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Taro Mucilage: Extraction, Characterization, and Application in Cosmetic Formulations

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Synopsis

Taro mucilage, a hydrocolloid present in the rhizome of *Colocasia esculenta* (L.) Schott, was extracted and characterized by infrared spectroscopy, X-ray diffraction, scanning electron microscopy, thermal analysis, and proximal composition. In addition, cosmetic formulations based on extracted mucilage were developed and studied. The mucilage presented a semicrystalline structure with high thermal stability, the presence of granules along its surface area, and good emulsifying activity. High physical–chemical stability was also found in the mucilage and the cosmetic formulations during storage. All cream samples presented pseudoplastic behavior, with a flow behavior index lower than 1, which is a desirable characteristic for cosmetics, as it improves its applicability. The mucilage demonstrates potential for application in cosmetic products, and its commercial use as an ingredient in cosmetics could be a strategic tool for the creation of a new product chain and adding value to the culture of *Colocasia0 esculenta*.

INTRODUCTION

Colocasia esculenta (L.) Schott is a plant native to the humid tropical regions of Asia, belonging to the Araceae family, which is composed of at least 100 genera and more than 1,500 species. The plant has rhizomes with a high carbohydrate content (90–95%), protein (2.9–4.9%), fiber, and mucilage (1,2). The most widely cultivated varieties include *Colocasia esculenta var esculenta* and *Colocasia esculenta var antiquorum*. The first has a large central corm with suckers and stolons, and the second is the eddoe type, which has a small central corm and a large number of smaller cormels (3).

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In Brazil, *Colocasia esculenta*, popularly known as taro, is cultivated mainly in the South-Central regions, and the cultivars are classified as domesticated or wild depending on the calcium oxalate content present. The rose variety also named rose or pork yam is classified as wild and is used in swine feed (4,5), although still little exploited commercially. Taro is one of the oldest crops in the world used as food, and it has the potential to produce reasonable yields under conditions where most crops would fail, and this makes it a food security crop (6). The cultivation of this crop is generally carried out by small farmers and has great importance for the livelihood of many subsistence farmers in some developing countries, playing relevant economic and nutritional roles (3,6).

The mucilage contained in the rhizomes of the plant could be investigated for technological applications as an emulsifying hydrocolloid. Mucilages are hydrocolloids found in vegetables as products of plant metabolism and are molecules derived from the polymerization of monosaccharides which often have uronic acids in their constitution. These hydrocolloids form viscous masses or gels in the presence of water, and may have an amorphous (7–9) or semicrystalline structure (10). In this context, they act as thickeners, binders, suspending agents, emulsifiers, gelling agents, and stabilizers (11), presenting unique rheological properties (2,12). Some mucilages have been used as excipients in the production of cosmetics, pharmaceuticals, foods, textiles, paints, and stationery, replacing the synthetic excipients and emulsifiers (8,13). They are biocompatible, biodegradable, nontoxic, less expensive than synthetic products, and available in nature. It is important to highlight the recent trend and interest in relation to the use of herbal products and the replacement of synthetic additives by natural products (14,15). In previous research, sensory aspects in the use of *Colocasia esculenta* mucilage as an emulsifying agent in cosmetic emulsions were studied, and the results showed a potential use in cosmetic emulsions with good acceptance by consumers (16).

Now, with a focus on chemical and physicochemical aspects, the pink variety *Colocasia esculenta* (L.) Schott mucilage was extracted and characterized by different analytical techniques. In addition, this hydrocolloid was studied for the first time as an ingredient for cosmetic formulations, and its properties have been compared with a commercial biopolymer.

MATERIAL AND METHODS

MUCILAGE EXTRACTION

The mucilage of the rose variety *Colocasia esculenta* (TM) was extracted from the rhizome of the plant. The rhizomes were washed, weighed, and peeled, and a portion of 300 g was mixed with 100 mL water and triturated in an industrial blender for 3 min. The crushed biomass was filtered through polyester cloth, frozen and dehydrated by lyophilization (LIOTOP L108, Liobras, Brazil), and then stored in polyethylene pots in a desiccator until use.

MUCILAGE CHARACTERIZATION

X-ray diffraction analysis (XRD) was performed using a Rigaku diffractometer (Miniflex 600, Rigaku, Japan) with a copper radiation source (CuKα: 1.5418 Å), 40 kV voltage, 15 mA and readings performed in the range of 3–60° (2θ), step width of 0.02° (2θ), and scanning speed of 2° per minute.

