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Quality Analysis of Shampoo Based on Rosemary Essential Oil (*Rosmarinus officinalis* L.) Concentration

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ABSTRACT*: Rosemary essential oil contains components such as camphor, 1,8-cineole, α-pinene, borneol, camphene, limonene, verbenone, caryophyllene, and myrcene. Rosemary oil is widely used in the cosmetics industry due to its fresh aroma and benefits in improving blood circulation, which can support hair growth. Rosemary is more commonly used as a food seasoning and fragrance ingredient, but its potential in hair care products still needs further development. This study aims to obtain the quality of shampoo with the addition of rosemary essential oil according to SNI 8860:2020, determine the most preferred formulation through a hedonic test, and identify the best formulation based on SNI and hedonic tests. The research method was carried out by adding variations in the concentration of rosemary essential oil in formulations X0 (0%), X1 (2%), X2 (4%), and X3 (6%) with two repetitions, with testing based on SNI 8860:2020 and hedonic testing using the Friedman-Conover method. The tests conducted included pH testing, determination of Total Plate Count (TPC), determination of Yeast and Mold Count (YMC), and hedonic tests with parameters such as color, aroma, texture, and comfort. The results showed that the pH values of the four formulations ranged from 6.35 to 6.55. The Total Plate Count values for all four formulations ranged from 5.426 × 10^1 to 7.319 × 10^1 CFU/ml. In the YMC test, all formulations showed negative results, indicating no yeast and mold growth. In the hedonic test, formulation X1 was the most preferred in terms of color and aroma, while formulation X3 was the most favored in terms of texture and comfort. Based on all test results, formulation X1 was concluded to be the best rosemary shampoo formulation.*

Keywords: *essential oil; hedonic test; rosemary; shampoo; SNI*

1. INTRODUCTION

As one of the hair care products, shampoo plays an important role in maintaining the cleanliness of the hair and scalp by removing dirt and excess oil. Shampoo generally contains surfactants or detergents as the main ingredients, along with various additives such as antioxidants, pH buffers, dispersing agents, preservatives, colorants, and fragrances that help maintain the product's quality and stability (Pravitasari, 2021). Currently, consumer demand for natural-based hair care products is increasing, in line with the growing concerns about the side effects of synthetic chemicals, such as skin irritation and other health risks, which encourage people to choose products perceived as safer and more environmentally friendly (Setiawan et al., 2023). One natural ingredient with potential for use in shampoo formulations is rosemary essential oil (*Rosmarinus officinalis* L.), which has aromatic characteristics and antimicrobial activity. However, research on the effects of adding rosemary essential oil on shampoo quality, particularly based on parameters established in the Indonesian National Standard (SNI), remains limited.

Rosemary is a type of herbal plant widely distributed across many parts of the world (Wilyananda, 2022). According to Kalinda (2020), rosemary contains compounds such as saponins, flavonoids, glycosides, alkaloids, and tannins. However, rosemary essential oils contains several major components, including camphor (5–31%), 1,8-cineole (15–55%), α-pinene (9–26%), borneol (1.5–5%), camphene (2.5–12%), limonene (1.5–5%), verbenone (2.2–11%), caryophyllene (1.8–5%), and myrcene (0.9–4.5%). Among these compounds, 1,8-cineole and α-pinene are known to exhibit antimicrobial activity (Nurasyfa et al., 2019).

According to Panahi (2015), rosemary oil is widely used in the cosmetics industry due to its pleasant aroma and its beneficial effects on eczema, acne, dermatitis, swelling, and inflammation. Given its spasmolytic activity, rosemary is believed to improve microcapillary perfusion, and after three years of use, it is hypothesized to increase blood supply to hair follicles, making it effective for treating Androgenetic Alopecia (AGA). According to Leporini et al. (2020), 1,8-cineole, α-pinene, camphor, and trans-caryophyllene are the most representative compounds in naturally inhibiting cholinesterase, showing promise for the management and treatment of neurodegenerative diseases.

Additionally, rosemary has a refreshing scent, making it suitable for shampoo production due to its fresh aroma. According to Esati (2022), rosemary is commonly used in Indonesia as a seasoning in cooking and as an aromatic ingredient. According to Rahimi (2019), rosemary has many uses in aromatherapy, as its terpenoid content causes vasodilation, which can improve blood circulation. In the community service conducted by Haris et al. (2024), rosemary has significant potential as a raw material for hair care products. The downstream product they have designed, but is not yet marketable, is a shampoo based on rosemary essential oil, indicating opportunities for further research on the product's effectiveness and formulation. Question

This study aims to develop a shampoo formulation with the addition of rosemary essential oil (*Rosmarinus officinalis* L.) that complies with the Indonesian National Standard (SNI) 8860:2020 testing requirements and to assess consumer acceptance through hedonic testing, ultimately determining the best formulation based on these two evaluations.

