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Mandacaru extract (Jamacaru cereus) obtained sustainably from Brazilian biodiversity, has undisclosed properties in human skin care

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1. Introduction

Dry skin usually has rough appearance, free of softness and flexibility. These signals are caused by the state of dehydration of the skin. Previous studies have shown that a short exposure to a low-humidity environment induce changes in the moisture contents in stratum corneum and skin surface pattern.

The stratum corneum (SC), the outermost layer of the epidermis serves at least three critical barrier functions acting against water loss, penetration of pathogens and the ingress of allergens and potentially toxic compounds [1, 2]. The maintenance of water balance in the stratum corneum (SC) is regulated through the intercellular lipids that provide a barrier to the transport of water and a complex mixture of low molecular weight water-soluble compounds such as amino acids, organic acids, urea and inorganic ions, collectively referred to as natural moisturising factor (NMF) [2,3].

The epidermal protein filaggrin is the predominant source of free amino acids and their derivatives, which together contributes to more than 50% of the total NMF content. Filaggrin expression in the skin and, consequently, the levels of NMF in the SC were further found to be modified by both genetic and environmental factors1. The measurement of these parameters can be a useful tool to evaluate the efficacy of cosmetic products and actives with moisturizing and epidermal barrier protection claim.

Mandacaru *(Cereus jamacaru* D.C*.)* is a popular cactaceae in Brazil, region that has a very hot and dry weather, distributed in the states of northeastern and north of the state of Minas Gerais [5]. Mandacaru presents thorns for protection against predators [6]. Traditionally is used for great medicinal, economic and environmental importance. To avoid dehydration, Mandacaru developed many strategies: the cladodes are coated with a thick wax and internally are rich in soluble fibers for water storage, like mucilage, pectin, gums and some hemicelluloses. Vegetal mucilage has advantages such as being from generally low-cost

edible sources, availability and being involved in ecological processing (Jani et al., 2009). These mucilages play a major role in the physiology of these plants, ensuring low transpiration for adaptation in arid climates [7]. The research and exploration of new polysaccharides is due to the wide functional applications of this biopolymers with structural and physicochemical properties, and can be used as a cosmetic ingredient with many physiological functions

Worldwide, the Cactaceae family is represented by 125 genera with the identification of approximately 2,000 species. Brazil is considered the third largest center of diversity of this family, with 35 genera and 237 species [8]. The Cereus genus, belonging to the Cactaceae family, is recognized as important because it has species that are widely used by the population. These plants can alleviate health problems, offer fruits as a food source and can be used in ornamental systems and civil construction [9].

In northeast of Brazil, region that has a very hot and dry weather. To avoid dehydration, Mandacaru developed many strategies: the cladodes are coated with a thick wax and internally are rich in soluble fibers for water storage, like mucilage, pectin, gums and some hemicelluloses. The Mandacaru extract used in this study was extracted by the local community from Uauá in Bahia, Brazil, where the cladodes are sustainably harvested. Furthermore, the wise consumption of Mandacaru extract is providing income for producers, preserving and conservating a specie symbol of semi-arid biome of Brazil. The aim of this investigationis to identify properties of Mandacaru Concentrated Extract and to assess the potential benefits for skin that can be exploited by cosmetic industry**.**

2. Materials and Methods

Sugar assessment

The exploratory analysis of sugar qualitative composition in concentrated extract of Mandacaru was performed by GC-MS analyzes in order to observe low molecular weight structures and MALDI-MS to analyze the macromolecules. Thus, humectant properties of concentrated mandacaru extract in the skin were observed by corneometry and evaporimetry, in addition to the verification of the NMF stimulus by ELISA sandwich protein quantification.

Aiming to obtain the profiles of simple and correlated sugars, the dried extracts were subjected separately to derivatization reactions. The mixture of 1 mL BSTFA with 20 µL TMS was named Agent S. In a 5 mL vial, 10 mg of each dry extract, 500 µL Agent S and 200 µL pyridine were packed. This bottle was hermetically sealed and the entire system was subjected to a temperature of 80 ° C for a period of 3 hours with the aid of a thermostatically controlled bath. Then, the samples were kept at rest until they reached room temperature. An aliquot of 1 µL of the respective silylated samples was analyzed by GC-MS.

