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"A Mildly Acidic Amino Acid-Based Foaming Care Solution for Intimate Areas"

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1. Introduction

The health of the female intimate area depends on a stable microbial community structure and an appropriately acidic pH environment[1]. In healthy individuals, the vaginal microbiota is predominantly composed of Lactobacillus species, including L. iners, L. crispatus, L. jensenii, and L. gasseri[2]. These bacteria maintain a low pH environment through anaerobic fermentation of glycogen and secrete bacteriocins and hydrogen peroxide, effectively inhibiting pathogen growth and enhancing local immune defense[3]. The production of lactic acid depends on glucose availability, which is regulated by estrogen levels; consequently, vaginal pH fluctuates throughout the menstrual cycle, pregnancy, and various life stages[4].

In recent years, the concept of vaginal health has expanded from disease management to the routine care of healthy women, promoting the incorporation of probiotics, plant extracts, and natural lubricants into intimate care products[5]. External factors such as sexual activity and hygiene practices can also disrupt microbiota balance, increasing the risk of infection[6]. Therefore, ideal intimate care products should be mild and hypoallergenic, capable of maintaining natural pH and microbial stability while minimizing dryness and irritation. Compared to vaginal douching, external cleansers are considered safer and less invasive for daily intimate hygiene, particularly for women who are infection-prone or undergoing antibiotic treatment[7].

Although a wide range of intimate hygiene products are available on the market, many traditional cleansers still rely on highly irritating synthetic surfactants, which can damage the vulvar skin barrier[8], disrupt the normal microbiota, and ultimately increase the risk of infection. Therefore, the selection of intimate cleansers should comprehensively consider the ingredient properties, pH regulation capability, and potential impact on vaginal microbiota, all of which are critical for infection prevention. It is well established that the vulvar skin barrier is more fragile and more sensitive to irritants compared to other body areas. The protective hydrolipidic film must be maintained through the scientific selection of appropriate products[9]. Moreover, the vulvar area is frequently exposed to multiple irritants, including occlusion, friction, sweat, vaginal secretions, and urine, making it more susceptible to irritant and allergic contact dermatitis[10, 11]. According to international guidelines, gentle daily cleansing is essential for

maintaining vulvar hygiene and overall intimate health[12]. Regular cleansing helps remove contaminants such as vaginal secretions, urine, and fecal residues, prevents malodor, preserves the integrity of the skin barrier, and reduces infection risk. Therefore, adopting mild and appropriate cleansing methods is considered a key measure to promote intimate health. Given the vulnerability and sensitivity of the vulvar skin barrier, amino acid-based surfactants—synthesized from amino acids and fatty acids and structurally similar to the body's natural proteins and lipids—have become critical choices in intimate care formulations due to their low irritation potential and excellent cleansing properties[13]. Incorporating moisturizing and microbiota-supporting active ingredients can further enhance barrier protection and microbiota stability, thereby improving the overall care and health of the intimate area.

Based on the above needs, this study developed a mildly acidic amino acid-based foaming cleanser, utilizing sodium lauroyl sarcosinate as the primary surfactant, supplemented with sodium cocoyl glycinate to enhance mild cleansing, and incorporating sodium isostearoyl lactylate and hydrolyzed corn starch to improve moisturization. An ecological nutrient complex was specifically added to support skin microbiota balance and inhibit pathogen growth during cleansing. This study aimed to evaluate the overall performance of the formulation in terms of cleansing efficacy, foam characteristics, pH compatibility, and microbiota balance, providing a safer and more effective solution for female intimate care.

2. Materials and Methods

2.1 Materials

IW-1 was formulated with sodium lauroyl sarcosinate, sodium cocoyl glycinate, potassium cocoyl hydrolyzed oat protein, maltooligosyl glucoside, glycerin, sodium isostearoyl lactylate, capryloyl glycine, arginine, hydroxypropyl cyclodextrin, hydrolyzed corn starch, hydroxyacetophenone, 1,2-hexanediol, ethylhexylglycerin, citric acid, and water. IW-2 was based on the IW-1 formulation with the additional incorporation of inulin and α-glucooligosaccharide. All ingredients were blended according to specified proportions. Pure water was used as the Control.

