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Characterization of Hydrogels Containing Mandelic Acid Nanoemulsions and Different Essential Oils

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Hydrogels are polymeric matrices having minimal toxicity, elastomeric consistency and high permeability, making them useful for the controlled release of actives. These products have extensive applications in the cosmetic area as drug vehicles. In this work, hydrogels were prepared with concentrations of Polyvinylpyrrolidone (PVP, 7.5%wt), Polyethylene glycol (P.E.G., 3%wt) and agar (1%wt) containing pseudoboehmite, mandelic acid with essential oil of Palmarosa, Lavender, Geranium and/or Lemongrass, subjected to 25 kGy radiation. The hydrogels were characterized using sensory analysis, isothermal dehydration with air entrainment and dehydration as a function of time. The results showed that the hydrogels containing different essential oils undergo dehydration as a function of time from 2% to 4%. The hydrogel containing Lavender essential oil showed 23% isothermal dehydration with air entrainment. As for the degree of satisfaction, the hydrogel with Lemongrass essential oil was the most suitable for the consumer market. Therefore, it is concluded that these analyses are relevant for cosmetic development.

Keywords: *pseudoboehmite, nanoemulsions, mandelic acid, essential oils.*

1. Introduction

Nanotechnology is an area of science dedicated to researching structured systems on a nanometric scale. For example, in dermo-cosmetics, nanotechnology has increased cosmetic actives capacity to penetrate and remain longer in the skin, resulting in scientifically proven aesthetic improvements[1].

The cosmetic composition consists of an aqueous phase containing hydrophilic agents and preservatives, while the oil phase comprises active lipophilic ingredients[2].

The cosmetic active in this article is mandelic acid, which has anti-ageing properties. Currently, it is used as a component of rejuvenating creams for treating fine wrinkles and lines of expression, improvement in skin texture, and whitening dark spots[3].

Pseudoboehmite is a fine ceramic-type nanocarrier used in pharmaceutical synthesis because it plays a vital role in controlled release[4]. This nanomaterial has a high surface area, adsorbs active principles and is non-toxic[5]. The synthesis is through the sol-gel process, which has the advantages of low cost, easy handling, the possibility of obtaining materials on a nanometric scale and adding properties concerning different materials[6].

The hydrogel obtained based on PVP was subjected to ionizing radiation in the agar's presence, favouring the solution's gelation. This polymeric matrix forms a system capable of offering advantages compared to conventional pharmaceutical forms, as they present good biocompatibility and promote the controlled release of drug activities[7-9].

This article aims to contribute to the cosmetics area by producing hydrogels with a concentration of 7.5% by mass of PVP, irradiated with doses of 25 kGy for sterilization, and containing nanoemulsions of mandelic acid and different essential oils.

2. Materials and Methods

In the preparation of nanoemulsions, pseudoboehmite was used in a sol-gel process: incorporation of the principle active to pseudoboehmite (aqueous phase), solubilization of the surfactant with essential oils (oil phase) and subsequent mixing of these components under constant agitation.

From this prepared emulsion, the nanoemulsions were obtained by centrifuging the samples for 15 minutes at speeds of 1000 rpm, 2500 rpm, and 3500 rpm[10]. The resulting nanoemulsions contained concentrations of pseudoboehmite (3%wt) and essential oils (7%wt), following the best results in the literature[11]. In addition, the concentration of the active mandelic acid (AM) (2.1%wt) and the polysorbate 20 (Tween 20) in the emulsions were used as described in the literature[12]. The composition of the nanoemulsions can be observed in Table 1.

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Table 1. Composition of nanoemulsions with mandelic acid.