For analysis by MALDI-MS, 2,5-dihydroxybenzoic acid at a concentration of 20 mg / ml in acetonitrile and ultra-purified water containing 0.1% trifluoracetic acid at a ratio of 3:7 v/v was used as a matrix. Sample preparation for analysis includes adding 5 µL of each extract to 5 µL of said matrix. Next, 1 µL of each sample was applied to a MALDI specific plate. This system was packed in the equipment to obtain the spectra. In order to achieve better crystallization, the samples were serially diluted 4 times with the addition of the matrix solution.

Assessments of skin hydration by Corneometry and Evaporimetry (in vivo)

Subjects recruited, they were instructed to discontinue use of any cosmetic products on their forearms 48 hours before the start of the study. On the study day, the subjects who reported to the laboratory got explanations from the researcher on the study procedures, ethical and legal aspects, risks and benefits, medical support and forms of reimbursement for participation costs. They were also asked to sign both copies of the Term of Free Informed Consent. Before the beginning of the measurements, the subjects stay for 30 minutes in air-conditioned environment at 22 ± 2 ° C and 55 ± 5% relative humidity. After the stabilization period, the corneometry and evaporimetry (TEWL) measurements are obtained. The evaluations were conducted before product application, after 2 and 8 hours of the applying.

The measurements of corneometry (capacitance) were performed using the Corneometer® 825 probe coupled to a Multi Probe Adapter, MPA 5 (CKeletronics, Germany). Hydration provided by applying Mandacaru extract can be seen by the increase in the capacitance value measured by the Corneometer® probe.

The measurements of evaporimetry (TEWL) were made using a Tewameter® 300 probe coupled to Multi Probe Adapter, MPA 5, (CKeletronics, Germany). The film build-up provided by applying Mandacaru extract can be seen by the decrease in the transepidermal water loss (TEWL) value measured by the Tewameter® probe.

Preclinical study for in vitro evaluation of efficacy on skin moisturizing

Human keratinocytes (Hacat - Banco de Células do Rio de Janeiro (BCRJ), Rio de Janeiro, RJ, Brazil) was cultured in Dulbecco's modified Eagle's medium containing 4,5 g/L glucose (DMEM, Lonza, Walkerville, MD, USA) supplemented with 10 % fetal bovine serum (Cultilab, Brazil) and 1 % penicillin/streptomycin/amphotericin (Lonza) at 37° C in a humidified atmosphere with 5 % CO2. After 80–90 % confluence, keratinocytes were seeded into 6-wells plates (2,5x105 cells per well) for further treatment with Mandacaru extract and filaggrin quantification. The measurement of filaggrin was performed in the cell lisate of human keratinocytes cultured by ELISA sandwich technique using commercial kits (Cat. SEJ103Hu, USCN, Houston, USA). A protein assay (Bradford, Cat.B6916, Sigma-Aldrich, Missouri, USA) was performed on all samples to determine the protein concentration.

3. Results

Sugar assessment - GC-MS

The main monosaccharides found in the plant kingdom are pentoses and hexoses, ie, they have 5 and 6 carbon atoms, respectively. These sugars may be aldo sugars or keto sugars. As for stereochemistry, the number of different stereoisomers is related to the number of chiral carbons for each type of sugar. In GC-MS analyzes performed in this work, the mass spectra for each chromatographic peak were compared with the mass spectra present in the NIST and Wiley libraries, providing a similarity index in this comparison.

Figure 1 refers to the chromatographic profile of the pressed and concentrated mandacaru extract. Indicates high levels of sorbate and phenoxyethanol derivatives and low

amount of sugars between 19 to 35 minutes. However, the monosaccharides as well as the two disaccharides within 34 to 35 minutes could be detected from the pressed and concentrated extract. Table 1 presents the areas of the relevant chromatographic peaks and the structural proposals.