2.2 Methods

2.2.1 Formulation Characterization

The physicochemical parameters (pH, density), sensory attributes (appearance, color), and foam performance of the formulations were evaluated using instruments including the Mettler Toledo SevenExcellence pH meter, QGB-50 pycnometer, and DFA100 foam analyzer.

2.2.2 Patch test

The human skin patch test was conducted in accordance with the Cosmetic Safety Technical Specification (2015), and the evaluation and recording of results followed the recommendations of the International Contact Dermatitis Research Group (ICDRG). All subjects provided written informed consent prior to participation, having been fully informed of the study objectives, procedures, and potential adverse effects. Participants, aged 20 to 40 years, met all inclusion criteria. During the test, a small amount of each product was applied to the back skin via patch testing for 0.5 and 24 hours. After removing the patches and allowing

transient erythema to subside for 30 minutes, skin reactions were assessed based on ICDRG guidelines (Figure 1)

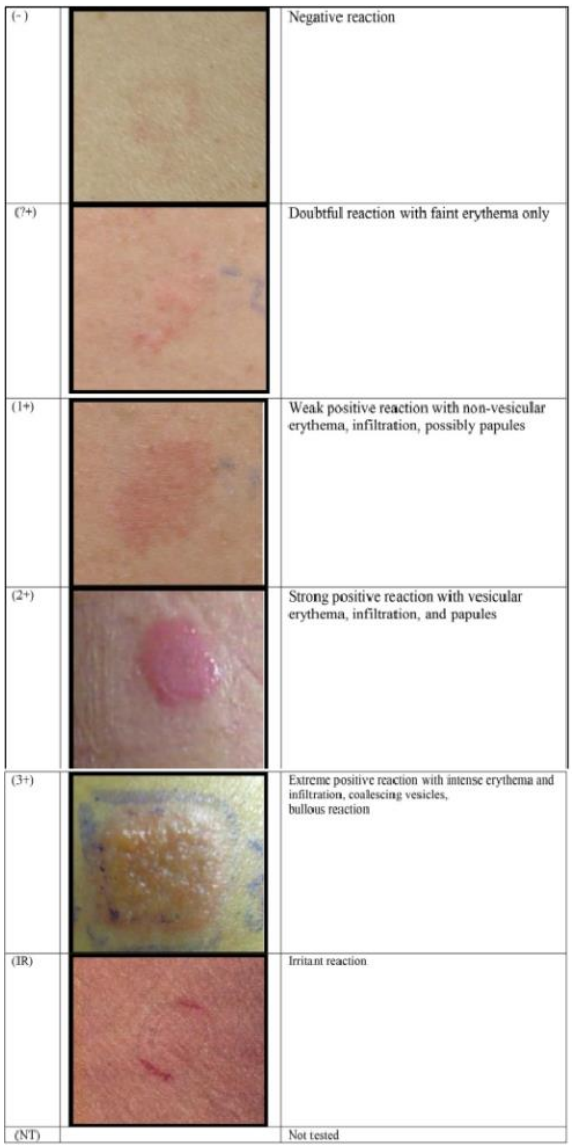

Figure 1. Interpretation and Recording Method for Patch Test Results Recommended by the International Contact Dermatitis Research Group (ICDRG)[14]

2.2.3 Changes in skin pH, stratum corneum hydration, and TEWL

Four subjects were selected, and test areas were delineated on the inner forearms. Skin parameters were measured using the Cutometer® dual MPA 580 System combined with the CTplus platform. Skin pH, stratum corneum hydration, and transepidermal water loss (TEWL) were recorded for the Control, IW-1, and IW-2 groups before use and 1 hour after application. Measurements were performed with the Skin-pH-Meter PH 905 probe for pH, the Corneometer CM 825 probe for hydration, and the Tewameter TM Hex probe for TEWL. To minimize external interference, subjects washed their arms with water prior to testing and rested in a controlled environment (22 ± 2 °C, 50 ± 10% RH) for 20 minutes. Each test site was measured three times,

and the average value was used for analysis. Data were processed using GraphPad Prism software, and statistical differences were evaluated by two-way ANOVA.