	Composition (%wt)						
	Mandelic acid	Pseudoboehmite (PSB)	Lavender Oil (O.L.)	Geranium Oil (O.G.)	Palmarosa Oil (O.P.)	Lemongrass Oil (OLE)	Tween 20
AM1	2.1	3.0	7.0	-	-	-	8.8
AM2	2.1	3.0	-	7.0	-	-	8.8
AM3	2.1	3.0	-	-	7.0	-	8.8
AM4	2.1	3.0	-	-	-	7.0	8.8

After preparation, 3 ml of the approved nanoemulsions in Table 1 were added to the hydrogels containing 7.5%wt PVP, 3%wt P.E.G., and 1%wt agar. The experiments were placed in Petri dishes for testing the next day to avoid contamination.

Once the cosmetic was produced, a sensory analysis test was carried out on the following day using the Likert scale. These experiments utilized employee, student and teacher volunteers at Senac Campus Santo Amaro, totalling 95 respondents. Data was condensed for evaluation of sensory analysis, effectiveness and applicability. This research is registered on Plataforma Brasil under CAAE 31929619.4.0000.0089. Participants completed an informed consent form.

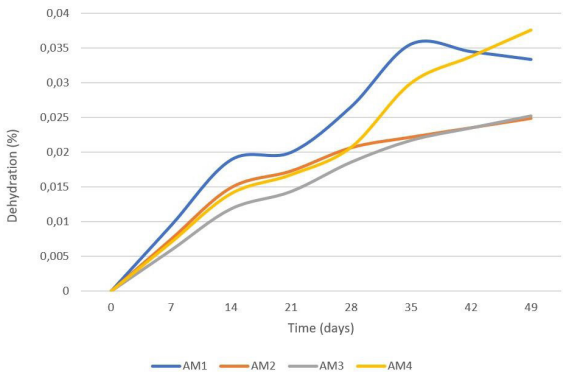

Figure 1. Dehydration´s variation as a function of time.

3. Results and Discussions

The characterization of hydrogels with nanoemulsions of mandelic acid containing different essential oils was carried out according to the following parameters: dehydration as a function of time, isothermal dehydration with air drag, and sensory analysis.

The results obtained showed that the hydrogels containing different essential oils undergo dehydration as a function of time in the order of 2% to 4%, as shown in Figure 1.

Regarding isothermal dehydration with air entrainment, this investigation aimed to verify whether changes in the composition of the hydrogels interfere with the dehydration behaviour when in contact with human skin, allowing for variation in the absorption time of the active ingredient.

In this case, the hydrogel containing lavender essential oil showed a 23% loss, as shown in Figure 2.

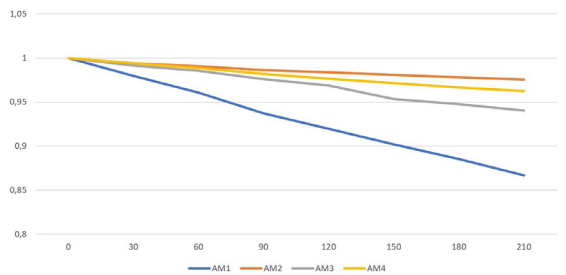

Figure 2. Variation of isothermal dehydration with air entrainment.

In the case of sensory analysis, participants were asked about the degree of absorption of the product (Figure 3), slippage (Figure 4), appearance (Figure 5), odour (Figure 6), and feeling of comfort (Figure 7). The Likert scale was used, which has the advantage of the application. The desired data can be obtained and tabulated uncomplicated, as the interviewee can easily express their agreement with the investigative statement. The application of the research shows consistency and coordination with the cosmetic industry.

The absorption of a product was defined by the time it takes to be absorbed into the skin or no longer appear on the skin[13].

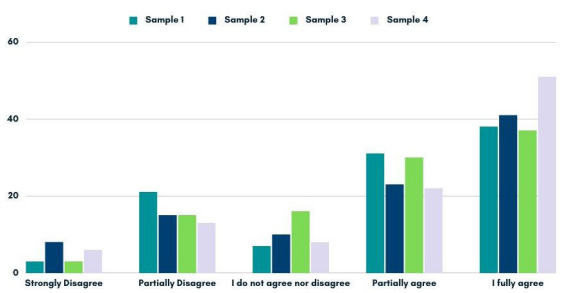

Figure 3. Degree of satisfaction regarding product absorption.

