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Study of the Physicochemical Properties of Different Hair and Body Shampoo Brands Available in the Local Market of Al Khums, Libya

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A B S T R A C T

Background: Shampoos, for both hair and body, are essential agents for removing sebum and environmental contaminants. Recent research has focused on the evolving requirements of these formulations, emphasizing their composition, functional roles, and evaluative criteria. **Aims:** The aim of this study was to perform a comparative physicochemical analysis of hair care and body care shampoo formulations, searching for physical or chemical differences to justify the varied use**.** The goal of this study was to assess the physicochemical characteristics of hair and body shampoo samples consistent with those observed differences.

Methods: Ten randomly selected commercial brands by chosen different brands that was more trading by Libyan people (five hair shampoos and five body washes from various manufacturers) were analyzed. The evaluation included surface tension, foam height, pH, Total Dissolved Solids (TDS), Refractive Index (R.I.), Brix%, and moisture content.

Results: The data exhibited notable differences between the two product categories. Body shampoos generally displayed lower surface tension values, which suggests a higher efficiency of the surfactant systems in reducing interfacial tension compared to hair formulations. Furthermore, body shampoos demonstrated higher foam heights, aligning with consumer sensory expectations for skin cleansing. Conversely, some hair shampoos produced lower foam volumes, which may be attributed to the presence of conditioning agents added to protect the hair shaft. Hair shampoos also tended to be more acidic, a property beneficial for maintaining cuticle integrity. Both formulations displayed high TDS levels, indicating the consistent use of electrolytes as rheology modifiers to achieve desired viscosity.

Conclusion: Overall, the differences observed in both product types were likely greater due to intentional differences made for the sake of specific functional biologically needs (skin health v. hair health) and sensory performance.

Keywords: shampoo, surface tension, pH, Total Dissolved Solids TDS

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1. Introduction

In the realm of physics and chemistry applied to consumer goods, everyday cleansing agents have grown far more sophisticated due to advances in personal care formulations, take shampoos and body washes as prime examples. What was once a straightforward substance for removing dirt and oil has now become a multifunctional system. Looking back, a quality shampoo was simply expected to perform three basic tasks, lift away grime from hair fibers, restore surface reflectivity (shine), and keep strands easy to comb or style. Now, shampoo is a subjective term that can describe an even larger variety of formulations and functions, so there is no longer one standardized definition to represent a shampoo. Thus, there has become an acceptable expectation of basic functional criteria for the consumer, which would be an acceptable product. These basic functional criteria would be the ability to clean the secretions of the sebaceous gland, remove environmental pollution, and remove residuals from the previously applied hair product (e.g., polymeric materials). After cleaning, there should not be a negative impact on the condition of the hair after rinsing regarding management or combing, wet, or dry, act as a carrier to deposit beneficial substances, which are relatively non-irritating, non-harmful to the scalp or the eye [1]. The amount of foam a product produces is not directly linked to how well it cleans [2], the ability to generate a considerable amount of foam is still viewed as a very important component in consumer acceptance as, from pure psychology terms, consumers like foaming formulas. Some formulations may lead undesirable effects such as excessive dryness of the hair, or irritation to the eye or corneal opacification in some formulations, indicating that conditioning and formulation approaches are clearly important [1]. The primary function of these types of products is to utilize surfactants to remove oils and soil (Sebum) [3]. While the primary ingredients may be similar for hair shampoo and body wash, they are formulated with careful physicochemical properties to meet their individual functional and biological purposes. Hair shampoo has the objective of keeping the cuticle scales intact while cleansing the scalp. Hair shampoos are formulated with a low (pH) (acidic) [4], consumers often associate abundant lather with superior cleaning power. Therefore, shampoo manufacturers typically add surfactants that produce rich foam. Shampoos are also formulated to have a slightly acidic pH (between 3.5 and 5.5). This helps close the hair cuticle and gives hair a smoother look. In contrast, body washes should be formulated with a pH close to that of the skin's natural acid mantle, in order to protect the skin's barrier function [2]. It is important to measure the physicochemical properties of these products in order to consider their functional properties. While rheological properties, influenced by Total Dissolved Solids (TDS) and additional electrolytes, govern physical stability and viscosity, surface tension is a more straightforward measure of surfactant effectiveness [5,6].

