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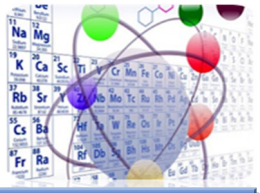

Performance Evaluation of Aloe Vera-Based Moisturizers with Gelatin, Polyacrylic Acid (PAA), and Xanthan Gum Combinations: Analysis of Moisture, pH, and Viscosity

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ABSTRACT

Aloe vera-based moisturizer formulations incorporating gelatin, xanthan gum, and carbomer aim to optimize moisture retention, viscosity, and pH stability. This study analyzed the physicochemical characteristics of these ingredient combinations through testing of pH, viscosity, and skin moisture after moisturizer application. The results showed that all combinations had a stable pH in the range of 5.05 to 5.15, which corresponds to the natural pH of the skin. The formulation with xanthan gum gave the highest viscosity, while the gelatin combination produced the lowest viscosity, which allowed faster penetration but shorter hydration effect. The best formulation in moisture retention was obtained from the combination of Aloe vera with carbomer, which provided a balance between pH stability, viscosity and hydration capacity. This study confirms that the combination of ingredients is effective in creating a stable moisturizer suitable for cosmetic applications.

Keywords: Aloe vera, gelatin, xanthan gum, carbomer, moisturizer, viscosity, pH

1. INTRODUCTION

Skin moisturizers are essential cosmetic products that function to maintain skin hydration and protect it from dryness.[1] One of the natural ingredients widely used in moisturizer formulations is Aloe vera, which has hydrophilic properties and is able to form a protective layer that maintains skin moisture.[2,3] The polysaccharide content in Aloe vera plays an important role in helping to retain moisture through the mechanism of water absorption and gel formation on the skin surface.[4,5] However, in order to make moisturizer formulations using Aloe vera more effective, other gelling agents are needed that can improve the viscosity, stability and spreadability of the product.[6]

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Gelatin, which is a hydrolyzed animal protein, is known to have the ability to form three-dimensional networks through a gelling process influenced by temperature. The structure produced by gelatin can improve the physical stability of the formulation and extend the duration of moisturization on the skin.[7] In addition, gelatin exhibits thermoreversible properties, allowing formulations to remain stable at low temperatures but liquefy at higher temperatures. This provides flexibility in maintaining product stability across different storage and use conditions.

Xanthan gum, a polysaccharide obtained through bacterial fermentation, is often used in the cosmetic industry due to its ability to form stable gel structures under various environmental conditions. Xanthan gum also has pseudoplastic properties, which means that its viscosity will decrease when the product is applied to the skin, providing a light and comfortable sensation.[8] It is these properties that make xanthan gum particularly useful in moisturizer formulations, where a combination of light texture and long-lasting hydration is required.

Besides gelatin and xanthan gum, carbomer is also a commonly used thickening agent in cosmetic formulations. Carbomer is a synthetic polymer capable of significantly increasing viscosity in a wide range of pH ranges. Carbomer forms a strong network with the ability to stabilize the formula and maintain the consistency of the product texture, while ensuring that the pH of the formulation remains within the ideal range for the skin, which is around pH 4.5-5.5.[9] pH stability is an important factor to prevent skin irritation and maintain the balance of the skin microbiome.[10]

This study aims to evaluate the combination of Aloe vera with gelatin, xanthan gum, and carbomer in the formation of gel-based moisturizers. The main focus of this study was to assess the pH stability, viscosity, and moisture retention capacity of the resulting formulations. The colloidal system formed from the combination of these ingredients is expected to produce a moisturizer with optimal characteristics, such as high stability, smooth texture, and the ability to maintain skin moisture in the long term. Previous studies have shown that interactions between gelling ingredients can produce synergistic effects in terms of colloidal stability and product physicochemical properties.[7,8]

In addition, research into the formulation of gel-based moisturizers with ingredients such as gelatin, xanthan gum, and carbomer has shown that this combination is capable of delivering significant results in terms of viscosity, pH stability, as well as effectiveness in moisture retention.[11,12] This research seeks to expand the understanding of the mechanism of interaction between gelling agents in colloidal systems, as well as to determine the most optimal combination of ingredients to produce moisturizers with the best characteristics.

2. EXPERIMENTAL

2.1. Instrument

This study used several key instruments to evaluate the characteristics of the formulated moisturizer. A Moisture analyzer was used to measure the moisture level of the skin before and after moisturizer application. A pH meter was used to ensure that the formulation had a skin-safe pH, which is within the ideal pH range of 4.5 to 5.5. In addition, a viscometer is used to measure the viscosity of each moisturizer formulation. Some other supporting instruments include a magnetic stirrer to ensure perfect homogenization in the ingredient mixing process, as well as spatulas and gel molds to facilitate the gel mixing and molding process.