Micrographs were obtained by scanning electron microscopy with dispersive energy system coupled (SEM-EDS) using Zeiss equipment (EVO/MA 15 Wave α-Max, Zeiss, Jena, Germany). Lyophilized samples were overlaid with gold, and a potential difference of 20 KV was employed. Micrographs were obtained at magnifications of 100×, 500×, 1,000×, and 4,000×.

Fourier transform infrared spectra (FTIR) were obtained using a Perkin Elmer spectrophotometer (Spectrometer Frontier, Perkin Elmer, Waltham, MA). The KBr disc method was employed (1% sample and 99% KBr), and the samples were analyzed in the region of 4,000 to 400 cm^{-1}, with a resolution of 2 cm^{-1} and 16 accumulated scans.

The samples were submitted to thermogravimetric (TG) and differential scanning calorimetry (DSC) analyses on a thermal analyzer (SDT Q600, TA Instruments, New Castle, DE). The TG and DSC analyses were performed in a synthetic air atmosphere at 25–600°C, using a flow rate of 50 mL/min and a heating rate of 10 °C/min.

The content of carbohydrates, ash (mineral residue), crude fiber, lipids, crude protein, and moisture was determined. The analyses were performed following protocols described by the National Animal Reference Laboratory (17).

An aqueous suspension containing 2% mucilage was prepared, and the pH was measured using a pH meter (Q400AS, Quimis, Diadema, Brazil) previously calibrated with buffer solutions with pH 4.0 and pH 7.0.

EVALUATION OF MUCILAGE EXTRACTION YIELD

The extraction yield was determined as a function of the lyophilized mucilage content obtained in relation to the wet rhizome content submitted to extraction. A rhizome weighing 3.192 kg was peeled and crushed, and the mucilage was extracted and subjected to the lyophilization process. The yield was calculated by the difference in mass between lyophilized mucilage content and the total wet mass of the rhizome.

EVALUATION OF EMULSIFYING POTENTIAL AND EMULSIFICATION STABILITY OF MUCILAGE

The emulsifying capacity (EC) was determined according to the method described by Wang and Kinsella (18), with some modifications. A quantity of 0.5 g of lyophilized sample was suspended in 25 mL of water and agitated on a mechanical stirrer (TE 139, Tecnal, Diadema, Brazil) at medium speed (550 rpm) for 30 s. After this time, soybean oil was added at a flow rate of 10 mL/min under constant stirring at 550 rpm. The phase inversion point was recorded when there was an increase in the electrical resistance of the emulsion measured by a digital clamp meter (FT266C Clamp Meter, Profield, Ciudad del Este, Paraguay). The EC was calculated as the amount of emulsified oil (g) per gram of protein in the sample, according to equation 1. The measurements were performed in triplicate.

$$EC = \frac{\text{Amount of emulsified oil}(g)}{\text{Amount of protein in the sample}(g)} \quad (1)$$

The emulsifying activity (EA) of the sample was evaluated following the methodology proposed by Yasumatsu et al. (19), with some modifications. Seven grams of lyophilized

mucilage was suspended in 100 mL water and 100 mL soybean oil, and homogenized at 8,000 rpm in an extract dispenser (Q252-28, Quimis) for 1 min. The mixture was then separated into four tubes of 50 mL, each containing 30 mL of emulsion and immediately centrifuged at 4,000 rpm for 5 min. The EA was calculated by the ratio between the volume of the emulsified layer and the total volume in the tube, according to equation 2:

$$EA = \frac{\text{Volume of the emulsified layer(mL)}}{\text{Total volume in the tube(mL)}} \times 100 \quad (2)$$

To evaluate the emulsion stability, an emulsion was prepared according to the procedure described earlier, heated in a water bath at 80°C for 30 min, and cooled in tap water for 15 min. The emulsion was then centrifuged for 5 min at 4,000 rpm in a centrifuge (Sorvall ST16R, ThermoFisher Scientific). The emulsion stability (ES) was calculated as the ratio between the volume of the remaining emulsified layer and the total volume in the tube, according to equation 3.

$$ES = \frac{\text{Volume of the remaining emulsified layer(mL)}}{\text{Total volume in the tube(mL)}} \times 100 \quad (3)$$