2.3.4 Question

Four volunteers were enrolled in this study according to the following inclusion criteria:

Habitual use of intimate cleansers;History of gynecological conditions.

Upon receiving the test products and a pre-designed questionnaire, participants performed a blinded trial of two formulations based on specified usage frequency and application areas. Volunteers were instructed to:

A. Use each product three times;

B. Avoid using other intimate cleansing products during the trial period;

C. Discontinue use immediately and report to the researchers if any adverse reactions occurred;

D. Complete the post-use questionnaire truthfully and thoroughly based on their actual experience.

3. Results

The physicochemical and sensory characteristics of IW-1 and IW-2 are summarized in Table 1. The formulations appeared transparent, clear, colorless, and odorless. The pH values ranged from 5.4 to 5.6, and the density was 1.03 g/mL. These properties indicate that the formulations are suitable for skin application.

Table 1. Physicochemical and sensory parameters of IW-1 and IW-2

	Physicochemical Parameters	Sensorial Parameters
IW-1	pH range: 5.4-5.6 Density (g/ml): 1.03	Appearance: liquid Color: Clear
IW-2	pH range: 5.4-5.6 Density (g/ml): 1.03	Appearance: liquid Color: Clear

As shown in Figure 2, the changes in average foam height of IW-1 and IW-2 over time were compared. After 60 seconds of stirring, the foam height of IW-1 was 119.4 mm, and that of IW-2 was 120.1 mm. After 1800 seconds, the foam heights decreased to 92.7 mm and 93.6 mm, respectively. The difference in foam height was used to evaluate foam stability, with results indicating that IW-2 exhibited superior foam stability compared to IW-1.

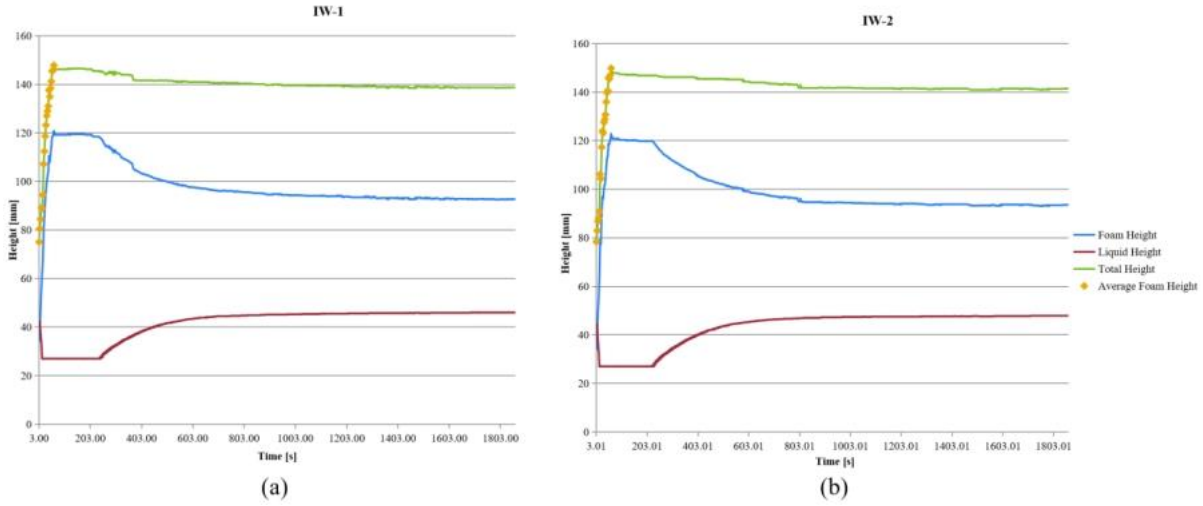

Figure 2. Evaluation of Foam Height

As shown in Figures 3 and 4, the foam structure data and morphology of IW-1 and IW-2 were compared. The number of bubbles per unit area and the average bubble area were used to assess foam density. After 5 minutes of stirring, IW-1 exhibited 105.936 bubbles/mm² with an average bubble area of 9440 μm², while IW-2 showed 105.739 bubbles/mm² and 9457 μm², indicating higher foam density for IW-1. After 15 minutes, the bubble number decreased to 3.9876 bubbles/mm² for IW-1 and 4.309 bubbles/mm² for IW-2, with corresponding average bubble areas of 250800 μm² and 232077 μm², respectively, demonstrating that IW-2 maintained higher foam density over time.