2. Material and Methods

Sample Collection

To ensure a representative assessment of products available in the local market, ten commercially available formulations comprising five hair shampoos and five body shampoos were randomly purchased from selected pharmacies in Al Khums City, Libya. Pharmacies were specifically chosen as procurement points to guarantee that the samples had been stored under standardized professional conditions (controlled temperature and humidity), thereby ensuring the integrity of their physicochemical properties. The samples were coded as 1–5 for hair shampoos and 6–10 for body washes show at in Table (1).

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Table (1): Specification of the Selected Hair and Body Shampoo Samples

Sample No.	Sample Category	Brand Name
1	Hair Shampoo	Dove
2	Hair Shampoo	Vaseline
3	Hair Shampoo	Pantene
4	Hair Shampoo	Lifebuoy
5	Hair Shampoo	Clear
6	Body Shampoo	Fa
7	Body Shampoo	Agrado
8	Body Shampoo	Genera
9	Body Shampoo	Felce Azzurra
10	Body Shampoo	Neutro Derma

Moisture Content Analysis

The moisture content (total volatile matter) of the samples was determined using the atmospheric oven-drying method in accordance [7]. Standards. Approximately 2.0 g of each shampoo and body wash sample was accurately weighed into a pre-dried porcelain crucible. The samples were then placed in a digital thermostatic oven maintained at 105°C ± 2°C. Drying continued until a constant weight was achieved, indicating the complete removal of volatile components. To ensure statistical reliability and precision, all measurements were conducted in triplicate (n=3). The moisture percentage was calculated based on the weight loss relative to the initial sample mass.

Sample Preparation

Standard test solutions for each sample were prepared using distilled water at a uniform concentration of 10% (w/v). These solutions served as the basis for all subsequent physicochemical evaluations.

Surface Tension Measurement

The surface tension was determined using the Drop Weight Method (Stalagmometer). This technique involves measuring the weight or counting the number of drops for a fixed volume of the sample solution compared to distilled water as a reference standard [5]. The data calculated by following equation (1)

$$R_2 = R_1 \times \frac{n_1(w_1 - w_3)}{n_2(w_1 - w_2)} \quad (1)$$

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W_1 is weight of empty beaker.

W_2 is weight of beaker with distilled water.

W_3 is weight of beaker with shampoo solution.

n_1 is number of drops of distilled water.

n_2 is number of drops of shampoo solution

R_1 is surface tension of distilled water.

R_2 is surface tension of shampoo solution.

Foaming Capacity Test

Foaming ability was evaluated using the Cylinder Shaken Method [2]. A predetermined volume of the 10% shampoo solution was transferred into a graduated cylinder. The cylinder was shaken vigorously for 30 seconds (approximately 20 uniform shakes) to generate foam. The initial foam height (cm) was recorded immediately to assess foaming capacity, while stability was observed over a fixed duration.

pH and TDS Quantification

pH Assessment: To evaluate the biological compatibility of the products with skin and hair, the pH of the prepared solutions was measured using a calibrated digital pH meter [8]. Total Dissolved Solids (TDS): The concentration of electrolytes (salts), which serve as rheology modifiers, was quantified using a digital conductivity meter. Results were recorded in parts per million (ppm) to reflect the ionic strength of each formulation [6].

Refractive Index and Brix Measurement

The Refractive Index (R.I.) was measured using a refractometer, calibrated with distilled water, to assess the purity and concentration of dissolved solids. A drop of each sample was placed on the prism, and the R.I. was read directly. Subsequently, the Brix percentage (Brix %), representing the total weight of non-volatile dissolved solids, was derived from the R.I. values to characterize the formulation density [3].

3. Results and Discussion

The quality and efficacy of personal care products are fundamentally dependent on the correct balance of their physicochemical properties. Knowledge of these properties is essential to ensure functionality and consumer safety.

Table (2): Comparison of Moisture Content in Hair and Body Shampoos

Sample No.	Sample Type	Sample Color	Moisture Content (M.C) %
1	Hair Shampoo	Creamy White	66.54 ±0.45
2	Hair Shampoo	Orange	61.19 ± 0.32
3	Hair Shampoo	Creamy White	58.76 ± 0.51
4	Hair Shampoo	Sky Blue	59.71 ± 0.28

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Sample No.	Sample Type	Sample Color	Moisture Content (M.C) %
5	Hair Shampoo	Pink	50.40 ± 0.58
6	Body Shampoo	Pink	80.60 ± 0.35
7	Body Shampoo	Sky Blue	78.74 ±0.42
8	Body Shampoo	Sky Blue	88.69 ± 0.25
9	Body Shampoo	Faint Green	84.63 ± 0.38
10	Body Shampoo	Creamy White	85.01 ± 0.47

Note: Values are presented as Mean ± Standard Deviation (SD) for triplicate measurements (n=3).

