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Original Research Article

In vitro hair study, to evaluate the performance of 1% selenium sulfide +3% salicylic acid shampoo compared to 2% ketoconazole +2% salicylic acid shampoo in improving hair smoothness, hair softness, hair moisture, hair shine, hair manageability and reducing the hair frizz

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ABSTRACT

Background: Recently, there's been more focus on finding hair care products that improve quality, manageability, and scalp health. Different active ingredients are used in products to improve these properties, with selenium sulfide and salicylic acid being important for their antifungal and keratolytic effects. Therefore, this study evaluates the efficacy of a novel hair care formulation, 1% selenium sulfide and 3% salicylic acid shampoo (Product A), in improving hair quality compared to a benchmark product, 2% ketoconazole and 2% salicylic acid shampoo (Product B). The main goal was to evaluate the impact of these formulations on hair smoothness, softness, moisture, shine, manageability, and frizz reduction through an *in-vitro* hair swatch study.
Methods: The study involved baseline treatment followed by the application of the respective shampoos, with subsequent evaluation of hair quality parameters by a trained expert panel.
Results: Results indicated that both products significantly improved hair smoothness and softness. However, product A outperformed product B in hair manageability and frizz reduction, with a 20% improvement in manageability and a 32% reduction in frizz. Product B, while showing greater improvement in moisture retention (13% vs. 6%), experienced a decline in shine, whereas product A maintained shine levels.
Conclusions: Statistical analysis revealed significant differences in performance, with product A showing superior results overall. These findings suggest that product A offers a more balanced and effective solution for hair care, particularly in manageability and frizz control. Further research, including clinical trials, is recommended to validate these results and explore long-term effects.

Keywords: Hair care products, Selenium sulfide, Salicylic acid shampoo, Manageability, Frizz reduction, Hair quality

INTRODUCTION

In recent years, the pursuit of effective hair care products has gained significant attention, particularly in addressing issues such as hair quality, manageability, and scalp health.[1] Various active ingredients are utilized in formulations to enhance these properties, with selenium sulfide and salicylic acid being prominent due to their antifungal and keratolytic effects, respectively.[2-5,8]

This study focuses on evaluating the efficacy of a novel formulation comprising 1% selenium sulfide and 3%

salicylic acid shampoo. It aims to determine its performance in improving hair quality compared to a benchmark product, 2% ketoconazole and 2% salicylic acid shampoo. The parameters assessed include hair smoothness, softness, moisture, shine, manageability, and frizz reduction.

A hair swatch study closely resembles real-world conditions and provides a realistic substrate for testing the effects of shampoos including softness, shine and manageability.[3] This allows for more accurate assessment of how a shampoo performs on actual hair, leading to insights that are relevant to consumer experience. Through this *in-vitro* study, we seek to provide comprehensive data that may guide classification and labeling of investigational product, contributing valuable insights to the field of hair care and enhancing consumer options for effective scalp and hair management.

Objectives

The objective of this study is to evaluate the performance of 1% selenium sulfide + 3% salicylic acid shampoo compared to 2% ketoconazole + 2% salicylic acid shampoo on hair swatches in improving hair smoothness, hair shine, hair softness, hair moisture, manageability and reducing the hair frizz.

METHODS

This invitro study was conducted in the period of April 2024-May 2024 at KET's scientific research centre. Ethical approval was not required as the study did not involve any human participants. The study was designed as an *in-vitro* hair assessment to evaluate the efficacy of two shampoo formulations: 1% selenium sulfide + 3% salicylic acid shampoo (product a) and 2% ketoconazole + 2% salicylic acid shampoo (Product B). The study was conducted in two main phases

Phase 1: baseline treatment

Sample preparation: A total of six hair swatches were collected for testing.

Treatment with SLES: Each swatch was treated with 5% sodium lauryl ether sulfate (SLES) and then thoroughly rinsed with water.

Baseline assessment: After drying, baseline assessments were conducted on the hair swatches to evaluate initial hair quality parameters.