2. MATERIALS AND METHODS

2.1. Shampoo Formulation and Preparation

The shampoo preparation process began with weighing the required ingredients. The first step was to dissolve 10 grams of sodium lauryl sulfate in 20 ml of hot water to form Solution 1. Next, 0.25 grams of menthol was dissolved in 70% ethanol to form Solution 2. Then, 0.2 grams of propyl paraben was dissolved in 5 ml of hot water to create Solution 3. After that, 3 grams of Na-CMC

was dissolved in 10 ml of hot water to produce Solution 4. Solutions 1, 2, 3, and 4 were then mixed with 65 ml of distilled water. After mixing, 4 grams of cocamide DEA was added. Subsequently, rosemary essential oil was added to the mixture at varying concentrations of 0%, 2%, 4%, and 6%. The resulting shampoo products were then evaluated for quality based on the SNI, including parameters such as pH, Total Plate Count (TPC), and Yeast and Mold Count (YMC). Additionally, hedonic testing was performed to assess color, aroma, texture, and comfort of use.

The formulation used in this study is as follows:

Tabel 1. Formulation of shampoo

Ingredients	X0	X1	X2	X3
Rosemary Essential Oil (ml)	0	2	4	6
SLS(g)	10	10	10	10
C-DEA (g)	4	4	4	4
Na-CMC (g)	3	3	3	3
Propyl Paraben (g)	0,2	0,2	0,2	0,2
Menthol (g)	0,25	0,25	0,25	0,25
Distilled Water (ad)	100	100	100	100

Source: Hia, N. P. K. (2019)

2.2. Data Processing

For product testing based on SNI standards, data collection was carried out using a Completely Randomized Design (CRD), which is one of the simplest experimental designs and is characterized by completely unrestricted randomization for each treatment (Rahmawati, 2020). The general additive linear model form of CRD is as follows:

$$Yij = \mu i + \tau i + \varepsilon ij \text{ atau } Yij = \mu i + \varepsilon ij \quad (1)$$

Data analysis was performed using the Analysis of Variance (ANOVA) method at a 5% significance level. Further testing was conducted using Duncan's Multiple Range Test (DMRT).

For the product testing based on hedonic evaluation, 30 untrained panelists were randomly selected. Panelists were asked to rate the tested product attributes based on their personal preferences. The data was then analyzed using the Friedman-Conover test with the following formula:

$$A = Pn^2 + Pn^2 + Pn^2 + Pn^2 + \cdots + Pn^2 \quad (2)$$

The sum of squares for the treatment (B) was calculated:

$$B = \frac{1}{n}\sum R^2 J \quad (3)$$

followed by the calculation of the T-critical value (L):

$$TT = \frac{(n-1)[\frac{B-(nk(k+1)^2}{4}]}{A-B} \quad (4)$$

The variable T follows an F-distribution with degrees of freedom $k_1 = k - 1$ and $k_2 = (n - 1)(k - 1)$. If the T value is less than or equal to the F-table value, it is concluded that there is no significant effect between treatments (in other words, H_0 is accepted). Conversely, if the T value is greater than the F-table value, it is concluded that at least one pair of treatments shows a significant difference (H_1 is accepted), and the following formula is used:

$$UU = t0.975\frac{2n\,(AA-BB)}{(nn-1)(kk-1)}1/2 \quad (5)$$

3. RESULTS AND DISCUSSION

3.1 Shampoo Quality Testing Results Based on SNI Testing

Testing was conducted to determine whether the rosemary essential oil shampoo meets the standards set in SNI 8860:2020. The results of this testing serve as a reference for assessing the quality of the rosemary essential oil shampoo and ensuring its safety before it can be further developed and used. The tests conducted included pH testing, total plate count, and mold and yeast testing.

3.1.1 Product Acidity

In the testing of the rosemary essential oil shampoo, the pH results are presented in Table 2.