DEVELOPMENT OF COSMETIC FORMULATIONS

Four cosmetic formulations were developed using the ingredients described in Table 1. A volume of 1,000 mL of each cream formulation was prepared by heating the ingredients of the oil phase (Phase A: 90 g) and the aqueous phase (Phase B: 3 g in F1 and F3; 1 g in F2 and 5 g in F4 dispersed in approximately 800 mL of water) separately, to a temperature of 75° ± 5°C. Phase B was poured into Phase A under constant stirring (600 rpm) to avoid blistering using a mechanical stirrer (TE 139). Stirring was continued until the emulsion temperature reached 40°C and then added to Phase C (Phase C: 10 g of the solid

Table I
Cosmetic formulations

	Concentration (% w/w)			
Ingredients	#F1	F2	F3	F4
Phase A: oily				
Glyceryl monostearate	3	3	3	3
Cetearyl alcohol	3	3	3	3
Helianthus annuus seed oil	1	1	1	1
Cocos nucifera oil	2	2	2	2
Phase B: watery				
TM	-	0.1*	0.3*	0.5*
Xanthan gum	0.3	-	-	-
Distilled water	q.s.	q.s.	q.s.	q.s.
Phase C				
Sodium benzoate	0.5	0.5	0.5	0.5
Caprilyl glycol	0.5	0.5	0.5	0.5
Distilled water	q.s.	q.s.	q.s.	q.s.

#F1: control formulation using 0.3% xanthan gum, *F2: formulation using 0.1% mucilage, *F3: 0.3% mucilage, and *F4: 0.5% mucilage, q.s.: quantum satis/quantum sufficit.

ingredients solubilized in approximately 200 mL). The emulsion containing all ingredients was constantly stirred until it reached room temperature, and then distilled water was added to reach the final volume. The formulations developed remained standing for 24 h for stabilization before starting the characterization tests.

FORMULATION STABILITY UNDER STRESS CONDITIONS

Twenty-four hours after preparation, the samples were conditioned in transparent glass vials with 2/3 of their capacity, with sealed caps, to avoid the loss of gases and steam to the medium, and subjected to cycles of thermal stress: 24 h at 45°C and 24 h at 5°C for 12 d, totaling six complete cycles.

The samples were analyzed after preparation and at the end of each thermal stress cycle. The physical–chemical analyzes performed in each sample were pH, density, viscosity, and rheological parameter evaluation.

The pH was measured using a benchtop pH meter (Q400AS, Quimis), previously calibrated with buffer solutions, and the pH measurements were taken directly on the samples. The density evaluation was performed with the aid of a stainless steel pycnometer, which is recommended for semisolid products. The calculation for relative density determination was performed through equation 4:

$$d = \frac{M_2 - M_0}{M_1 - M_0}, \tag{4}$$

where d = density, M_0 = mass of the empty pycnometer (g), M_1 = mass of the pycnometer with distilled water (g), and M_2 = mass of the pycnometer with the sample (g).

The apparent viscosity of formulations was measured using a Microprocessor Rotary Viscometer (Q860M21, Quimis) with a spindle 3. The temperature of the samples was maintained at 20° ± 1°C with the aid of a thermostated bath. The flow curves were obtained by measuring the viscosity (η) in mPa.s and increasing shear rates (γ) of 0.1–1 s^{-1}. The rheological parameters were adjusted to the Ostwald De Waele model (potency law), and the values of consistency index (k) and flow behavior index (n) were obtained by equation 5. τ = shear stress.

$$\eta = k(\gamma)^{n-1}. \tag{5}$$

The data of characterization parameters of the formulations were submitted to analysis of variance and Tukey's test [(significance of 95%) ($p < 0.05$) XLSTAT Software (version 2018 Free, Microsoft Excel, Addinsoft, Paris, France)].

RESULTS AND DISCUSSIONS

CHARACTERIZATION OF TARO MUCILAGE (TM)

X-ray diffractometry.

The X-ray diffractogram of TM (Figure 1) shows that the mucilage of the rhizomes of *Colocasia esculenta* (L.) Schott presents a semicrystalline profile, which is a characteristic of many