Phase 2: Product application

Product application: The dried hair swatches were divided into two groups, with three swatches assigned to each product. Each group was treated with the respective shampoo formulations. All the hair swatches were wet with tap water. Then, one gm of product was applied on every swatch using syringe and spread out evenly onto each hair swatch, lathered for 1 minute and kept aside for 2 minutes. After 2 minutes, hair swatch was rinsed with tap water till complete removal of lather. Excess water was removed with the help of napkin and allowed to dry naturally.

Post-application assessment: Following drying, the same parameters assessed at baseline were evaluated again.

Evaluation parameters

The expert panel, comprising three trained assessors, evaluated the hair swatches based on the parameters (Table 1).[6]

Table 1: Hair parameters with bipolar intensity scale.

Hair parameters	Scale
Hair smoothness (sensory assessment)	(Low----------High)
Hair softness (sensory assessment)	(Low----------High)
Hair moisture (sensory assessment)	(Slightly ---------Very)
Hair shine (visual assessment)	(Low----------High)
Hair manageability (visual assessment)	(Low----------High)
Hair frizzing (visual assessment)	(Low----------High)

Each parameter was graded using a 0-10 point bipolar intensity scale.[7] The average scores from the panelists were calculated for analysis.

Statistical analysis

Statistical analysis of final data was done using Wilcoxon Signed rank test and Mann Whitney U test. Wilcoxon Signed rank test in order to test whether or not there is a significant difference between performance of both the products (i.e., Product A and B) while Mann Whitney U test in order to compare performance of product A and B.

RESULTS

The results of the *in-vitro* hair study were assessed through the expert panel evaluations, comparing the efficacy of product A (1% selenium sulfide + 3% salicylic acid shampoo) and product B (2% ketoconazole + 2% salicylic acid shampoo). The following subsections detail the findings based on baseline (T0) and post-application (T1) assessments.

Mean scores of expert panel assessments

Table 2 summarizes the mean scores assigned by the expert panelists for both products at baseline and after application:

Table 2: Pre and post application of product: mean baseline versus T1 for product A and B for all parameters.

Parameters	Product A (T0)	Product A (T1)	Product B (T0)	Product B (T1)
Hair smoothness	6.67	7.78	6.00	7.00
Hair softness	6.67	7.44	5.67	6.44
Hair moisture	6.00	6.33	5.11	5.78
Hair shine	7.00	7.00	6.67	5.78
Hair manageability	7.33	8.78	7.44	8.00
Hair frizzing	3.11	2.11	3.67	3.33

Observation on the basis of mean scores of expert panel assessments: Mean of scores provided by three experts panelists were calculated for the three swatches treated in each product group. Mean scores observed at T1 versus T0 were as follows:

For product A: T1>T0 for smoothness, softness, moisture, manageability. Mean shine scores were equivalent and T1<T0 for hair frizzing.

For product B: T1>T0 for smoothness, softness, moisture, manageability. A decrease in mean T1 shine score was observed when compared with T0. While T1<T0 for hair frizzing

Percentage improvement from baseline (T0) to post application (T1)

Table 3 presents the percentage improvement for each parameter for both products.

Observations on the basis of % improvement from baseline (T0) to post application (T1):

Hair smoothness and softness: Both products demonstrated significant improvement in hair smoothness and softness post-application.

Hair moisture: Product B showed a higher percentage improvement in hair moisture (13%) compared to product A (6%).

Hair shine: Product A maintained its shine scores with no improvement, while product B experienced a decline (-13%).

Hair manageability: Product A exhibited the highest percentage improvement (20%) in manageability compared to product B (7%).

Hair frizzing: Product A showed a more substantial reduction in frizz (-32%) compared to product B (-9%).

Overall, these results suggest that product A generally outperformed product B in several key parameters, particularly in manageability and frizz reduction.

Statistical representation

Statistical analysis of the final data was done using Wilcoxon Signed rank test and Mann Whitney U test.