Table 2. The average result of pH test

Samples	Average	Standard
X0	6.35 ± 0.07	4.0 – 8.0
X1	6.50 ± 0.14	4.0 – 8.0
X2	6.45 ± 0.21	4.0 – 8.0
X3	6.55 ± 0.21	4.0 – 8.0

The results of the One-Way ANOVA analysis showed no significant difference, with a significance value of 0.698 (P > 0.05), in the pH levels of the four samples of rosemary essential oil shampoo. The highest pH was found in the X3 shampoo formulation, with a value of 6.55 ± 0.21, while the lowest pH was found in the X0 formulation, with a value of 6.35 ± 0.07. This indicates that the addition of rosemary essential oil did not have a significant effect on the increase in shampoo pH, as the difference between the highest and lowest pH values was not substantial.

The increase and decrease in pH were not significant, which aligns with a study by Amanda and Helmi (2023), where three hair tonic formulations with added rosemary oil at concentrations of 0.1%, 0.2%, and 0.3% resulted in varying pH levels, with changes that tended to be unstable. Additionally, a study by Sofiyana et al. (2023) on rosemary oil roll-on formulations with concentrations of 2%, 4%, and 8% also showed no significant increase in pH with each formulation. These findings indicate that the addition of rosemary essential oil to shampoo does not affect the increase or decrease in pH levels. Question

3.1.2 Total Plate Count (TPC) Results

The Total Plate Count (TPC) test conducted on the rosemary essential oil shampoo product yielded results as shown in Table 3.

Table 3. The average result of TPC test

Sample	Average (cfu/ml)	Standard
X0	7,319 x 10^1 ± 0,77b	1 x 10^3 CFU/g
X1	5,869 x 10^1 ± 5,23a	1 x 10^3 CFU/g
X2	6,778 x 10^1 ± 2,64b	1 x 10^3 CFU/g
X3	5,426 x 10^1 ± 0,40a	1 x 10^3 CFU/g

The results of the One-Way ANOVA analysis showed a significant difference among the four shampoo samples, with a significance value of 0.010 (P < 0.05). The highest Total Plate Count (TPC) was found in sample X0, with a value of 7.319 x 10^1 (73.19), while the lowest TPC was found in sample X3, with a value of 5.426 x 10^1 (54.26). These values are still within the safe limits according to SNI. A high TPC value in cosmetic products may indicate excessive microbial contamination, which can affect the quality and safety of the product. Fluctuations in the TPC values were observed. These fluctuations in TPC across the shampoo samples with varying rosemary oil concentrations may be caused by several factors, one of which is storage conditions and improperly sealed packaging. During storage and distribution, there is a possibility of microbial growth due to such conditions (Rachman et al., 2021).

An increase in the concentration of rosemary essential oil in the shampoo is inversely related to bacterial growth, where higher concentrations lead to lower bacterial growth. Rosemary has antimicrobial properties that can reduce bacterial proliferation in a product. The antimicrobial activity of rosemary is primarily attributed to 1,8-cineole and α-pinene, which have been reported to exhibit inhibitory effects against Gram-positive and Gram-negative bacteria, as well as fungal pathogens (Nurasyfa et al., 2019). Specifically, two major constituents of rosemary essential oil namely the monoterpene α-pinene and the monoterpenoid 1,8-cineole have demonstrated antifungal effects against Candida albicans, operating through a concentration-dependent mechanism (Shahina et al., 2022). The antibacterial activity of *Rosmarinus officinalis* L. extract can be linked to its ability to inhibit bacterial growth, biofilm formation, and the destruction of bacterial cell walls (Abdallah et al., 2019). Critical Question

3.1.3 Yeast and Mold Count (YMC) Contamination

The Yeast and Mold Count (YMC) test conducted on the rosemary essential oil shampoo product yielded results as shown in Table 4.

Table 4. The average result of YMC test

Sample	Average	Standard
X0	Negative (0)	1 x 10^3 CFU/g
X1	Negative (0)	1 x 10^3 CFU/g
X2	Negative (0)	1 x 10^3 CFU/g
X3	Negative (0)	1 x 10^3 CFU/g

The test results for the four shampoo samples showed that none of them exhibited mold or yeast growth. This result meets the quality standards of SNI 8860:2020, which sets the maximum allowable yeast and mold count at 1 x 10^3 colonies per gram. This outcome is also influenced by the antifungal properties of rosemary, which inhibit the growth of mold and yeast in the shampoo. The presence of mold and yeast in cosmetic products, such as shampoo, should be avoided, as it may indicate fungi contamination that can compromise the quality and safety of the product. Fungal contamination in cosmetics can lead to changes in color, odor, and texture, and may increase the risk of skin irritation or infections for users (Harlita et al., 2023). Mold and yeast contamination can occur due to factors such as storage temperature, oxygen exposure from improper sealing, and product composition, including high moisture content, pH, nutrients, and the presence of other microorganisms (Purwanto et al., 2023).

