (Ferreira, 2010), taking 120.00 ± 5.00 minutes for the created foam fully disappear. Thus, the formulation III was stable in the tests to which it was submitted, compared to the other formulations. It is noteworthy that it would be interesting the addition of a new thickening agent in the formulation to obtain viscosity results closer to the ones found commercially, with the purpose of satisfying the final consumer.

Table 4. Accelerated stability of shampoo formulations III and IV.

Formulation	Temperature (ºC)	Time (days)	Appearance, Color and Odor	pH	Conductivity (μScm^{-1})	Viscosity (cP)
III	5ºC ± 2	0	N	6.850 ± 0.000	29.86 ± 0.000	2210 ± 0.000
		30	N	6.923 ± 0.025	24.47 ± 0.150	930.0 ± 26.46
		60	N	7.010 ± 0.010	21.80 ± 0.370	636.67 ± 25.17
	25ºC ± 2	0	N	6.850 ± 0.000	29.86 ± 0.000	2210 ± 0.000
		30	N	6.913 ± 0.015	24.76 ± 1.360	1056 ± 35.12
		60	N	6.943 ± 0.021	22.51 ± 0.105	1066 ± 30.55
	40ºC ± 2	0	N	6.850 ± 0.000	29.86 ± 0.000	2210 ± 0.000
		30	N	7.037 ± 0.031	22.99 ± 1.328	600.0 ± 26.46
		60	N	7.185 ± 0.005	21.80 ± 0.258	636.0 ± 25.17
IV	5ºC ± 2	0	N	6.150 ± 0.000	25.43 ± 0.000	70.00 ± 0.000
		30	N	7.027 ± 0.031	27.09 ± 0.696	171.0 ± 24.66
		60	M	-	-	-
	25ºC ± 2	0	N	6.150 ± 0.000	25.43 ± 0.000	70.00 ± 0.000
		30	N	6.937 ± 0.012	26.513 ± 0.558	150.0 ± 9.165
		60	M	-	-	-
	45ºC ± 2	0	N	6.150 ± 0.000	25.43 ± 0.000	70.00 ± 0.000
		30	N	7.060 ± 0.036	24.46 ± 0.647	253.67 ± 4.726
		60	M	-	-	-

Appearance, color and odor: N – Normal, M – Modified.

Emulsions

Emulsions prepared with 3 and 5% of cupuaçu butter presented a slightly yellowish color, compared with the preparations done without adding the butter. Preliminary stability tests involving centrifugation and temperature cycles, to which the formulations were submitted, did not present alterations in the formulations, maintaining homogeneity during the process.

The pH of the formulations stayed around 5.0 during all cycle of preliminary stability for both formulations. Conductivity values that ranged from 158.80 ± 0.01 to 169.97 ± 17.49 for the 3% emulsion and from 173.70 ± 0.01 to 178.70 ± 16.58 to the 5% emulsion, while the viscosity ranged from 2600 ± 0.01 to 2800 ± 0.01 for the 3% emulsion and 2800 ± 0.01 to 3220 ± 0.01 to the 5% emulsion.

After the 14-day period, the formulations of emulsion were evaluated for accelerated stability, which results are shown in Table 5.

The formulations, during accelerated stability, did not present variations in their appearance, color and odor, for 60 days, remaining with their initial characteristics.

The pH value of the formulations containing 3% of cupuaçu butter ranged from 5.40 ± 0.01 a 5.32 ± 0.01, while the formulation containing 5% ranged from 5.40 ± 0.00 to 5.11 ± 0.01. The obtained values allowed to verify the compatibility of the formulations with the pH levels of the skin, which varies from 4.5 to 6.0 due to the acid composition of the hydro-lipid mantle (Boock et al, 2006).

The conductivity values ranged from 156.30 ± 0.00 to 95.25 ± 2.64 and from 169.70 ± 0.01 to 104.40 ± 5.14 for the emulsions containing 3 and 5% of cupuaçu butter respectively. The values remained above 1.3 µS.cm-1 throughout the test indicating that the emulsions are of the oil in water (O / W) type, therefore, the water is in the external phase of the emulsion, with no inversion of phases in the system (Teixeira, 2014).