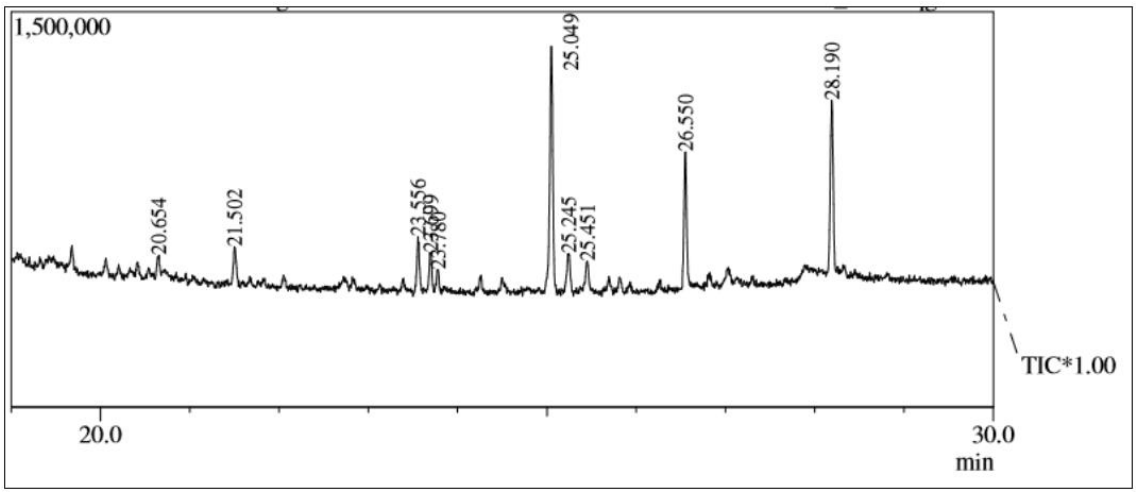

Figure 1. GC-MS chromatographic profile of the aqueous extract of mandacaru. Expansion of the chromatogram (19 to 30 minutes).

Table 1. Analytical information of the chromatogram shown in Figure 1.

Tempo de retenção	Área	Proposta	IS (%)
20,654	175625	NI	75
21,502	289494	NI	65
23,556	382901	hexose	89
23,700	294856	hexose	
23,780	129059	NI	
25,049	2041990	4-trimethylsilyloxyphenethyl-N,N-bis(trimethylsilyl)amine	86
25,245	276995	pentose	86
25,451	205663	NI	73
26,550	1074092	hexose	97
28,190	1426742	Poliálcool cíclico (6 carbonos)	93
34,138	483455	ftalato	91
35,873	5776597	hexose-hexose	91

MALDI

Matrix Assisted Laser Ionization / Desorption - MALDI refers to a mild ionization technique, which allows for ionizing, for example, biopolymers such as DNA, proteins, peptides, sugars without causing extensive fragmentation / degradation enabling reliable analysis of a wide variety of macromolecules. In this context, pectic substances are considered complex heteropolysaccharides extracted from plants, which can be detected and / or identified by MALDI-MS (Figure 2). Protopectin occurs naturally in the early stage of plant growth. Throughout vegetative development protopectin gives rise to pectinic acid and pectic acid, which are generically called pectins.

The MALDI-MS spectra shown in figure 2 was obtained using samples of mandacaru concentrated extract. From these spectra it was possible to observe the formation of protonated molecule with m/z ratio of 3799 for extract under study. In addition, there is a very intense signal with m / z of 3476 considering concentrated extracts. Since the m/z ratio of 3476 stood out for its intensity.