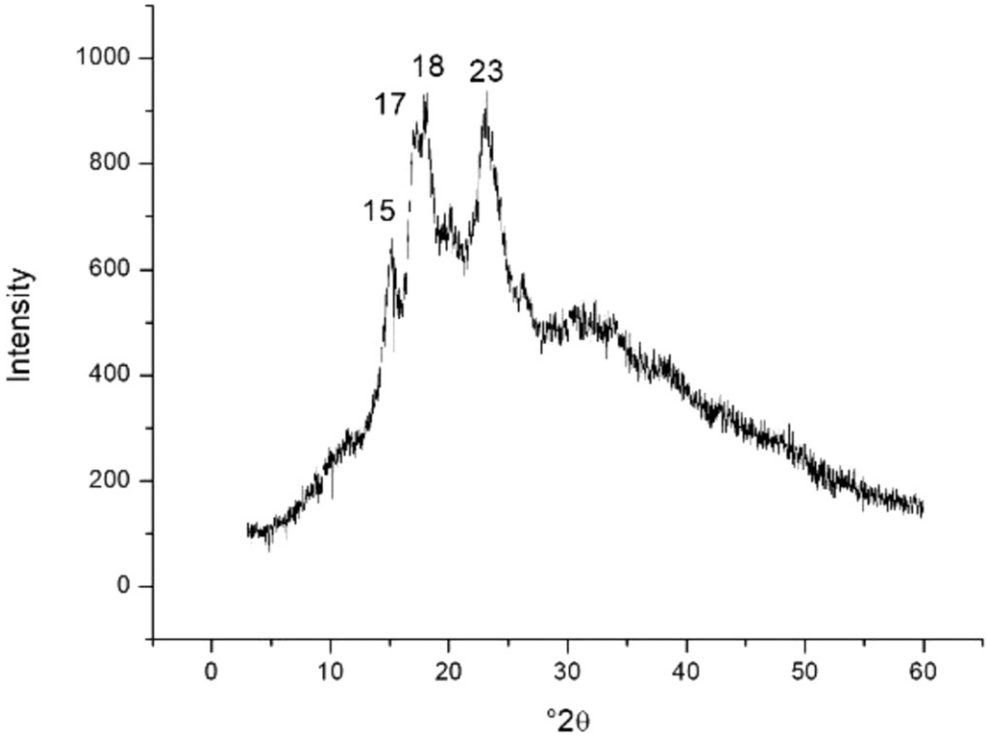

Figure 1. X-ray diffraction for the mucilage of *Colocasia esculenta* (L) Schott.

natural polymers and previously reported by Mishra et al. (10) in mucilagen of fen-Greek. This crystallographic profile is mainly due to the presence of starch in the sample. The intensity of diffraction with principal peaks at 15, 17, 18, and 23° (2θ) characterizes this starch as type A (20), because of the presence of amylopectin with a lower chain length (21).

Scanning electron microscopy.

Scanning electron microscopy of the mucilage of *Colocasia esculenta* (L.) Schott revealed an irregular surface area containing structures with asymmetric edges resembling broken ceramic pieces (Figure 2A and B). The presence of starch granules in circular and irregular shapes deposited on the TM surface (Figure 2C and D) also was observed, similarly to that described by Andrade et al. (9) in the mucilage from *Colocasia esculenta*. The starch present in the mucilage does not interfere in its emulsifying power, but the starch may be interesting for the development of cosmetic emulsions, since it is responsible for the velvety effect and softness in creams.

The EDS analysis indicated the presence of carbon and oxygen, as already expected for this type of sample, as well as magnesium, phosphorus, chlorine, and potassium (Table 2). The major minerals described in the literature for *Colocasia esculenta* were Mg, P, and K in different proportions, and some authors correlate these variations to the soil in which the plant was cultivated, genetics, and species variations (13,22).

Thermal analysis.

The sample presented three exothermic events (Figure 3). The first event occurred between 29 and 100° C and was attributed to the loss of adsorbed material and water in the

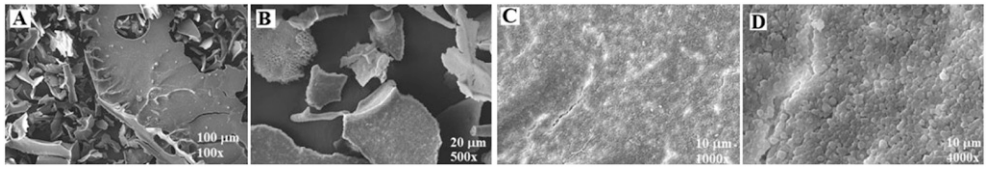

Figure 2. Scanning electron microscopy for TM. Amplitudes of 100 × (A), 500 × (B), 1,000 × (C), and 4,000 × (D).

polymer structure (23). The second mass loss event started at 225° C, being attributed to the degradation of the organic matter, with a maximum peak at 254° C. The last event occurred at 369° C, being attributed to the final degradation of the sample (carbonization) (24). The total mass loss was 91.14%, and the final mineral residue was 8.86%, close to that found in the ash analysis, possibly referring to the oxides containing potassium, magnesium, or phosphorus, as observed in the DES analysis.