Viscosity is an important criterion on the stability evaluation, once that, alterations indicates physicochemical and/or microbiological instabilities (Ferreira, 2010). Emulsions presented viscosity values that ranged from 2600 ± 0.01 to 3800 ± 0.01 for the formulation containing 3% of cupuaçu butter and from 2800 ± 0.01 to 3800 ± 0.01 for those containing 5% of butter.

Table 5. Accelerated stability of emulsions 3 and 5% of cupuaçu butter.

Formulation	Temperature (ºC)	Time (days)	Appearance , Color and Odor	pH	Conductivity (mScm-^{1})	Viscosity (cP)	Refractive index
E3%	5ºC ± 2	0	N	5.400 ± 0.000	156.30 ± 0.000	2600 ± 0.000	1.36 ± 0.00100
		30	N	5.327 ± 0.025	128.17 ± 0.416	-	-
		60	N	5.303 ± 0.006	95.26 ± 2.64	3300 ± 0.000	1.36 ± 0.00100
	25ºC ± 2	0	N	5.400 ± 0.000	156.30 ± 0.000	2600 ± 0.000	1.36 ± 0.00100
		30	N	5.347 ± 0.050	111.73 ± 2.802	-	-
		60	N	5.443 ± 0.025	101.30 ± 6.127	2900 ± 0.000	1.36 ± 0.00100
	40ºC ± 2	0	N	5.400 ± 0.000	156.30 ± 0.000	2600 ± 0.000	1.36 ± 0.00100
		30	N	5.360 ± 0.020	144.13 ± 6.100	-	-
		60	N	5.320 ± 0.036	116.23 ± 10.597	3910 ± 0.000	1.36 ± 0.00100
E5%	5ºC ± 2	0	N	5.400 ± 0.000	169.70 ± 0.000	2800 ± 0.000	1.36 ± 0.00100
		30	N	5.147 ± 0.006	130.73 ± 0.751	-	-
		60	N	5.113 ± 0.011	104.40 ± 5.144	3340 ± 0.000	1.36 ± 0.00100
	25ºC ± 2	0	N	5.400 ± 0.000	169.70 ± 0.000	2800 ± 0.000	1.36 ± 0.00100
		30	N	5.173 ± 0.032	127.93 ± 0.404	-	-
		60	N	5.217 ± 0.042	119.20 ± 1.711	2820 ± 0.000	1.36 ± 0.00100
	45ºC ± 2	0	N	5.400 ± 0.000	169.7 ± 0.000	2800 ± 0.000	1.36 ± 0.00100
		30	N	5.163 ± 0.006	138.33 ± 4.21	-	-
		60	N	5.150 ± 0.030	136.26 ± 3.67	4220 ± 0.000	1.36 ± 0.00100

Appearance, color and Odor: N - Normal, M - Modified; pH - pH value.

The viscosity of an emulsion is related to the oils and/or butters used. Emulsions developed showed higher viscosity values compared to other authors who worked with oils, such as Pianovski et al. (2008) who obtained values that ranged from 1716.51 and 1520.05 cP in formulations using Pequi oil. The increase of viscosity at 45°C occurred due to water evaporation, but no signs of instability were observed in the other parameters.

The refractive index was 1.36 ± 0.001 throughout the evaluation period, showing high stability by the formulations. The refractive index is related to the degree of fatty acid saturation, besides indicating variations of free fatty acids concentration, oxidation and heat treatment, being used in both characterization and quality control of oily products (Machado et al, 2006).

The spreadability results of the formulations are shown in Figure 1, where a better spreadability was observed for the cupuaçu butter formulations compared to the control formulation. Still, the formulations 3% and 5% do not present significant difference between them in the spreadability ($p>0.05$), but both differ from the control formulation ($p< 0.05$).

The evaluation of spreadability is an important criterion for emulsions as it indicates the extent of the area where the cream spreads on skin application (Raiser et al., 2018a; Zanin et al., 2001). Thus, it is observed that the addition of cupuaçu butter to the formulation increased its spreadability, favoring its application.