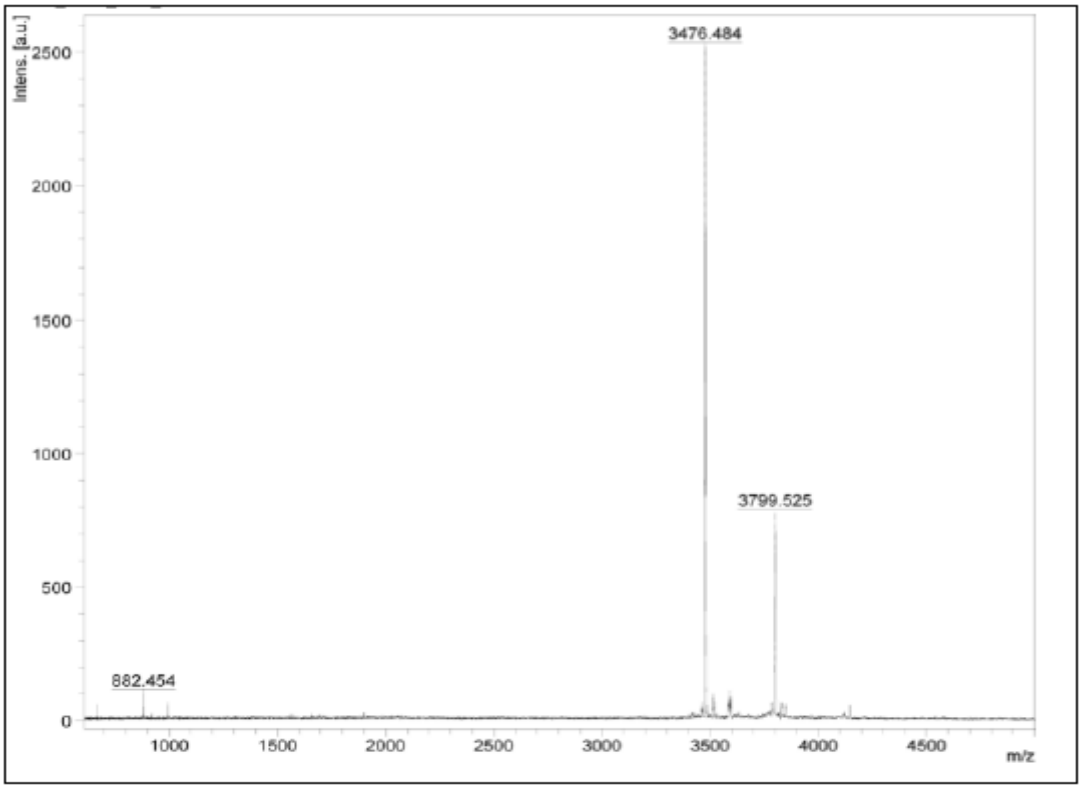

Figure 2. MALDI-MS mass spectrum of the pressed and Mandacaru extract. m/z ratio between 800 and 5000 Da.

The detection of these high molecular weights for both study samples may give evidence of the presence of polysaccharides and/or pectin derivatives to the overall content of these extracts.

Filaggrin quantification

As assessed, Mandacaru extract has presented non-cytotoxic effect in low dosages. As is possible to see in Figure 3, the treatment of the cultures with 0.316 and 0.1% of the Mandacaru extract was able to increase the filaggrin levels by 40.24 and 33.91%, respectively. This increase was statistically significant when compared with the baseline control, but not when compared each other.

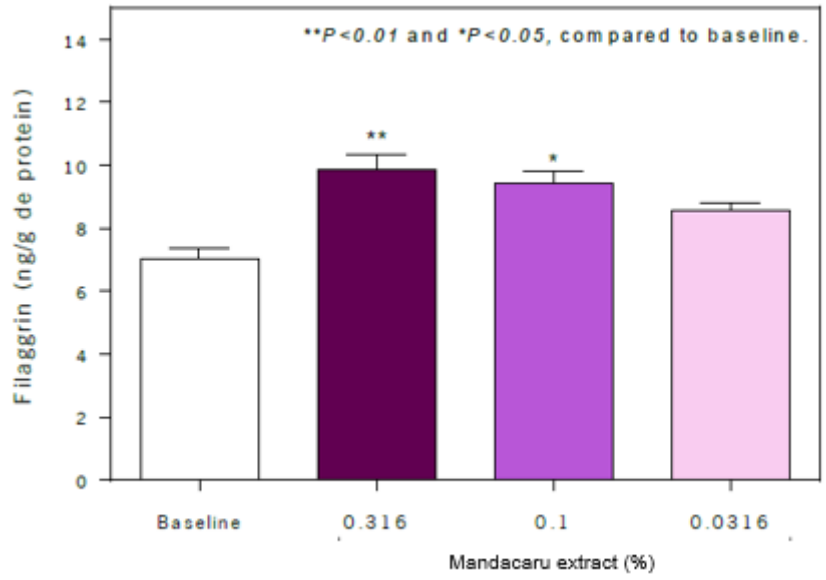

Figure 3. Effects of the Mandacaru extract on the production of filaggrin in culture of human keratinocytes. Data represent the mean ± standard deviation of 3 replicates (Anova, Bonferoni).