At temperatures of 254°–423° C, the mass loss is due to depolymerization of the hydrocolloid, and the exothermic peak occurs because there is structural disorganization and consequent release of energy, similar to that presented by Andrade (24).

FTIR analysis.

The infrared spectrum (Figure 4) of the TM sample showed a broadband at 3,365 cm^{-1} region, corresponding to the axial deformation of hydroxyl groups (OH-), characteristic of polysaccharides, and found also by Goh et al. (25) in the mucilage of chia (*Salvia hispanica* L.). The bands found in the region of 2,930 cm^{-1} are attributed to the axial deformation of the C–H bond, and represent the –CH and aromatic group of sugars in polysaccharides (25). At 1,642 cm^{-1} region, the band corresponds to the *C = 0* stretch of the

Table II.
Yield values, proximal composition, mineral composition, emulsifying capacity, emulsifying activity and emulsion stability for MC

Proximal composition (g/100g)			
Total carbohydrate		62.47	
Proteins		21.19	
Lipids		0.65	
Raw fiber		0.46	
Mineral residue (ash)		8.5	
Moisture		6.73	
Yield in mucilage		8.83	
Mineral content and oxygen (%)			
Carbon	39.52	Phosphor	2.03
Oxygen	46.84	Chlorine	0.76
Magnesium	0.30	Potassium	11.4
Physico-chemical parameters			
Emulsifying activity (%)		55	
Stability of the emulsion (%)		80	
Emulsifying capacity (g soybean oil/g protein)		1,172.72	
pH		5.91	

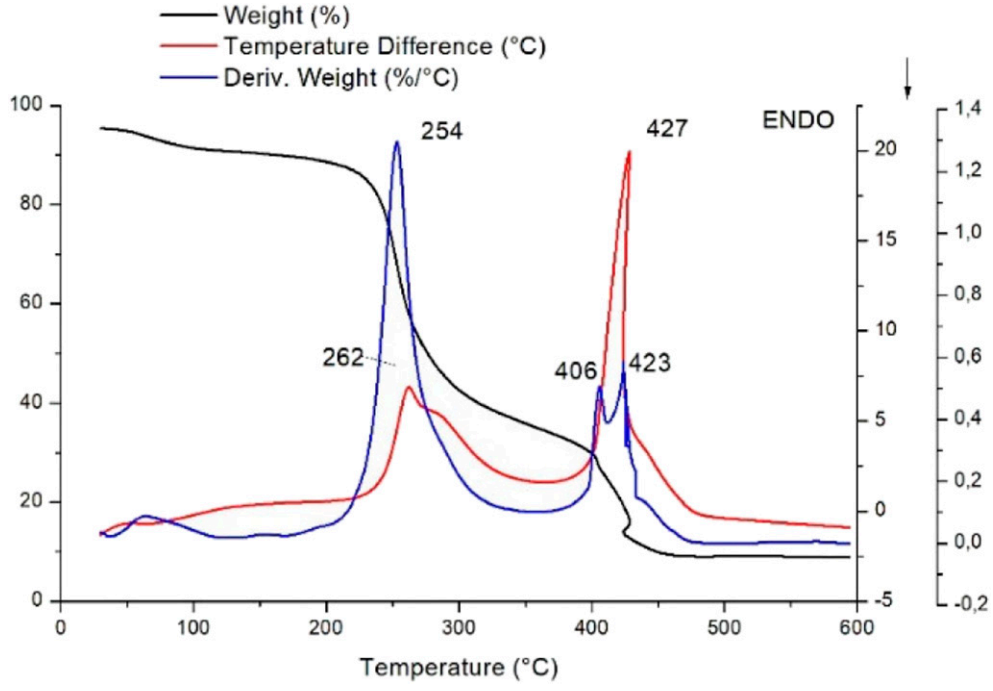

Figure 3. *Colocasia esculenta* MC mucilage thermogram.

nucleic acids, and amide I and amide II of the proteins present in the mucilage. Absorption bands between 1,650 and 1,444 cm^{-1} are typical of symmetric elongation of carboxylic groups of uronic and galacturonic acid residues (23,25). In 1,244 cm^{-1}, the molecular groupings are of amines and amides (26) of the acetyl group belonging to amino sugars. Between 1,200 and 800 cm^{-1} is the region that represents the fingerprint of the arabino-galactan macromolecule (23,25,27,28), also present in TM.