Wilcoxon Signed rank test in order to test whether or not there is a significant difference between the performance of both the products (i.e., Product A and B).

Mann Whitney U test in order to compare the performance of product A and B.

All p values were reported based on two-sided significance test and all the statistical tests were interpreted at 5% level of significance level. Table 4 provides p for Wilcoxon Signed rank test for all parameters under consideration for both products i.e., product A and B. For all those parameters, whose $p>0.05$, we accept the null hypothesis and for all those parameters, whose $p<0.05$, we reject null hypothesis. From above table it is clear that for highlighted values, corresponding null hypothesis is rejected and has significant difference after product application for that specific parameter.

Table 3: Percentage improvement of product A and B: baseline versus T1 for all parameters.

Parameters	Product A (T0)	Product A (T1)	% improvement	Product B (T0)	Product B (T1)	% improvement
Hair smoothness	6.67	7.78	17	6.00	7.00	17
Hair softness	6.67	7.44	12	5.67	6.44	14
Hair moisture	6.00	6.33	6	5.11	5.78	13
Hair shine	7.00	7.00	0	6.67	5.78	-13
Hair manageability	7.33	8.78	20	7.44	8.00	7
Hair frizzing	3.11	2.11	-32	3.67	3.33	-9

Table 4: Hypothesis test summary for Wilcoxon Signed rank.

Parameters	Z value		P value	
	Product A	Product B	Product A	Product B
Hair smoothness	-2.887	-2.460	0.004	0.014
Hair softness	-2.333	-2.333	0.020	0.020
Hair moisture	-1.732	-1.857	0.083	0.063
Hair shine	0	-2.828	1.000	0.005
Hair manageability	-2.739	-1.890	0.006	0.059
Hair frizzing	-3.000	-0.690	0.003	0.490

*The significance level is 0.05 (α)

Table 5: Hypothesis test summary for Mann Whitney U test.

Null hypothesis	Test	Z value	P value	Decision
Distribution of application of product is same for both the products	Independent sample Mann Whitney U-test	-2.845	0.04	Reject the null hypothesis

*The significance level is 0.05 (α)

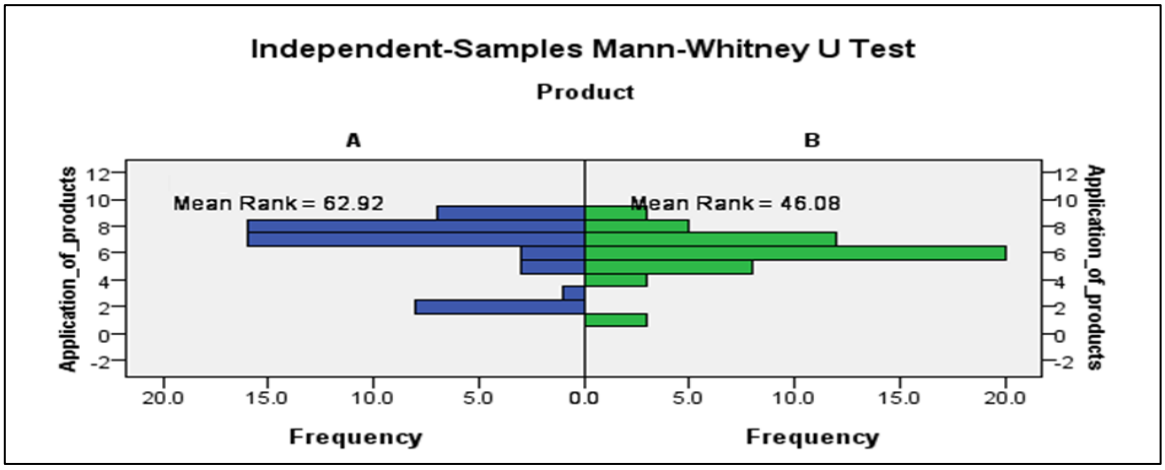

Figure 1: Independent samples Mann-Whitney U test shows comparison of products.