2.2. Materials

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The ingredients used in this study consist of several main and supporting components. The base ingredient of the moisturizer was Aloe vera, which is known for its humectant properties that help keep the skin moisturized. For the thickening agent, three main ingredients were used: gelatin, which plays a role in the formation of a three-dimensional network in the gel, xanthan gum, which provides stability and viscosity to the formulation, and carbomer, which provides stability at various pH conditions. In addition, glycerin is used as an additional humectant to improve moisture retention, and phenoxyethanol is added as a preservative to maintain the microbiological stability of the product. Aquades was used as a solvent in the ingredient blending process.

2 .3. Research Procedure

This study was conducted through several main stages. In the initial stage, ingredients such as gelatin, xanthan gum, and carbomer were dissolved in aquades according to predetermined concentrations. The Aloe vera base is then mixed with these thickening agent solutions to form a stable colloidal system. The mixture was homogenized using a magnetic stirrer until a uniform gel was formed. After the formulation was completed, three main parameters were tested: moisture retention, pH, and viscosity. Moisture retention testing was conducted using a moisture analyzer on three different subjects, with the moisturizer applied to their skin, and the moisture level measured before and after application. Moisturizer without thickening agent was used as a control. A pH test was conducted using a pH meter to ensure the formulation remained within a safe pH range for the skin. Each combination of formulations was tested to determine how the ingredients affected pH stability. Next, viscosity testing was performed with a viscometer to measure the thickness of the formulation. These viscosity results provide information on the consistency and texture of the resulting product. The data from each test was analyzed to determine the combination of ingredients that gave the best results in terms of pH stability, optimal viscosity, and moisture retention ability.

3. RESULTS AND DISCUSSION

3.1. Analysis of Characterization Results

Three main tests were conducted on a combination of aloe vera with various additional Ingredients (gelatin, PAA, xanthan gum) and other supporting ingredients such as Aquades,glycerin, and polyxhenhanol. The results of each test are as follows:

1. pH Test

The results of the pH test indicate that all three formulations—Aloe Vera + Gelatin, Aloe Vera + PAA, and Aloe Vera + Xanthan Gum—exhibit relatively stable pH levels ranging From 5.05 to 5.15, with a slight increase observed in the Aloe Vera + PAA formulation. This pH range is consistent with the natural pH of the skin, which typically lies between 4.5 and 5.5, making it ideal for preventing skin irritation and maintaining the microbiome balance. Scientifically, a stable pH solution around 5.0 suggests that all three combinations Remain within the weak acid range, supporting skin protection from infections and irritations. This finding aligns with previous research indicating that moisturizers within this pH range Support skin health and prevent conditions such as dermatitis. A study by Leonardi et al also demonstrates that a stable low pH helps strengthen the skin barrier and reduce Transepidermal water loss (TEWL).[13]

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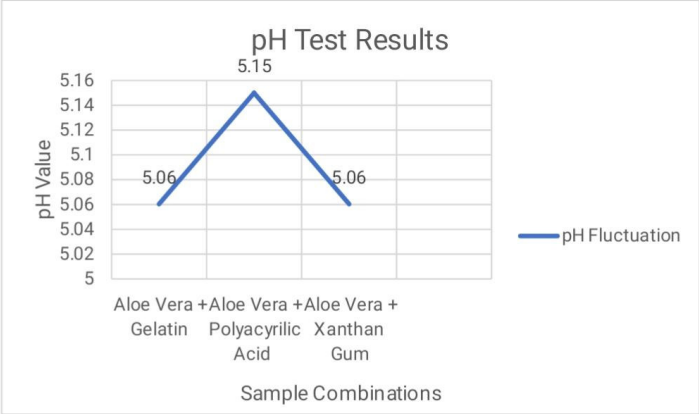

Figure 1. pH Test results

2. Viscosity Test

The viscosity test results reveal significant differences among the three Aloe Vera formulations combined with different thickening agents. The Aloe Vera + Xanthan Gum mixture exhibited the highest viscosity at 81,750 mPa·s, followed by Aloe Vera + PAA at 49,050 mPa·s, and Aloe Vera + Gelatin, which had the lowest viscosity at 1,327 mPa·s.

Xanthan gum is known as a highly effective thickening agent, providing a thick and stable texture to products. Research by Tadros indicates that xanthan gum can form stable gel structures even at low concentrations, which is why it is commonly used in the cosmetic and pharmaceutical industries.[14] Conversely, the Aloe Vera + Gelatin formulation is more fluid due to the thermoreversible nature of gelatin, which does not form as strong a gel structure as xanthan gum at room temperature.