The potential antioxidant action of the emulsions showed that the formulations presented a low percentage of antioxidant activity, about 9.90% and 10.19% for the emulsions containing 3 % and 5 % of cupuaçu butter, respectively (Figure 2), however, superior to the control formulation, which does not have cupuaçu butter (8.85% of DPPH inhibition). Increasing the butter concentration in the formulation, did not increase the potential antioxidant activity on the formulations ($p>0.05\%$). Still, it was verified that even at lower values of potential antioxidant activities, the cupuaçu butter added onto the formulations can act synergistically with synthetic antioxidants, reducing the amount normally added to these products, such as butyladed hydroxytoluene (BHT) (Raiser et al., 2018a).

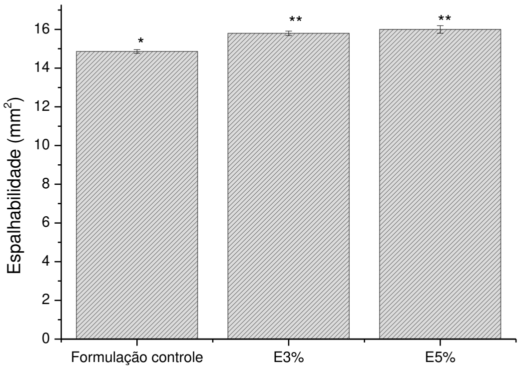

Figure 1. Spreadability of the control formulation and of the containing 3% (E3%) and 5% (E5%) cupuaçu butter formulations.

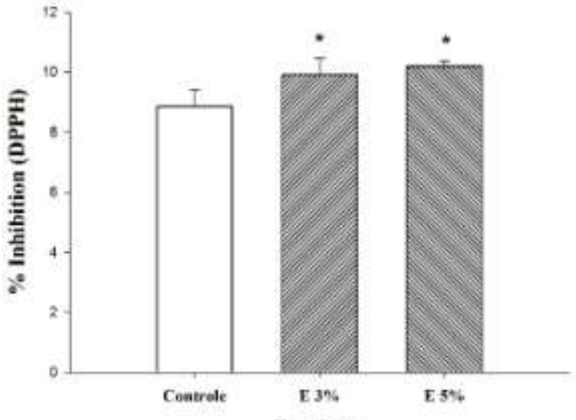

Figure 2. Potential antioxidant activity of the control formulation and of the containing 3% (E3%) and 5% (E5%) cupuaçu butter formulations.

Conclusion

The cupuaçu butter, obtained from the cupuaçu pulping byproducts has been shown to be applicable in the development of different formulations of commercial interest such as shampoos and emulsions. Also, the development of these products is advantageous since it uses waste that would originally be discarded, providing savings, as well as adding value to the product.

Acknowledgment

The financial support from the Brazilian agencies CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico) and FAPEMAT (Fundação de Amparo à Pesquisa do Estado de Mato Grosso/Process nº 571424/2014), is gratefully acknowledged

.

References

BRASIL. Anvisa - Agência Nacional de Vigilância Sanitária. Farmacopeia Brasileira. 5. ed. Brasília: Anvisa 1-2, 2010.

BRASIL. Anvisa - Agência Nacional de Vigilância Sanitária. Guia de estabilidade de produtos cosméticos. 1.ed. Brasília: Anvisa, 2004

ABIHPEC. Panorama do Setor de HPPC 2018, 2018. https://abihpec.org.br/publicacao/panorama-do-setor-2018

ABIHPEC. Aumenta procura por produtos para pele, 2014. https://abihpec.org.br/abihpec-aumenta-procura-por-produtos-para-pele/

ABADIO FINCO, F. D. B. et al. Antioxidant Activity and Characterization of Phenolic Compounds from Bacaba (*Oenocarpus bacaba Mart.*) Fruit by HPLC-DAD-MS n. Journal of Agricultural and Food Chemistry 60:7665–7673, 2012.

AZEVEDO, A. B. A.; KOPCAK, U.; MOHAMED, R. S. Extraction of fat from fermented Cupuaçu seeds with supercritical solvents. Journal of Supercritical Fluids: 27: 223-237, 2003.

BOOCK, K. el tal. Desenvolvimento de emulsões com cristais líquidos e ativos hidratantes e estudo da eficácia hidratante in vivo. Cosmetics and Toiletries 18: 49-50, 2006.

BRAGA, A. C. C. et al. Atividade antioxidante e quantificação de compostos bioativos dos frutos de abricó (*mammea americana*). Alimentos e Nutrição Araraquara 21: 31–36, 2010.