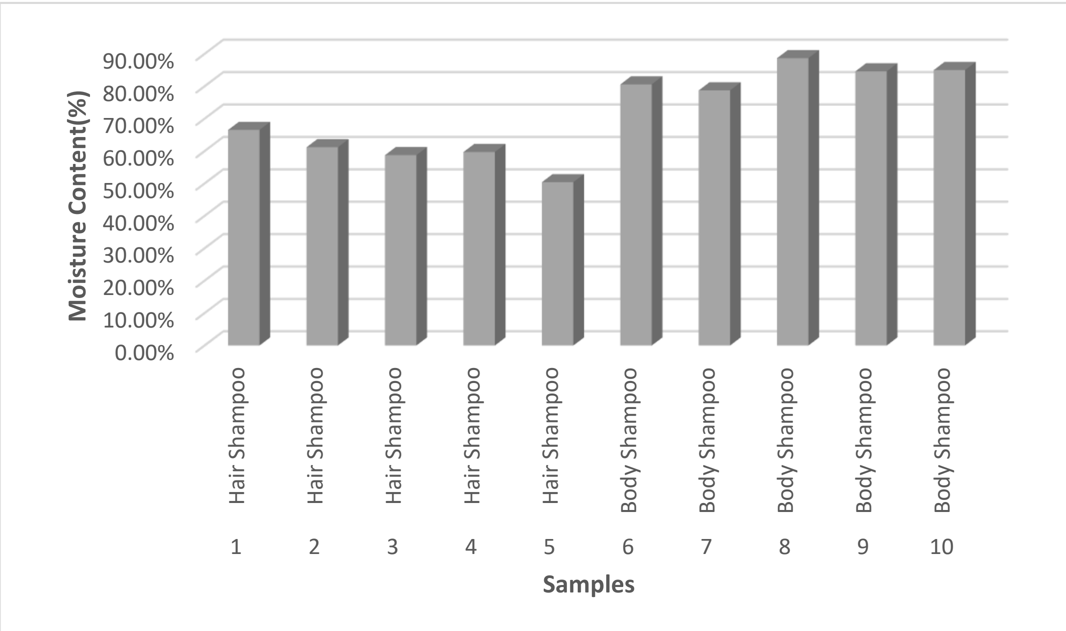

Figure (1): Comparison of Moisture Content in Hair and Body Shampoos

Moisture Content (MC) is the complementary category of Total Solids concentration. The results displayed in Table 2 clearly indicate that hair shampoos (Samples 1–5) contained moisture contents (50.40%–66.54%) that were consistently lower than those of body shampoos (Samples 6–10) (78.74%–88.69%). This observation is significant, as it indicates that hair products are more commonly formulated with a higher concentration of thickeners and conditioning agents (such as silicones and polymers). These non-volatile solids are essential for enhancing hair manageability and adjusting the viscosity of the formulation [3]. The reasoning behind this compositional difference lies in

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the fact that hair shampoos require a higher viscosity to ensure the product remains stable and easy to apply.

Table (3): Comparative Analysis of Physicochemical Properties of Hair and Body Shampoos

Sample No.	Sample Type	pH	Conductivity (µS/cm)	TDS (mg/L)	Salinity (ppm)	Refractive Index (R.I.)	Brix (%)
1	Hair Shampoo	5.45	1675	1006	1694	1.3371	2.9
2	Hair Shampoo	5.88	1179	725	1191	1.3373	3.0
3	Hair Shampoo	6.70	1553	870	1578	1.3373	3.0
4	Hair Shampoo	6.83	1406	979	1634	1.3373	3.0
5	Hair Shampoo	6.63	1517	909	1511	1.3373	3.0
6	Body Shampoo	5.30	1200	643	1071	1.3372	2.9
7	Body Shampoo	6.68	2120	1278	2130	1.3372	2.9
8	Body Shampoo	6.25	1664	977	1699	1.3372	2.9
9	Body Shampoo	5.73	2410	1457	2430	1.3372	2.9
10	Body Shampoo	6.26	2740	1810	2620	1.3372	2.9