3.2 Shampoo Testing Results Based on Hedonic Test

3.2.1 Color

Color is one of the important parameters that must be considered, as it relates to product quality, consumer perception, and acceptance. Color plays a crucial role for consumers and can influence product attractiveness. The average hedonic test scores can be seen in Figure 1.

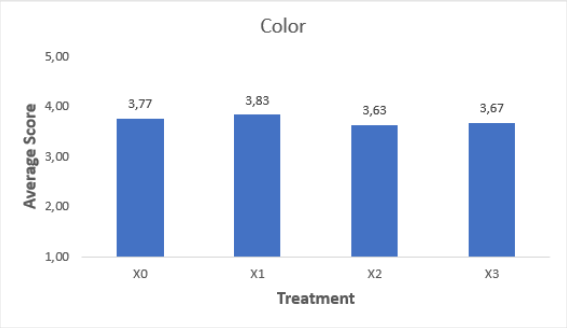

Figure 1. Graph of hedonic test result for color parameter

Based on the average test scores, X1 the shampoo with a 2% concentration of rosemary essential oil had the highest score, with a value of 3.83. The Friedman test for the color parameter showed a T value of 0.423, which is smaller than the F table value of 2.71 (T < Ftable). This indicates that, based on the hedonic test, there was no significant effect on the color parameter of the shampoo. Among the four shampoo samples, three had a clear yellowish color X1, X2, and X3 while one sample, X0, had a clear white color. The three yellowish-clear shampoos were visually similar, as shown in Figure 2.

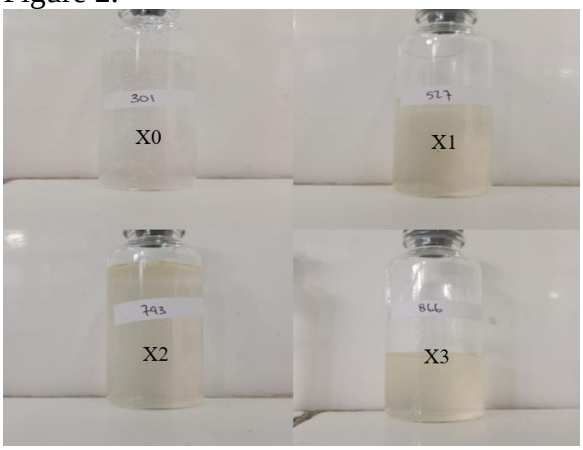

Figure 2. Rosemary essential oil shampoo

The color difference between sample X0 and the other three samples is influenced by the addition of rosemary essential oil. Sample X0 did not contain any rosemary essential oil, resulting in a whiter appearance compared to the other samples. This is also supported by the research of Nurul et al., 2020. The study discussed the formulation of shampoo by adding neem leaf infused oil. The addition of neem leaf infused oil affected

the appearance of the shampoo, particularly its color parameters. Rosemary oil has a clear yellow color, and its addition increases the concentration used, which in turn triggers a change in color (Sofiyana et al., 2023). However, the differences in rosemary essential oil concentrations in this study did not result in a major visual impact on the shampoo's appearance.

3.2.2 Aroma

Aroma is an aspect derived from the human sense of smell in response to a substance. It is considered a key factor in the attractiveness and perceived suitability of a product. In shampoo products, aside from their benefits, consumers often choose based on aroma. The average test scores can be seen in Figure 3.

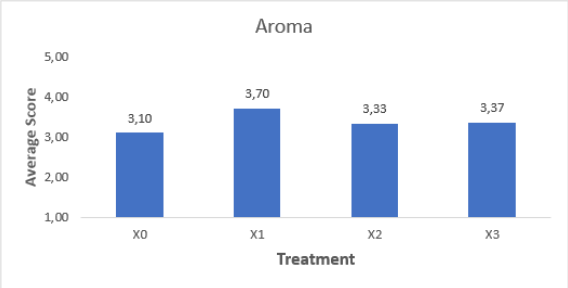

Figure 3. Graph of hedonic test result for aroma parameter

Based on the average scores from 30 panelists, the X1 shampoo sample (2% concentration) had the highest score with a value of 3.70. According to the results of the Friedman-Conover test, the T value obtained was 2.812, which is greater than the F table value of 2.71 (T > Ftable). These results indicate that there is a significant difference among the four shampoo samples in terms of aroma. A follow-up Conover test was then conducted, with the results shown in Table 5.