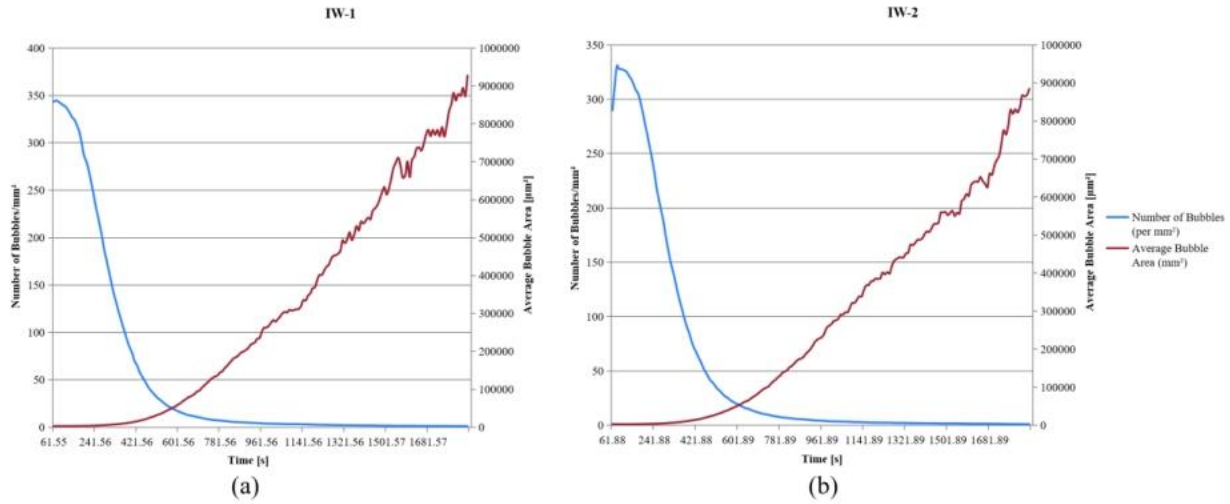

Figure 3. Analysis of Foam Structure

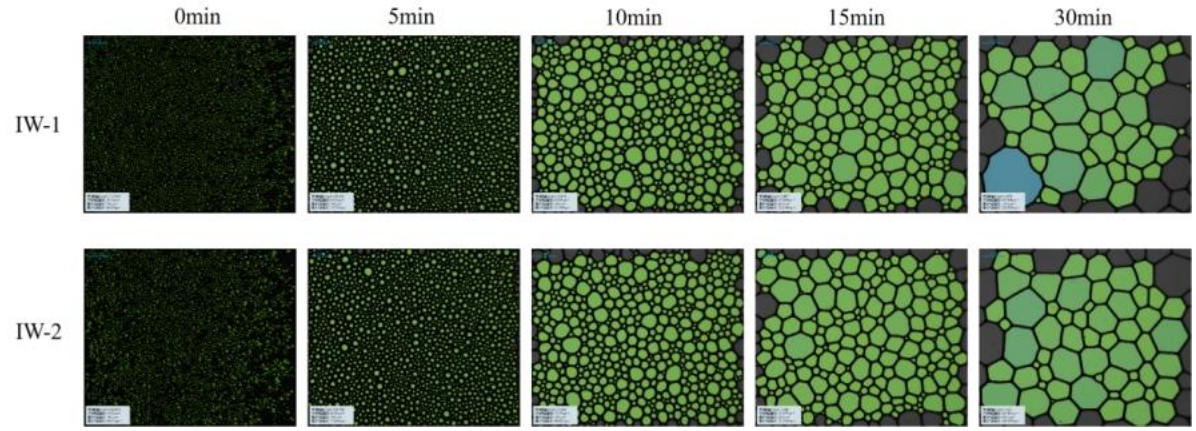

Figure 4. Characterization of Foam Structure

The results of the skin patch test are summarized in Table 2. At both 0.5 and 24 hours after application, all four subjects exhibited no adverse skin reactions (grade "-") across the Control, IW-1, and IW-2 groups. No signs of erythema, edema, irritation, or other abnormal skin responses were observed. These findings indicate that both IW-1 and IW-2 formulations, as well as the Control, demonstrated excellent skin compatibility under the conditions tested.