The measured pH range (5.30 to 6.83) for all samples demonstrates overall compatibility with the biological acid mantle. Notably, hair shampoos are formulated at a slightly acidic pH to ensure hair cuticle protection and minimize fiber swelling [9]. Analysis of Total Dissolved Solids (TDS) revealed a clear distinction between the two categories; body shampoos (Samples 6–10) exhibited higher and more varied TDS values, peaking at 1810 mg/L, compared to hair shampoos which reached up to 1006 mg/L. These elevated levels in body washes are attributed to the strategic addition of electrolytes primarily Sodium Chloride ($NaCl$), which are essential for optimizing viscosity and achieving the desired properties in surfactant-based formulations [5, 6]. Finally, the consistency of the Refractive Index (1.3371 – 1.3373) confirms rigorous quality control and ensures the visual clarity required for commercial products [10].

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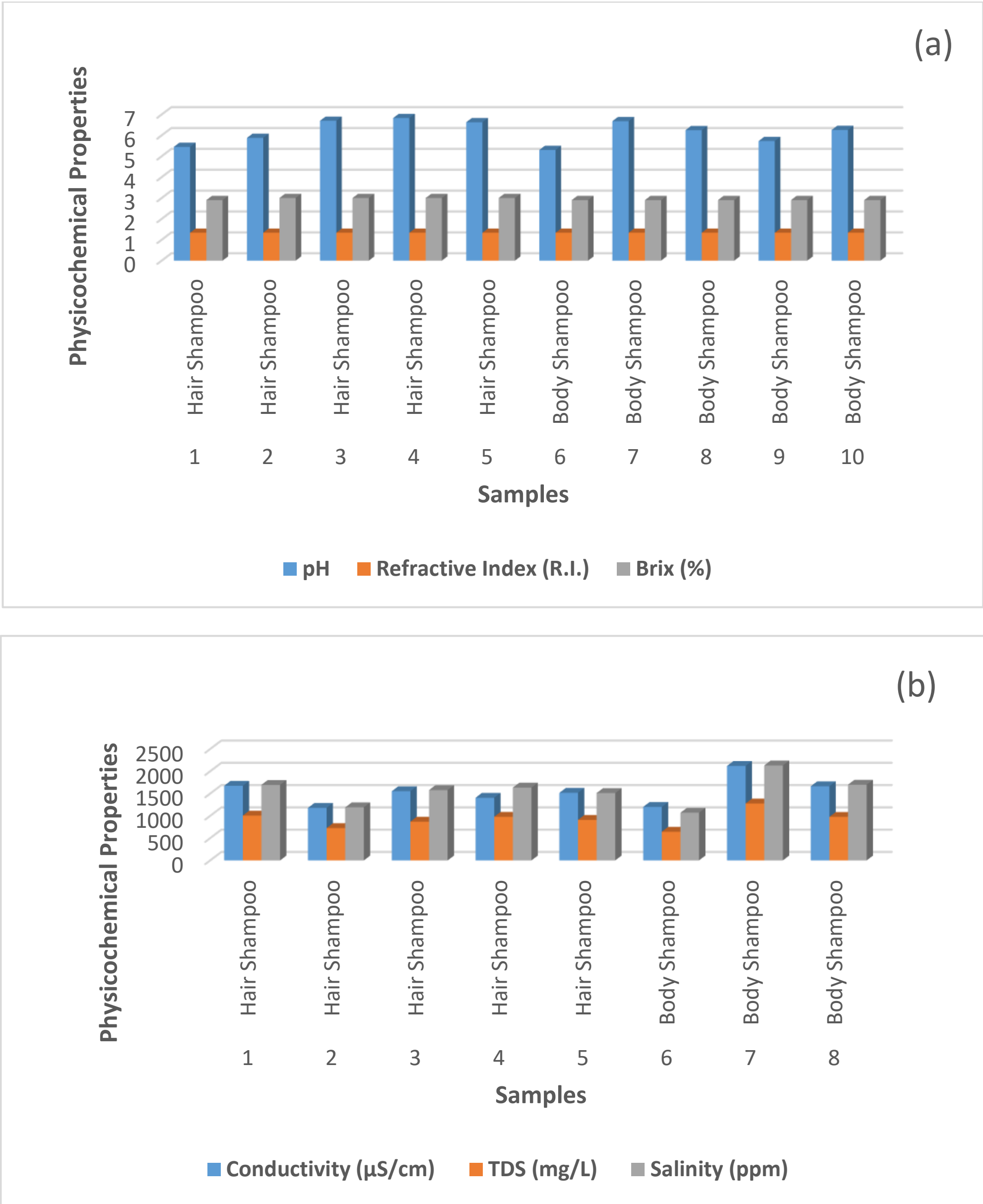