Table 5. Conover test result for aroma parameter

Sample	Rank Sum	Post-Test
X0	63	17,54a
X1	88,5	17,54bcd
X2	74,5	17,54abc
X3	74	17,54abc

The Conover post-hoc test showed that the X0 shampoo sample did not significantly differ from X2 and X3, but it did show a significant difference compared to X1. Meanwhile, X1, X2, and X3 were not significantly different from each other. These differences are attributed to the varying concentrations of rosemary essential oil in each sample. Panelists preferred the aroma of the rosemary essential oil shampoo at a 2% concentration because the scent was noticeable but not overpowering. This is due to the fact that higher concentrations of rosemary essential oil result in a stronger aroma. The greater the amount of essential oil added to the product, the more intense the fragrance becomes (Hasbullah et al., 2021).

3.2.3 Texture

Texture is a characteristic of a surface that can be perceived visually or through touch. In the hedonic test, the texture parameter refers to the consistency and feel of the product when applied to the hand. The average test score results can be seen in Figure 4.

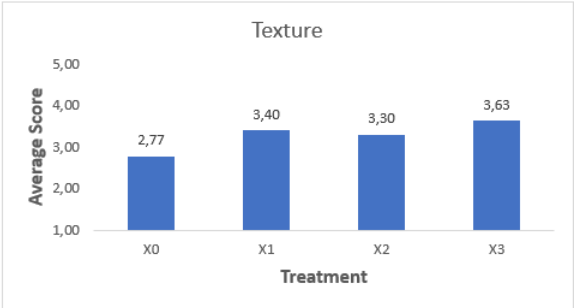

Figure 4. Graph of hedonic test result for texture parameter

Based on the average test scores from 30 panelists, X3 (6% concentration) had the highest score with a value of 3.63. According to the results of the Friedman-Conover test, the obtained T value was 4.813, which is greater than the F table value of 2.71 (T > Ftable). This result indicates that there is a significant difference in the texture parameter in the hedonic test among the samples. A follow-up Conover test was then conducted, and the results are presented in Table 6.

Table 6. Conover test result for texture parameter

Sample	Rank Sum	Post-Test
X0	58	16,52a
X1	78,5	16,52bc
X2	74,5	16,52ab
X3	89	16,52bcd

Based on the results of the follow-up Conover test, the X0 shampoo sample was not significantly different from the X2 sample, but X0 was significantly different from the X1 and X3 samples. The X1, X2, and X3 shampoo samples did not show significant differences from each other. Shampoo is generally known for its thick texture, which is partly achieved through the addition of Cocoamide DEA. This compound functions to enhance emulsion stability, resulting in a thicker product (Luketsi et al., 2022). According to the panelists, the X0 shampoo sample had a texture that was too thick, while the X1, X2, and X3 samples had a less viscous texture. The thickness of the shampoo may be influenced by the varying concentrations of added rosemary essential oil. Higher concentrations of essential oil tend to reduce the thickness of the shampoo. This is in line with the study by Fristika (2020), which discussed the addition of lemon extract to shampoo. In that study, a small amount of lemon peel extract increased the thickness of the resulting shampoo. At higher concentrations, essential oils can make shampoo more watery by decreasing the viscosity of the solution.

3.2.4 Comfort

In the hedonic test on shampoo comfort after application to the hands, sensory aspects such as texture, viscosity, residual traces, and the sensation of moisture or dryness were key factors in evaluating user preference. Respondents were asked to assess their level of liking toward the experience of using the shampoo on their hands, from ease of application to the sensations felt after rinsing, including skin softness, slippery or rough feeling after use, and the presence or absence of disturbing residue. The average test score results can be seen in Figure 5.

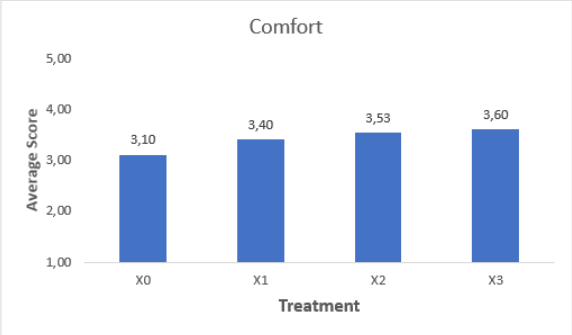

Figure 5. Graph of hedonic test result for comfort parameter

Based on the average test scores from 30 panelists, the X3 shampoo sample (6% concentration) had the highest score, with a value of 3.60. According to the results of the Friedman-Conover test, the obtained T value was 1.73, which is lower than the F table value of 2.71 (T < Ftable). Based on the Friedman test, it can be concluded that the comfort parameter among the four shampoo samples did not show significant differences; therefore, a follow-up Conover test was not necessary.