Regarding absorption, some formulations had a faster absorption in the skin than others, a sensation mentioned by the research participants. Figure 3 shows the degree of satisfaction regarding the absorption of the product. Using isothermal dehydration with air entrainment, the investigation aimed to verify whether changes in the composition of the hydrogels interfered with the dehydration behaviour when in contact with human skin, allowing for varying the absorption time of the active ingredient.

The degree of satisfaction refers to the sum of the percentage of agreement among participants, ranging from strongly disagree to agree entirely.

Sample 4 (hydrogel with mandelic acid and lemongrass essential oil) achieved 72.6% satisfaction, ranking first. The sample with the lowest degree of satisfaction was sample 3 (hydrogel with mandelic acid and palmarosa essential oil), with a percentage satisfaction of 66.3%.

Spreadability is the expansion over a surface after some time[14]. It is imperative that the spreadability, or sliding, is adequate to provide well-being to the consumer and for the continuity of the cosmetic treatment[15]. The degree of satisfaction regarding slippage can be seen in Figure 4.

This research shows consistency and concurrence with the cosmetic industry.

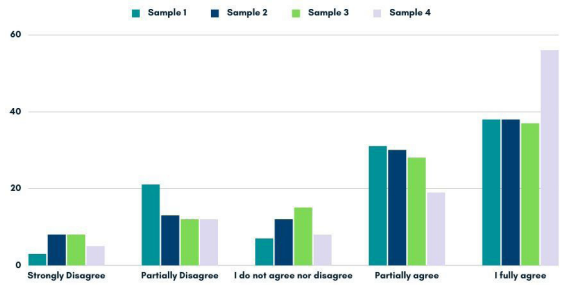

Figure 4. Degree of satisfaction regarding product slippage.

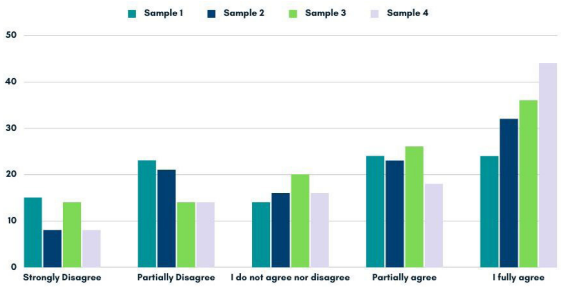

Figure 5. Degree of satisfaction regarding the appearance of the product.

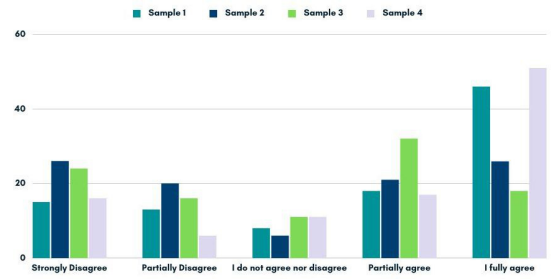

Figure 6. Degree of satisfaction regarding the odour of the product.

Sample 4 (hydrogel with mandelic acid and lemongrass essential oil) achieved better slippage with 74.7% satisfaction. On the other hand, sample 3 (hydrogel with mandelic acid and palmarosa essential oil) had the lowest degree of satisfaction in the evaluation of slippage (65.2%).

The visual aspect of a cosmetic is of great relevance when choosing the product, as it must "embrace" the consumer from the first moment, stimulating the senses with packaging, colour, consistency and appearance[16]. Figure 5 shows the degree of satisfaction regarding the appearance of the product.

Sample 4 (hydrogel with mandelic acid and essential oil of lemongrass) achieved a satisfaction level of 62.1%, while sample 1 (hydrogel with mandelic acid and essential oil of lavender) obtained a level of 48.4%.