Proximal composition, yield, and physicochemical properties of mucilage.

The proximal composition, yield in mucilage, EC and activity, emulsifying stability, and pH of emulsions are shown in Table 2. The yield in mucilage was 8.83%, and the mineral residue content (ash) was 8.50%, with a highlight on the content of potassium and phosphorus (Table 2). These results are close to those found by Andrade, Nunes, and Pereira (2). The carbohydrate and crude protein contents were 62.42 and 21.19%, respectively, and these values are close to those reported by Njintang et al. (12). The pH of the mucilage was slightly acidic, with a value of around 5.91.

The EA and stability of the emulsion (SE) presented values of 55 and 80%, respectively. Lima Junior et al. (29) studied the EA of *Ora-pro-nóbis* and found values of 83%. Wu et al. (30), when studying the galactomannans of different gums, found values for EA and ES ranging from 40% to 80%. In the case of the EA of TM, the values are within the range found by these authors, and the high value calculated for ES may have occurred due to the presence of starch in the mucilage, as shown by the XRD analysis. The starch could be gelatinized as the beginning of this phenomenon occurs at 12.7° C and increases the viscosity at 77° C (9), and may have contributed to the stability of the emulsion.

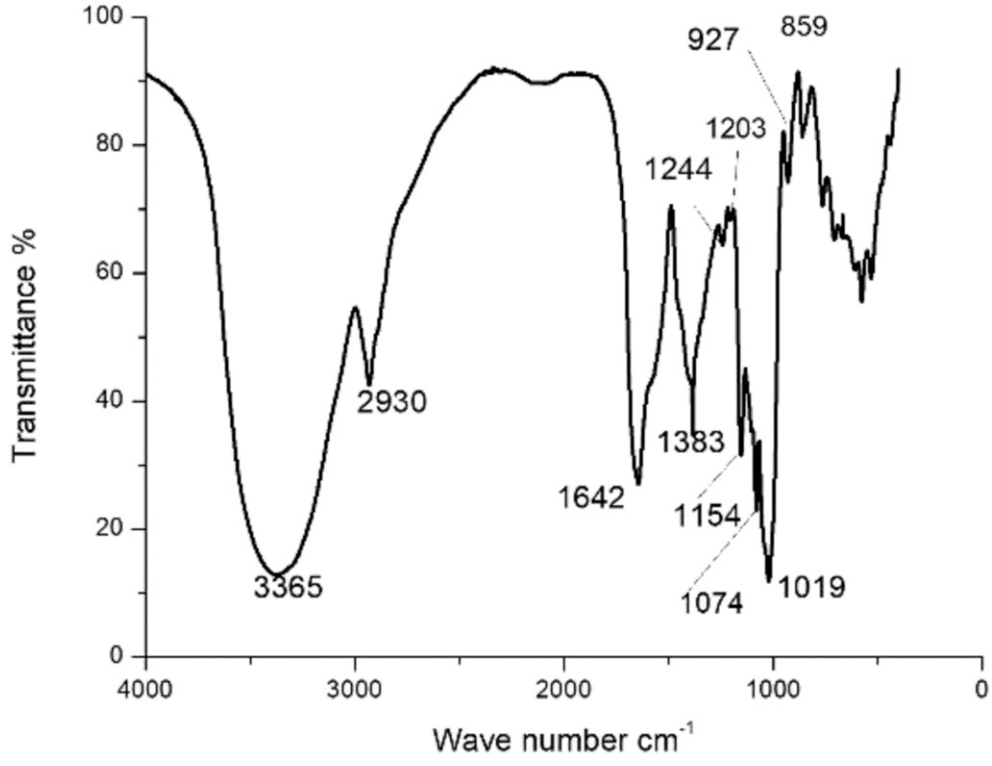

Figure 4. Fourier transform infrared spectroscopy (FTIR) for TM.

The mucilage of taro showed a high EC (1,172.2 g of emulsified oil per gram of protein), and this is mainly due to the presence of carbohydrates and proteins in high concentrations. According to Andrade et al. (2), the emulsifying property of the mucilage of *Colocasia esculenta* is related to the chemical composition, due to the presence of carbohydrates representing the hydrophilic part and the presence of proteins that are the hydrophobic part, which are part of the macro molecule AGP, which can be confirmed in the FTIR spectrum by the presence of bands which represent AGP's fingerprint.