CHIROLI, M.; CAMPOS, R.; SILVA, L. L. DA. Doadores De Viscosidade Utilizados Em Xampus: Revisão De Literatura, 2000 a 2012. Visão Acadêmica 14: 71–83, 2013.

CORREA, B. M. et al. Centesimal and mineral composition and antioxidant activity of the bacaba fruit peel. Bioscience Journal 35: 509-517, 2019.

CUNHA, A. R.; SILVA, R. S.; CHORILLI, M. Desenvolvimento e avaliação da estabilidade física de formulações de xampu anticaspa acrescidas ou não de extratos aquosos de hipérico, funcho e gengibre. Revista Brasileira de Farmácia 90: 190–195, 2009.

FERREIRA, A. DE O. Guia prático de farmácia magistral. 4. ed. São Paulo: Pharmabooks editora, 2010.

FRANGE, R. C. C.; GARCIA, M. T. J. Desenvolvimento de emulsões óleo de oliva/água: Avaliação da estabilidade física. Revista de Ciencias Farmaceuticas Basica e Aplicada 30: 263–271, 2009.

FUJIWARA, G. M. et al. Avaliação de diversas formulações de xampus de cetoconazol quanto ao emprego de diferentes antioxidantes e solubilizantes. Visão Acadêmica 10: 43–57, 2014.

GAMA, R. M. DA et al. Avaliação dos dizeres de rotulagem e das características físico-químicas de xampus infantis. Infarma 26: 45, 2014.

LOURENÇO, E. A. D.; LYRA, M. A. M. M. DE. Desenvolvimento e estudo de estabilidade de Xampu Anti- caspa a base de Piritionato de Zinco 2 %. Revista Eletrônica da Estácio Recife 1: 1–10, 2015.

MIGUEL, M. D. et al. O cotidiano das farmácias de manipulação. Visão Acadêmica 3: 103-108, 2002.

PEREIRA, M. G. et al. Stabilization of the lipase of Hypocrea pseudokoningii by multipoint covalent immobilization after chemical modification and application of the biocatalyst in oil hydrolysis. Journal of Molecular Catalysis B: Enzymatic 121: 82-89, 2015.

PIANOVSKI, A. R. et al. Uso do óleo de pequi (*Caryocar brasiliense*) em emulsões cosméticas: desenvolvimento e avaliação da estabilidade física. Brazilian Journal of Pharmaceutical Sciences 44: 249–259, 2008.

RAISER, A. L. et al. Evaluation of stability and potential antioxidant activity of munguba (*Pachira aquática* Aublet) oil in cosmetic emulsions. Latin American Journal of Pharmacy 37: 1491–1497, 2018a.

RAISER, A. L. et al. Stability and Potential Antioxidant Activity Essay of Pequi Oil (*Caryocar brasiliense* Camb.) in Cosmetic Emulsions. Latin American Journal of Pharmacy 37: 144–51, 2018b.

SCHONS, J. I. et al. Extração assistida por ultrassom e caracterização do óleo da castanha-do-brasil (*Bertholletia excelsa* HBK). Interciencia 42: 586-590, 2017.

SILVA, G. T. P.; SILVA, G. F. DA. Desenvolvimento e avaliação da estabilidade físico-química de um xampu contendo extratos de E*uterpe oleracea mart*. e B*ertholletia excelsa* H.B.K. The Journal of Engineering and Exact Sciences 3: 634–640, 2017.

SILVA, V. R. L. E et al. Influência do Cloreto de Sódio em Shampoos. Cosmetics & Toiletries (Brasil) 23: 60–65, 2011.

VASCONCELOS, M. N. L. et al. Estudo químico das sementes do Cupuaçu. Acta Amazonica. 5: 293–295, 2017.

VIEIRA, I. B.; MOREIRA, A. C.; FRIZZO, M. N. Análise microbiológica em formulações de xampu: o controle da qualidade em produtos com e sem conservantes. Revista Contexto & Saúde 17: 33, 132-145, 2017.

ZANIN, S. M. W. et al. Parâmetros físicos no estudo da estabilidade de emulsões. Revista Visão Acadêmica 2: 47–58, 2001.