The odour was defined as the sensory property the olfactory organ perceives when certain volatile substances are inhaled. It can present characteristics such as intensity, persistence, and saturation. The olfactory evaluation is essential for fragranced products (cologne, perfumes, etc.) and cosmetic beauty treatment products - odour can benefit the formulation, for example, in lotions or cleansing creams, where the perfume characterizes the freshness[17].

Figure 6 demonstrates the evaluation of the satisfaction of the samples related to odour.

Sample 4 (hydrogel with mandelic acid and lemongrass essential oil) had a higher degree of satisfaction, with a result of 67.3%. Sample 1 (hydrogel with mandelic acid and lavender essential oil) also stood out in the degree of satisfaction regarding the odour, totalling 64.2% and sample 2 (hydrogel with mandelic acid and geranium essential oil) had a satisfaction level of 47.4%.

The sensation that the product provides smoothness and softness refers to the comfort it brings after its application to the skin[15].

The following graph demonstrates the evaluation regarding the feeling of comfort of the product after its application. Figure 7 shows the degree of satisfaction regarding the product's feeling of comfort.

Sample 1 (hydrogel with mandelic acid and lavender essential oil) was the sample that obtained the highest degree of satisfaction regarding skin comfort, at 79%. Figure 8 summarizes the information collected to identify the sample with the highest degree of satisfaction regarding the five evaluated attributes.

Sample 4 (hydrogel with mandelic acid and lemongrass essential oil) obtained a higher degree of satisfaction in all

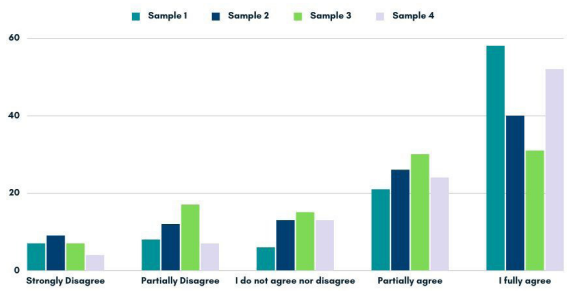

Figure 7. Degree of satisfaction regarding the feeling of comfort with the product.

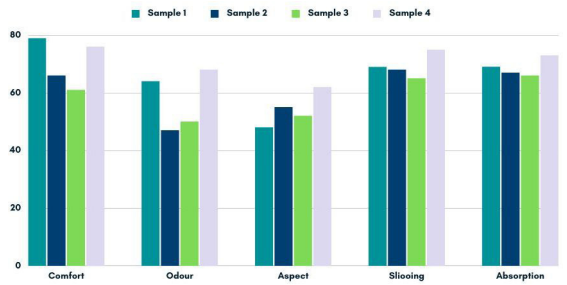

Figure 8. Degree of general satisfaction with the products.

aspects: absorption, sliding, appearance, and odour, except for the feeling of comfort after application, in which sample 1 (hydrogel with acid mandelic and lavender essential oil) had a better result. Therefore, sample 4 can be chosen as the best-performing sample with these data.

4. Conclusion

The results obtained showed that the hydrogels containing different essential oils suffer dehydration as a function of time in the order of 2% to 4%. In contrast, in the isothermal dehydration with air drag, the hydrogel containing the essential oil of lavender presented a 23% loss.

The application of sensory analysis provided consistent results, as it was carried out using a considerable participant size. Using the Likert scale, which proved simple to apply, sample 4 (hydrogel with mandelic acid and lemongrass essential oil) was ranked as the most acceptable.

The conclusion of the research made it possible to choose the cosmetic formulation with the highest degree of satisfaction and to confirm the importance of this type of test in developing a cosmetic product. Therefore, it is concluded that sensory analysis is indispensable in cosmetic development, directly influencing product choice.

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