STABILITY STUDY

The stability of semisolid emulsions prepared with mucilage of *Colocasia esculenta* (F2, F3 e F4) and xanthan gum (F1) was evaluated by comparing pH, density, viscosity, consistency index, and flow behavior index (initial and final) after six cycles of thermal stress (Table 3).

A small reduction in the pH values was observed with the increase of the mucilage content in the formulations (Table 3). This behavior is possibly associated with the slightly acidic pH (5.91) of TM, whose content increased from formulation F2 to F4. Similarly, after the thermal stress cycles, there was also a small reduction in pH, and this is possibly related to stabilization reactions inherent in complex mixtures such as cosmetic creams, which are formulated with different ingredients. It should be noted that this fact did not influence the acceptable characteristics of the product, since the pH remained close to the pH of human skin, which is around 5.5 (31).

Table III
Properties of creams formulated with *Colocasia esculenta* mucilage and xanthan gum after 24 h (initial time) of preparation and after the six cycles (12 d of thermal stress)

Sample	Time	pH	Density	η (mPas.s)	γ (s^{-1})	*k* (mPa.s^n)	*n*
F1	24 h	6.92^{g} ± 0.01	0.979^{e} ± 0.007	9,624.0	0.24	3,193.31	0.22
	12 d	6.80^{h} ± 0.05	0.989^{e} ± 0.003	7,152.0	0.24	2,441.17	0.24
F2	24 h	7.03^{a} ± 0.06	0.930^{a} ± 0.008	3,792.0	0.39	2,735.73	0.65
	12 d	6.73^{b} ± 0.11	0.972^{b} ± 0.002	10,920.0	0.39	7,243.77	0.56
F3	24 h	6.84^{c} ± 0.01	0.920^{c} ± 0.006	7,752.0	0.34	3,984.25	0.38
	12 d	6.68^{d} ± 0.01	0.923^{c} ± 0.003	8,520.0	0.34	5,089.15	0.52
F4	24 h	6.78^{e} ± 0.01	0.915^{d} ± 0.006	11,640.0	0.12	2,818.34	0.34
	12 d	6.68^{f} ± 0.03	0.928^{d} ± 0.054	5,184.0	0.12	2,443.54	0.65

#F1: control formulation using 0.3% xanthan gum.
*F2: 0.1% mucilage.
*F3: 0.3% mucilage.
*F4: 0.5% mucilage.
*Equal letters in the same column do not have significant differences according to the Tukey test ($p < 0.05$).
η: apparent viscosity millipascal-second (mPa.s); γ: shear rate (s^{-1}); *k*: consistency index; *n*: flow behavior index.

Formulations containing both xanthan gum (F1) and TM (F2, F3, and F4) showed relatively close values of density, although analysis by analysis of variance and Tukey's test showed statistically significant differences. The substitution of xanthan gum by TM did not lead to intense changes in product density. This characteristic can be considered interesting, since the density parameter can influence the spreadability, and the results indicate little difference between the creams with TM (F1: 0.1%, F3: 0.3%, and F4: 0.5%) and the standard formulation containing xanthan gum (F1: 0.3%).

The viscosity is a variable that characterizes rheologically a system and helps to determine if a product has consistency and fluidity. The rheological evaluation is important in the study of emulsions, since it can promote information about the physical stability of a product, especially when it is subjected to temperature variations (32).

The viscosity and shear rate data were adjusted to the Ostwald de Waelle model, and the consistency index (*k*) and flow behavior (*n*) were obtained. As can be seen in Table 3, high viscosity and consistency indices were observed both in the sample containing xanthan gum (F1: 9,624.0 mPa.s) and formulations containing TM (F2: 3,792.0 millipascal-second (mPa.s), F3: 7,752.0 mPa.s, and F4: 11,640.0 mPa.s). When using the same concentration (0.3%) of xanthan gum and TM (F1 and F3, respectively), it was demonstrated that the xanthan gum contributed to obtaining a product with a slightly higher viscosity (F1: 9,624.0 mPa.s and F3: 7,752.0 mPa.s). On the other hand, when the TM concentration was increased from 0.3% to 0.5%, there was an increase of about 21% in the value of the apparent viscosity of the product in relation to the standard formulation. In this sense, it was observed that the content of the mucilage greatly influences the apparent viscosity of the product.