From the Table 5, it is clear that the p value for Mann Whitney U test is 0.04, which is less than 0.05 (a common threshold for deciding significance). So, it can be concluded that there is significant difference in the performance of two products and we have enough evidence to say that the way the two products are applied is different.

From Figure 1, we can conclude that the distribution of application scores for product A tends to be higher than for product B, which suggests that product A is applied more frequently or at higher levels. This implies that product A shows more favorable results in terms of application frequency or intensity compared to product B.

DISCUSSION

The results of this *in-vitro* hair study provide valuable insights into the efficacy of the two tested shampoo formulations-1% selenium sulfide + 3% salicylic acid shampoo (product A) and 2% ketoconazole + 2% salicylic acid shampoo (Product B)-in improving various aspects of hair quality.

Both products demonstrated significant improvements in hair smoothness and softness, indicating their effectiveness in enhancing hair texture. However, product A showed superior results in terms of hair manageability and frizz reduction. The 20% improvement in manageability suggests that the combination of selenium sulfide and salicylic acid may create a synergistic effect, contributing to easier styling and overall better hair handling. While product B exhibited a higher improvement in hair moisture (13% vs. 6%), it is important to note that product A maintained its shine scores without any decline, whereas product B experienced a reduction. This may indicate that product A not only contributes to hydration but also preserves quality of hair, such as shine. Maintaining shine is a critical factor for consumers, as it is often associated with healthy hair.[12] The data generated from this study may help us for classifying and labeling the investigational product.

The keratolytic effect is dependent on the concentration of salicylic acid used in a shampoo/cream. Peeling products contain salicylic acid usually at concentrations between 0.5-3% while for selenium sulfide, prescription strength and nonprescription strength medications contain 2.5% and 1% selenium sulfide, respectively.[8]

Van Cutsem et al compared the *in vitro* antifungal activity of ketoconazole 2%, selenium sulphide 2.5%, and zinc pyrithione 1% and 2% against *M. furfur* in guinea pigs.[9] Ketoconazole was found to be the most effective for reducing *M. fufur* counts, but results with selenium sulphide and 1% and 2% zinc pyrithione were comparable. The anti-dandruff effects of ketoconazole were superior to those of selenium sulphide and zinc pyrithione.[9,10] When we compared the effectiveness of a 1% selenium sulfide + 3% salicylic acid formulation with a 2% ketoconazole + 2% salicylic acid shampoo on hair swatches, the former showed relatively better results.

Rapaport compared the anti-dandruff efficacy of four shampoos in 199 patients: selenium sulphide 1% (Selsun blue, Chattem, Inc.), zinc pyrithione 1% (Head and shoulders, Procter and gamble), coal tar extract 5% (Tegrin, GlaxoSmithKline), and a shampoo vehicle (Flex, Revlon). Subjects using Selsun blue experienced significantly greater improvement of symptoms than did any of the other groups.[11]

While this 1% selenium sulfide + 3% salicylic acid comparison with 2% ketoconazole + 2% salicylic acid shampoo, provides valuable insights, it is important to acknowledge its limitations. The *in-vitro* nature of the study may not fully reproduce the complexities of real-world hair care experiences. A lower concentration of selenium sulfide combined with salicylic acid yielded better results on hair swatches (invitro study). Future research should consider clinical trials with human volunteers to validate these findings and assess long-term effects and consumer satisfaction.

CONCLUSION

Product A and B, both products yielded significant insights into their performance in improving hair quality.

Both products demonstrated effectiveness in enhancing hair smoothness and softness; however, product A emerged as the superior formulation overall. It achieved higher improvements in manageability and a notable reduction in frizz. Although product B showed greater improvements in moisture retention, it suffered a decline in shine. These findings suggest that product A not only meets essential hair care needs but also offers additional benefits that may boost user satisfaction. As the demand for multi-functional hair care products continues to rise, product A may represent a valuable addition to the market. Further research, including clinical trials with human volunteers, is recommended to validate these findings and explore the long-term effects of these formulations on hair health.

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