Table 2. Summary of human skin patch test results

Group	Number of Subjects	Observation Time (h)	Number of Subjects by Skin Reaction Grade						
			-	?	+	++	+++	IR	NT
Control	4	0.5	4						
		24	4						
IW-1	4	0.5	4						
		24	4						
IW-2	4	0.5	4						
		24	4						

As shown in Figure 5, both IW-1 and IW-2 had no significant effect on skin pH compared with the Control, indicating good mildness and preservation of the skin’s acid-base balance. One hour after use, both formulations significantly increased stratum corneum hydration, with IW-2 showing a more pronounced improvement, suggesting superior immediate moisturizing efficacy. Additionally, TEWL significantly decreased following IW-2 application, indicating enhanced skin barrier function. Overall, both IW-1 and IW-2 improved skin hydration in the short term, with IW-2 demonstrating more notable effects in moisturizing and barrier repair.

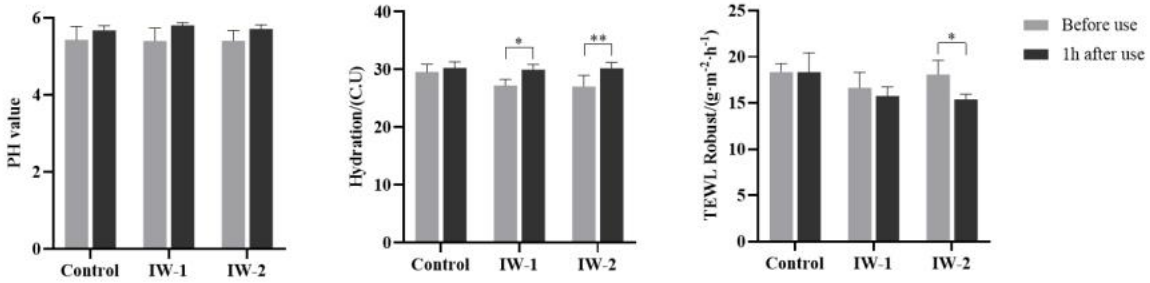

Figure 5. Skin pH, Hydration, and TEWL Changes Before and After Product Application

The questionnaire evaluation results are summarized in Table 3. Both IW-1 and IW-2 demonstrated high subjective satisfaction across all parameters, with mean scores ranging from 4.5 to 5. No significant differences (NS) were observed between the two formulations in any evaluated item. During use, no irritation, redness, desquamation, or abnormal secretions were reported. Foam richness, fineness, and ease of rinsing were rated highly for both products. After use, subjects did not experience tightness, dryness, or a residual film sensation on the skin, and no burning discomfort was noted in the mucosal area. These findings indicate that both IW-1 and IW-2 exhibited excellent user tolerance and cleansing performance, with no adverse sensory responses.

Table 3. Questionnaire results are reported.

Question	IW-1	IW-2	P-value
During use, any irritation in the intimate area?	4.75±0.5	5	NS
During use, any redness, desquamation, or abnormal secretions?	5	5	NS
Foam richness before rinsing?	4.75±0.5	5	NS
Foam fineness before rinsing?	4.5±0.58	5	NS
Was the foam easy to rinse off?	5	5	NS
After rinsing, any greasy or residual film sensation?	5	5	NS
After use, any tightness or dryness in the intimate area?	4.5±0.58	4.75±0.5	NS
After use, any burning sensation or discomfort in the mucosa?	4.75±0.5	4.75±0.5	NS

Data are presented as mean ± standard deviation. Questionnaires were completed after six days of product application. NS indicates no significant difference. The total score was 5, with higher scores reflecting a better user experience.