Regarding the stability test, it can be seen that the mucilage concentration also influenced the rheological behavior of the samples. Whereas viscosity reduction was observed in the formulation containing xanthan gum (F1) after submission to thermal stress cycles, in contrast to formulations containing 0.1 and 0.3% (F2 and F3) of the mucilage, thermal stress led to an increase in viscosity. However, this phenomenon was not verified when higher concentrations of mucilage (0.5%, F4) were used in the formulation, where

submission to thermal stress cycles promoted a 55.5% reduction in viscosity at the lowest shear rate studied (Table 3). Such a behavior is possibly associated with physical–chemical interactions between the constituents of the formulations, which are influenced by the concentrations of each component.

All samples presented characteristics of a pseudoplastic fluid (Figure 5), since there was reduction of viscosity when the shear rate was increased. This phenomenon is confirmed by the values obtained for the flow behavior indices *n* (Table 3), where all samples presented values below 1 ($n < 1$) (33). Pseudoplastic behavior is a desirable rheological property in cosmetic formulations because it improves their applicability and spreadability (34).

The viscosity data suggest that TM could be used as a substitute thickening agent for xanthan gum in cosmetic formulations. Such a property is quite interesting considering that xanthan gum is a relatively expensive product and TM could be produced in large quantities at relatively lower costs. The use of TM in cosmetic products would add value to this mucilage and could strengthen the production chain of *Colocasia esculenta* in developing countries where it has been cultivated.

CONCLUSIONS

The mucilage of rhizomes of *Colocasia esculenta* (L.) Schott rose variety has semicrystalline characteristics and relatively high thermal stability, considering the cosmetics and food industry standards. It has in its composition clusters of proteins and carbohydrates, which may be associated with the presence of arabinogalactan, that are responsible for the good

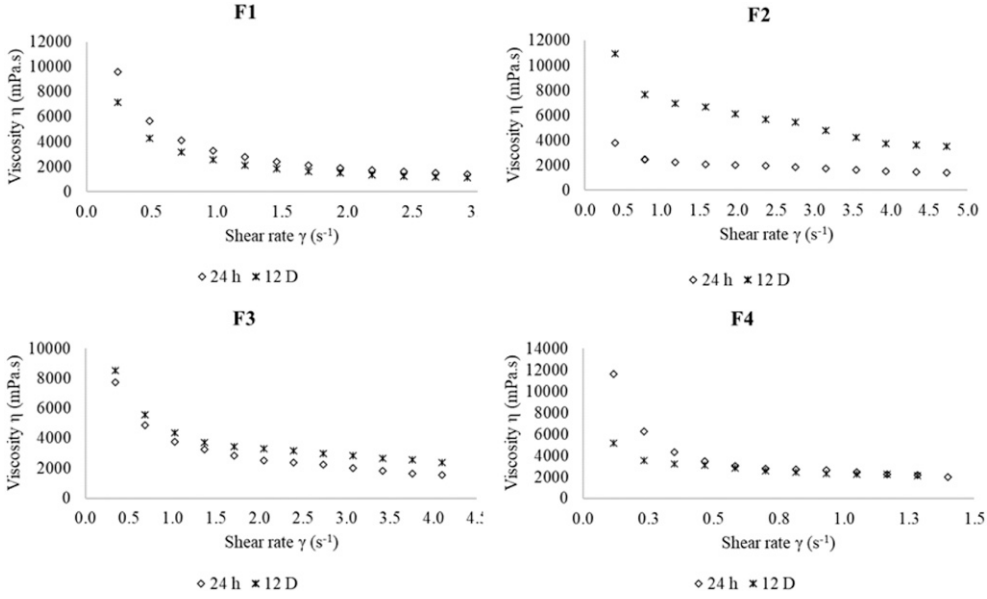

Figure 5. Rheological behavior of the emulsion samples in the stability study for 24 h, iced (I) and defrost (D). F1: control formulation using 0.3% xanthan gum, *F2: 0.1% TM, *F3: 0.3% TM, and *F4: 0.5% TM.

capacity and EA, besides stabilizing emulsions. TM contributes to obtaining stable cosmetic emulsions, similar to emulsions obtained using xanthan gum. All samples presented pseudoplasticity, with flow indexes lower than 1, a desirable characteristic in cosmetic formulations, as it improves their applicability. These results appear as important responses to the potential use of TM as an emulsifying agent for cosmetic emulsions, since the scenario has a good market forecast for plant-derived cosmetics. With high acceptance rates due to their nontoxicity and nonirritating characteristics, natural mucilages are gaining attention from the cosmetics sector, being an alternative to conventional biopolymers.

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