According to the results, we can conclude that the Mandacaru Extract can modulates the filaggrin production in human keratinocytes culture favoring the skin moisturizing and epidermal cohesion by the increase of natural moisturizing factors (NMFs) leve

Assessments of skin hydration by Corneometry and Evaporimetry

Corneometry

The results of the study regarding skin hydration potential are presented in figure 4.

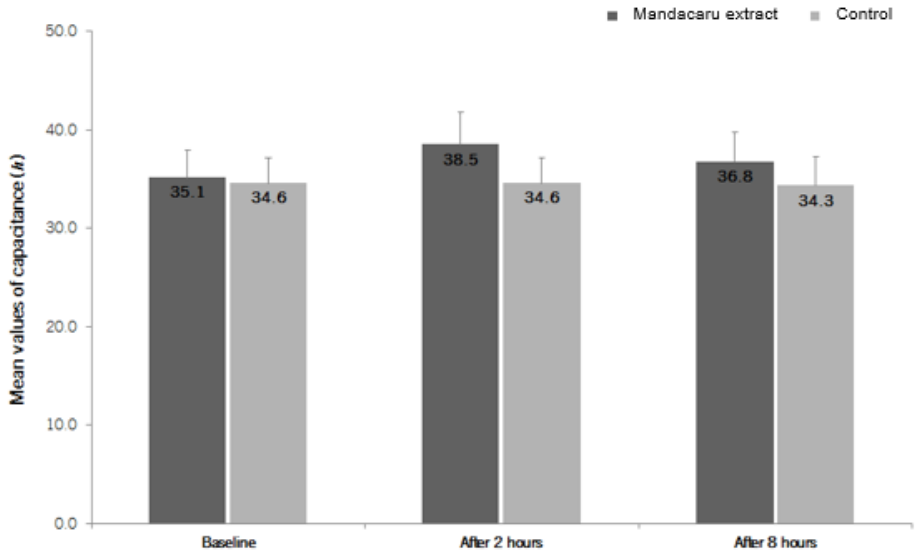

Figure 4. The mean values of capacitance (called ***h***) obtained for the Mandacaru Extract and control during the study after 2 and 8 hours. Mean values of capacitance. Mean ± SD, n = 19.

Baseline homogeneity was assessed by applying the bimodal paired Student's t-test method, considering a 95% confidence interval to the data of corneometry obtained for the Mandacaru extract and control in the beggining of the study. According to the results obtained, there was no significant difference (P > 0.05) between the baseline capacitance values among the sites where the Mandacaru extract was applied and the respective control. This indicates homogeneity among the sites. The significance of changes in skin hydration at each time of the assessment, both for the Mandacaru extract and the control, was assessed by applying the bimodal paired Student's t-test method, considering a 95% confidence interval, to the capacitance values obtained at the beggining of the study, in relation to the values obtained after 2 and 8 hours.

Table 2 summarizes the results obtained in the statistical assessment of significance of variations in capacitance values throughout the study for the Mandacaru extract and the control.