Figure (2a&b): Comparative Analysis of Physicochemical Properties of Hair and Body Shampoos

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Table (4): Surface Tension Values for Hair and Body Shampoos Compared to Distilled Water

R_1=constant=72.88dynes/cm		n_1 = constant = 412 drop		w_1=constant=110 g	
Sample No.	**Sample Type**	w_2 (g)	w_3 (g)	n_2 (drop)	**R_2 (dyne/cm)**
1	Hair Shampoo	18.32	20.22	1100	29.87
2	Hair Shampoo	18.68	19.98	676	46.70
3	Hair Shampoo	18.61	20.22	1080	29.93
4	Hair Shampoo	18.57	20.38	1000	32.52
5	Hair Shampoo	18.16	19.81	905	35.82
Average	**Hair Shampoos**	**18.47**	**20.12**	**932**	**35.00**
6	Body Shampoo	18.12	19.42	1080	29.43
7	Body Shampoo	18.70	20.15	1130	28.20
8	Body Shampoo	18.17	19.41	1050	30.17
9	Body Shampoo	18.42	20.34	1050	31.28
10	Body Shampoo	18.58	19.96	1060	28.32
Average	**Body Shampoos**	**18.60**	**19.86**	**1070**	**29.48**

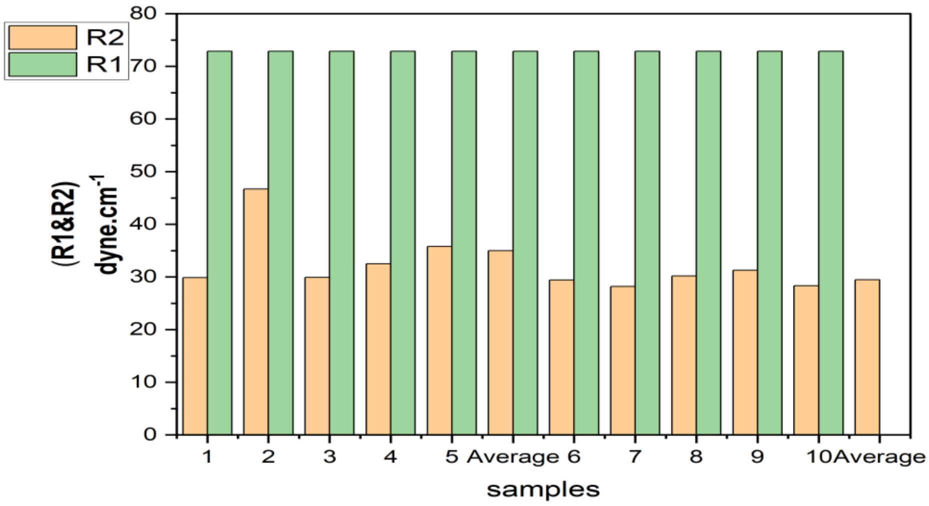

Figure (3): Surface Tension Values for Hair and Body Shampoos Compared to Distilled Water

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All samples in Figure 3 demonstrated a marked reduction in surface tension compared to distilled water (72.88 dyne/cm). The average surface tension for hair shampoos (35.00 dyne/cm) was notably higher than that of body shampoos (29.48 dyne/cm). This numerical difference suggests that body wash formulations may incorporate a higher concentration or a more potent mixture of surfactants. Conversely, the presence of conditioning agents in hair shampoos such as oils and polymers may slightly interfere with the surfactants' orientation at the air-water interface, thereby resulting in relatively higher surface tension values compared to body wash products.