4. Discussion

The vulvar skin is covered by an acidic hydrolipidic film, which plays a crucial role in maintaining skin barrier function. This film is formed by the combination of aqueous surface components and lipids secreted by sebaceous glands, providing lubrication, waterproofing,

and protection for the skin and hair[15]. Therefore, ideal intimate cleansers should utilize mild surfactants that effectively remove impurities while minimizing damage to the stratum corneum barrier. In recent years, amino acid–based surfactants have been widely used in rinse-off personal care products due to their excellent skin mildness and biodegradability. Compared to conventional anionic surfactants such as SLS and SLES, amino acid surfactants exhibit significantly lower irritation and reduce skin barrier disruption during cleansing[16]. Multiple studies have shown that these surfactants can maintain effective cleansing performance while significantly reducing transepidermal water loss (TEWL), thereby supporting the integrity of the stratum corneum[17]. As such, amino acid–based surfactants are considered a key choice in the development of mild facial cleansers, shampoos, and body washes.

Amino acid-based surfactants can effectively reduce the surface tension of water to 35–40 mN/m, exhibiting excellent initial foaming performance. However, the formation of fine and stable foam requires further reduction of surface tension to below 25 mN/m and relies on a high dilational modulus to enhance gas–liquid interface stability. Due to their molecular structure, amino acid surfactants such as sarcosinates and taurates are unable to independently generate dense foam and typically require co-formulation with auxiliary surfactants to optimize foam properties. In addition, the solubility of amino acid surfactants is closely related to the system pH; for example, the methyl group in sarcosinates inhibits hydrogen bond formation and disrupts headgroup packing, allowing for good solubility over a wider pH range[18].

Based on these characteristics, this study selected sodium lauroyl sarcosinate as the primary surfactant, supplemented with sodium cocoyl glycinate, achieving excellent foam performance while maintaining effective cleansing and mildness under weakly acidic conditions. To address the specific moisturizing needs of the intimate area, sodium isostearoyl lactylate and hydrolyzed corn starch were further incorporated as moisturizing agents. Experimental results showed that the addition of moisturizing ingredients in the IW-1 formulation did not adversely affect foam properties or sensory experience. Building on this, IW-2 introduced inulin and α-glucooligosaccharide as eco-nutrient ingredients to promote skin microbiome health, with no negative impact observed on overall system performance.Efficacy testing demonstrated that both IW-1 and IW-2 did not cause significant changes in skin pH, reflecting good skin compatibility. IW-2 further enhanced skin moisture retention, while IW-1 significantly increased stratum corneum hydration, confirming the effectiveness of the moisturizing components. Questionnaire results were consistent with objective measurements, with most participants reporting no sensations of tightness or dryness after use, further validating the mildness and moisturizing performance of the formulations.

In rinse-off personal care products, foam characteristics play a critical role in shaping consumer sensory experience. Studies have shown that physical properties such as foam richness, stability, and texture directly influence consumer perceptions of cleansing efficacy and usage satisfaction. Foam height and stability are commonly used as key indicators to evaluate detergent quality, reflecting foaming performance and cleansing ability. Additionally, foam density and lubricity are closely associated with consumers' subjective evaluations of foam quality[19]. Therefore, optimizing foam performance is essential for improving user satisfaction

and enhancing market competitiveness. In this study, the foam height, stability, and density of IW-1 and IW-2 were analyzed. Results indicated that the addition of ecological nutrients did not negatively affect foam properties but rather improved foam stability to some extent. Questionnaire results further supported these findings, with participants rating the foam performance of both formulations between 4.5 and 5, suggesting that the formulations effectively enhanced consumer sensory satisfaction.

5. Conclusion

This study developed a mildly acidic amino acid-based foaming cleanser, which demonstrated favorable performance in terms of cleansing efficacy, foam properties, pH compatibility, and support for ecological balance. These results suggest that the formulation offers a safer and more effective solution for female intimate care. However, the current research provided limited exploration regarding the product's impact on the intimate microbiome. Future studies should focus on evaluating the role of the foam cleanser in modulating the local microbial ecosystem, thereby offering more comprehensive scientific support for its application in female intimate hygiene.

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