Table 2. Summarized data of the statistical analysis of corneometry assessment.

	ht0 vs. ht2	**ht0 vs. ht8**
Control	0.4114 (no significant)	0.1205 (no significant)
Mandacaru extract	< 0.0001 (significant)	0.0015 (significant)

According to the data obtained, it was possible to verify that no significant variations (P > 0.05) were observed in the value of capacitance in the control site after 2 and 8 hours after of the application. This indicates that there were no significant changes in skin hydration. For the Mandacaru extract was observed significant increase (P < 0.05) in the values of capacitance after 2 and 8 hours of the application, which indicates that the application of Mandacaru extract improved the skin hydration. The significance in the increase of skin hydration due to the application of the Mandacaru extract in comparison to the control was assessed by applying the bimodal paired Student's t-test method, considering a 95% confidence interval, to the data of d***h*** obtained for the Mandacaru extract and control. The skin hydration delivered by the Mandacaru extract was significantly higher (P < 0.05) after 2 and 8 hours, when compared to the control (skin without Mandacaru extract application). It was possible to observed that the Mandacaru extract increased the level of skin hydration by 10.2 % after 2 hours and 5.9 % after 8 hours of the application, in relation to the control and the initial condition of the skin.

Evaporimetry

Figure 5 shows the mean values of TEWL obtained for the Mandacaru extract and control during the study.

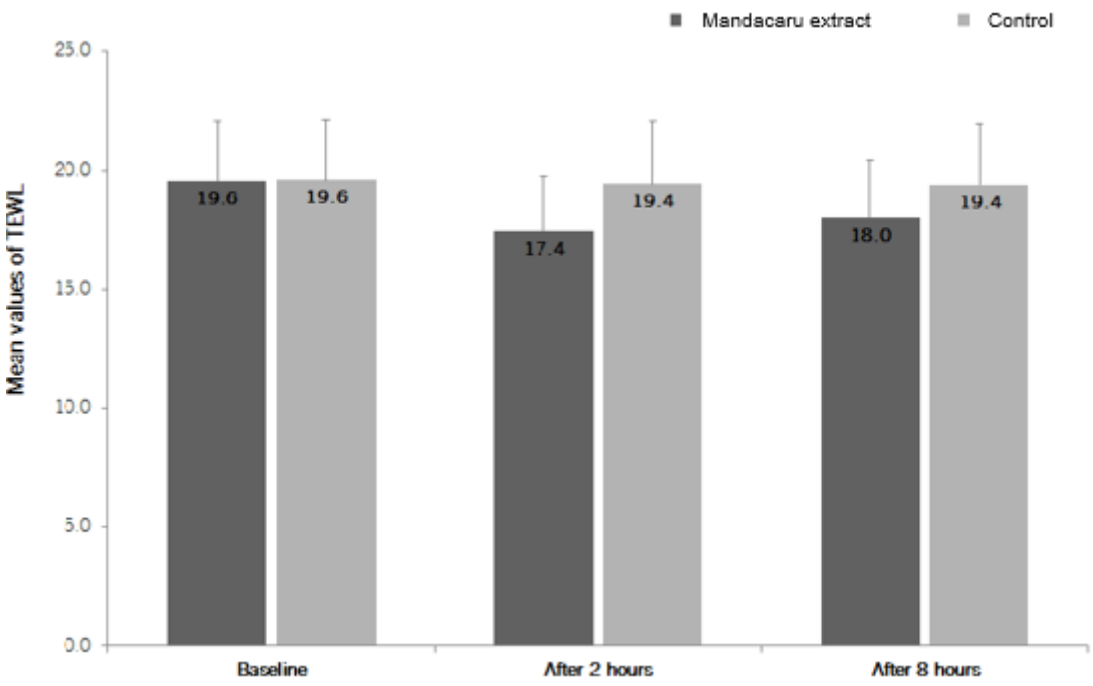

Figure 5. Mean values of TEWL of control and Mandacaru extract after 2 and 8 hours.. Mean ± SD, n = 19.

Baseline homogeneity was assessed by applying the bimodal paired Student's t-test method, considering a 95% confidence interval to the data of evaporimetry obtained for the Mandacaru extract and control in the beggining of the study. According to the results obtained, there was no significant difference ($P > 0.05$) between the baseline TEWL values among the sites where the Mandacaru extract was applied and the respective control. This indicates homogeneity among the sites.