Table (5): Average Foam Height for Hair and Body Shampoos

Sample No.	Sample Type	Foam Height (cm)
1	Hair Shampoo	8
2	Hair Shampoo	15
3	Hair Shampoo	7.5
4	Hair Shampoo	12
5	Hair Shampoo	13
Average	**Hair Shampoos**	**11.1**
6	Body Shampoo	11
7	Body Shampoo	17
8	Body Shampoo	8
9	Body Shampoo	22
10	Body Shampoo	16
Average	**Body Shampoos**	**14.8**

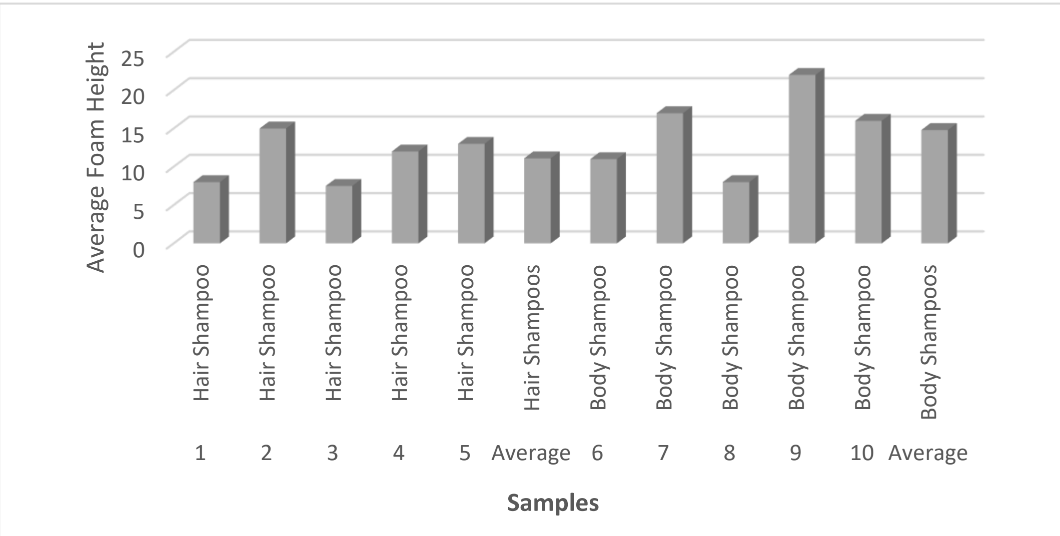

Figure (4): Average Foam Height for Hair and Body Shampoos

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Table 5 and Figure 4 demonstrate that body shampoos yield a mean foam height (14.8 cm) that is consistently higher than the average for hair shampoos tested (11.1 cm). These results align with consumer sensory expectations, as cleansing efficacy is traditionally associated with a rich and voluminous lather [1]. The superior foaming performance of body washes is attributed to a synergistic blend of co-surfactants specifically formulated to enhance foam stability and volume. In contrast, the lower foam height observed in certain hair shampoos such as Sample 3 (7.5 cm) reflects a strategic formulation balance. This reduction in foaming power is often a consequence of incorporating conditioning agents, which are prioritized to improve hair manageability and provide fiber protection, even at the expense of maximum foam production.

4. Conclusion

Physicochemical analysis reveals distinct functional and compositional differences between body and hair shampoo formulations. Body shampoo met sensory criteria and exhibited high surfactant performance by generating more foam with lower surface tension. Hair shampoo was designed with a higher concentration of Total Solids (lower M.C) to contain the conditioning agents required for hair protection, along with an emphasis on acidic (PH) values for cuticle integrity. The high TDS values seen in both formulations underscore the key role of electrolytes in regulating the rheological properties (viscosity) of each formulation.

Recommendations

In order to fully understand how electrolyte levels, affect the stability and sensory properties of the final product, extensive investigations into about viscosity need to be conducted and compared to the chemical analysis, specifically TDS. Since the first foam height is insufficient for thoroughly evaluating the sensory performance of the product, Foam Stability (the foam remaining after a designated time) should be employed as an additional quality marker. Rather than relying on a purely gravimetric comparative approach, to improve the reliability of interpreting the surface tension and foaming results, the true concentration of total active surfactant for each sample should be determined. The true concentration of the total active surfactant for each sample should be measured rather than depending on simple gravimetric comparisons in order to improve the numerical analysis of both surface tension and foaming results. It is recommended that further testing is conducted to identify the surfactants that perform well at foaming and surface tension in the presence of high ratios of conditioning agents and oils. Body product manufacturers should confirm that the pH of the skin remains consistently in the safe range of approximately 5.5 during dilution and storage to be safety and optimal efficacy of the formulation.

ETHICAL STATEMENT

Not Applicable

CONFLICT OF INTEREST

No conflict of interest.

AUTHORS' CONTRIBUTIONS

All authors contributed equally.

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