According to the panelists, the tested shampoo samples provided good comfort after application to the hands. Respondents noted that after use, their skin felt softer than before and did not experience dryness. The addition of rosemary essential oil to the shampoo also affected the comfort level of the tested samples. Rosemary essential oil can provide a soft and pleasant sensation on the skin (Sari et al., 2021). Higher concentrations of rosemary oil increased the softness of the shampoo. The formulation using Rosmarinus officinalis extract tends to have a soft and clear texture (Baruna et al., 2024).

3.3 Best Formulation Results Based on SNI Test and Hedonic Test

Based on the results of the Indonesian National Standard (SNI) test and the hedonic test, the best formulation was selected by considering a balance between safety aspects and sensory quality. All four shampoo formulations showed appropriate pH levels,

total plate counts, and yeast and mold counts within standard limits, ensuring the product's safety and stability. In addition, the hedonic test confirmed that all four formulations had appealing color, a pleasant fragrance, a smooth texture, and an optimal level of comfort for users. With the combination of these test results, the best formulation was determined as the one that best met both standards and user preferences. A summary of the test results from both evaluations is presented in Table 7 below.

Table 7. Recapitulation of test result for rosemary essential oil shampoo product

Test	Sample			
	X0	**X1**	**X2**	**X3**
pH	**6,35**	**6,50**	**6,45**	**6,55**
TPC	73,19	**58,69**	67,78	**54,26**
YMC	**0**	**0**	**0**	**0**
Color	3,77	**3,83**	3,63	3,67
Aroma	3,10	**3,70**	3,33	3,37
Texture	2,77	3,40	3,30	**3,63**
Comfort	3,10	3,40	3,53	**3,60**

From the summary, it was found that the X1 and X3 shampoo samples had better quality characteristics and were preferred by the panelists. X1 had a pH value of 6.50 and X3 had a pH value of 6.55, both of which comply with the SNI 8860:2020 standard. The Total Plate Count (TPC) for sample X1 was 5.869 x 10^1 cfu/ml and for X3 was 5.426 x 10^1 cfu/ml, both within the acceptable limits set by the standard. The Yeast and Mold Count (YMC) test also showed no growth in either shampoo formulation. In the hedonic test, sample X1 was preferred for its color and fragrance, while sample X3 was favored for its texture and comfort. However, from an economic perspective, the cost of rosemary oil used in sample X1 was lower than that of sample X3. Cost is a major factor that will ultimately affect the selling price of the shampoo, as a minimum cost must be met to avoid incurring losses (Sartika et al., 2023). With lower costs yet comparable quality, X1 outperformed X3. Therefore, the X1 shampoo formulation, containing 2% rosemary essential oil, is considered the best formulation among the four tested samples.

4. CONCLUSIONS AND RECOMMENDATIONS

Based on the tests conducted on the four shampoo samples, it can be concluded that, according to the SNI 8860:2020 standard, the addition of rosemary essential oil has a significant effect on the Total Plate Count (TPC) values. The pH test results showed an average range between 6.35 and 6.55. The TPC test results showed an average range of 5.426 x 10^1 – 7.319 x 10^1 CFU/ml. In the yeast and mold count (YMC) test, all samples showed negative results.

Based on the hedonic test involving 30 panelists, the addition of rosemary essential oil had a significant effect on the aroma and texture parameters. For color and aroma, formulation X1 was the most preferred. Meanwhile, for texture and comfort, formulation X3 was the most favored. Therefore, according to the hedonic test, the two most preferred formulations by the panelists were formulation X1 (2% concentration) and formulation X3 (6% concentration).

Among these two, the formulation containing 2% rosemary essential oil (X1) was the most preferred by panelists, while still meeting the quality standards of SNI 8860:2020. This concentration provides the best balance in terms of color and aroma without causing significant changes in product quality.

Based on this research, it is recommended to conduct further testing on the content of rosemary essential oil used to ensure the quality within the shampoo formulation, long-term stability tests to observe changes in shampoo quality during storage, as well as feasibility analysis based on its economic value.

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