The significance of changes in skin barrier at each time of the assessment, both for the Mandacaru Extract and the control, was assessed by applying the bimodal paired Student's t-test method, considering a 95% confidence interval, to the TEWL values obtained at the beggining of the study, in relation to the values obtained after 2 and 8 hours. According to the data obtained, it was possible to verify that no significant variations ($P > 0.05$) were observed in the value of TEWL in the control site after 2 and 8 hours after of the application. This indicates that there were no significant changes in skin barrier condition. For the Mandacaru Extract was observed significant decrease ($P < 0.05$) in the values of TEWL after 2 and 8 hours of the application. This indicates that the application of Mandacaru extract provided film-buildup on the skin. The significance of the film build-up due to the application of Mandacaru extract in comparison to the control was assessed by applying the bimodal paired Student's t-test method, considering a 95% confidence interval, to the data of $d\boldsymbol{e}$ obtained for Mandacaru extract and control.

The film build-up provided by Mandacaru extract application was significantly higher ($P < 0.05$) after 2 and 8 hours, when compared to the control (skin without Mandacaru extract application). It was possible to observe that Mandacaru extract decreased the level of the

TEWL by 9.9 % after 2 hours and 6.8 % after 8 hours of the application, in relation to the control and the initial condition of the skin.

4. Discussion

The present study demonstrates that the aqueous extract of Cereus jamacaru cladodes is rich in polysaccharides and exhibits significant effects on skin barrier function, including enhanced filaggrin expression, improved skin hydration, and reduced TEWL. These findings align with the working hypothesis that C. jamacaru extract can modulate skin barrier integrity through both physical and biological mechanisms. Phytochemical analyses revealed a high polysaccharide content in the extract, corroborating previous studies that identified substantial presence of polysaccharides with 3477 Da and it is a source of galactose, glucose, and mannose in C. jamacaru polysaccharide-rich extracts. The presence of these monosaccharides suggests a composition conducive to forming hydrophilic matrices capable of retaining water and providing a moisturizing effect when applied topically.

The observed upregulation of filaggrin expression is particularly noteworthy. Filaggrin plays a critical role in skin barrier function by aggregating keratin filaments and contributing to the formation of natural moisturizing factors (NMFs) upon proteolytic degradation. The enhancement of filaggrin expression by C. jamacaru extract suggests a biological mechanism through which the extract reinforces the skin barrier, beyond mere occlusive effects.

Comparatively, other plant-derived polysaccharides, such as those from Opuntia ficus-indica, have demonstrated similar skin hydration and barrier-enhancing properties [10]. However, the unique composition of C. jamacaru polysaccharides, along with its traditional use in Brazilian ethnomedicine , positions it as a promising candidate for novel dermocosmetic applications.

The reduction in TEWL observed in this study further supports the extract's efficacy in enhancing skin barrier function. By decreasing water loss, the extract helps maintain skin hydration, which is essential for overall skin health and resilience against environmental stressors.

Given these findings, future research should focus on the protective capacity of Cereus jamacaru extract against environmental stressors such as pollution, UV radiation, and chemical irritants. Understanding its ability to mitigate oxidative damage or inflammatory responses may reinforce its potential as an active component in protective skincare formulations. In addition, the promising effects observed on filaggrin expression and skin hydration suggest that this extract may hold therapeutic potential for the management of atopic conditions, such as atopic dermatitis, where skin barrier impairment and filaggrin deficiency are central pathogenic features. Expanding research into these specific pathophysiological contexts will be essential to validate the extract’s efficacy and define its scope of application in both preventive and reparative dermatology.

5. Conclusion

This study provides compelling evidence that the Mandacaru (Cereus jamacaru) extract obtained from sustainable sourcing in Brazilian semiarid possesses significant potential as a functional cosmetic active. Its high content of polysaccharides and sugars—such as fructose, glucose, and sucrose—likely contributes to its moisturizing and barrier-supportive effects. The extract improved skin hydration, enhanced skin barrier function by reducing TEWL, and upregulated filaggrin expression in reconstructed human epidermis, indicating a biological mechanism of action beyond occlusive hydration.

These findings suggest that Mandacaru extract may be a valuable natural ingredient for formulations targeting dry or compromised skin. Future studies should investigate its long-term effects, safety profile in diverse populations, and performance within complete cosmetic formulations to fully explore its commercial application in dermocosmetics.

6. References

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