The Aloe Vera + PAA combination has a lower viscosity than xanthan gum but remains sufficiently high. This observation is consistent with PAA's properties, which can form crosslinking structures, offering good mechanical strength without being as dense as xanthan gum

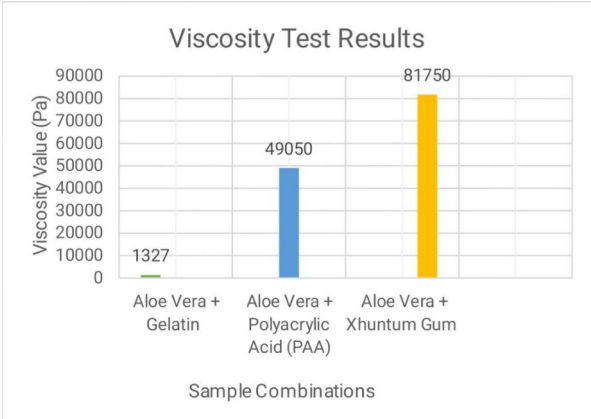

Figure 2. Viscosity Test

3. Moisture Test

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The moisture test results indicate that the Aloe Vera + PAA combination provides the highest moisture level on the skin, followed by Aloe Vera + Gelatin and Aloe Vera + Xanthan Gum. Although the xanthan gum combination yields good hydration, it exhibits greater variability compared to the other formulations. This variability may be attributed to the thicker texture, which may hinder moisture penetration into the deeper skin layers.

Previous research by Chen et al supports these findings, indicating that PAA demonstrates good moisture retention capacity due to its ability to effectively absorb water.[15] Gelatin-based formulations also provide adequate moisture retention due to their water-holding properties, albeit less optimally compared to PAA.

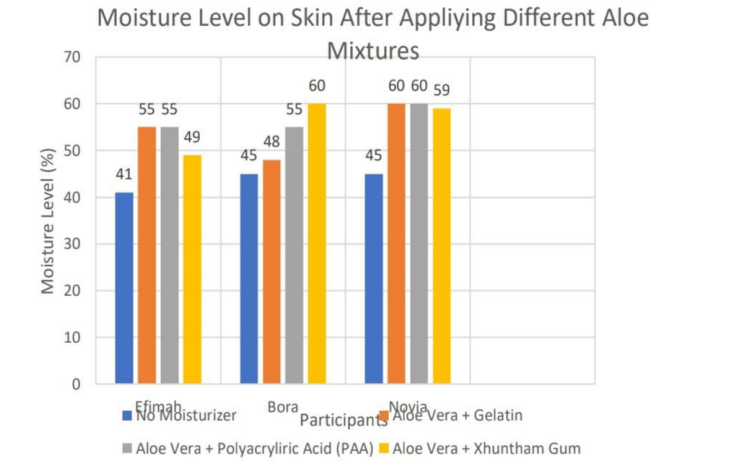

Figure 3. Moisture level by moisture Test

3.2. Relationship Between pH, Viscosity, and Moisture

From the above results, it is evident that pH and viscosity influence the final moisture retention of the skin. Formulations with a more stable pH, such as Aloe Vera + Gelatin and Aloe Vera + PAA, tend to produce more consistent moisture levels. Furthermore, the lower viscosity of the Aloe Vera + Gelatin formulation allows for faster penetration into the skin, although with a less prolonged moisture effect compared to Aloe Vera + PAA.

Conversely, while Aloe Vera + Xanthan Gum has a high viscosity that contributes to a thicker texture, it also results in greater variability in moisture retention. This may be due to excessive thickness, which hinders optimal penetration of moisturizing active ingredients into deeper skin layers.

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Overall, stable pH and balanced viscosity significantly contribute to a moisturizer's ability to maintain skin moisture. This research is consistent with prior studies that emphasize the importance of pH and viscosity in the formulation of effective moisturizers.

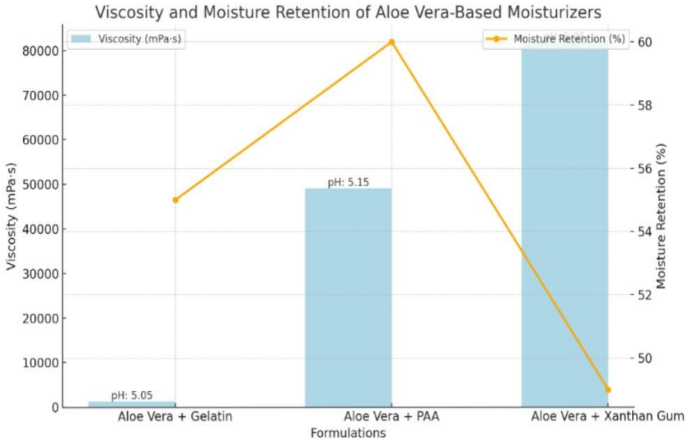

Figure 4. Viscosity and Moisture Retention of Aloe Vera-Based Moisturizers

4. CONCLUSION

The study on Aloe Vera-based moisturizers combined with gelatin, polyacrylic acid (PAA), and xanthan gum produced notable results. All formulations maintained stable pH levels (5.05–5.15), promoting skin health. Differences in viscosity were observed, with Aloe Vera + Xanthan Gum being the thickest (81,750 mPa·s), Aloe Vera + PAA moderate (49,050 mPa·s), and Aloe Vera + Gelatin the least viscous (1,327 mPa·s), allowing quicker absorption. Aloe Vera + PAA demonstrated the most consistent and effective hydration. The findings emphasize the interplay between pH, viscosity, and moisture, identifying Aloe Vera + PAA as the optimal formulation for sustained skin hydration.

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