OPTIMIZATION OF VCO LOTION PREPARATIONS WITH VARIATIONS CETYL ALCOHOL AND CARRAGEEN CONCENTRATIONS USING SLD METHOD

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ABSTRACT

Lotion is a cosmetic preparation of an emollient group that contains a large amount of water. This formulation possesses several properties, namely, as a source of moisture for the skin, providing an oily layer that makes the hands and body soft. VCO is utilized as a natural skin moisturizer to prevent tissue damage and protect the skin. VCO has a very high moisture content, which prevents skin dryness. A lotion was formulated with an emulsifying agent to stabilize the emulsion system. One of the constituent ingredients of the lotion is cetyl alcohol, which functions as an emulsifying agent. Cetyl alcohol can be substituted by carrageenan, which serves the same function with the added benefit of being a humectant. The aim of this study was to identify the formulation of VCO lotion and to investigate the effect of different concentrations of the emulsifying agents cetyl alcohol and carrageen on physical evaluation tests, namely organoleptic tests, homogeneity tests, spreading tests, pH tests, adhesion tests, emulsion type tests, and viscosity tests in lotion formulations. An experimental method was employed in this study. The research was carried out by making lotions from various ingredients containing the active ingredient VCO at a concentration of 7%, as well as varying concentrations of cetyl alcohol (range 2-5%) and carrageenan (range 1-3%) as an emulsifying agent and additional ingredients for the preparations whose optimization had been determined using the simplex lattice design method. The results indicate that the optimum formula of the VCO lotion has a concentration ratio of 2% cetyl alcohol and 3% carrageenan. The results of organoleptic, homogeneity, spreading, pH, adhesion, emulsion-type, and viscosity tests met the range of parameters for good lotion quality.

Keywords: Cetyl Alcohol, Carrageenan, Lotion, Preparation, VCO

INTRODUCTION

The skin is the largest organ in the human body. It constantly interacts with various products and foreign substances such as cosmetics and other healthcare products. Each product influences the skin differently, resulting in unique interactions among individuals (Wang et al., 2018). Dry skin is a common dermatological condition experienced by many individuals. It typically manifests as a dull complex with a flaky surface and rough texture. This skin type exhibits lower levels of water and natural moisturizing factors than the other skin types. Prolonged periods of dry skin can lead to serious dermatological conditions such as irritation and inflammation. Management of dry skin often involves the use of moisturizing cosmetics to prevent skin dehydration. Moisturizers are sophisticated formulations designed to enhance skin hydration mechanisms and preserve the structure and function of the skin under various environmental stressors, including dry air, sunlight exposure, advanced age, temperature fluctuations, and dermatological conditions that may accelerate water loss (Yunus, 2022).

One of the preparations used to moisturize the skin is the lotion. Lotions are topical emulsion preparations that can be easily applied to the entire body. Emulsions applied to the skin can be either oil in water (O/W) or water in oil (W/O) (Sudewi et al., 2021). This study employed eight oil-in-water (O/W)-type lotion formulations. Lotion is a cosmetic preparation that belongs to the emollient group and contains a higher amount of water. This formulation possesses several properties, such as serving as a source of moisture for the skin, providing an oily layer, and making hands and body soft, yet not greasy, and easily applicable. Hand and body lotion is the common term for this preparation in the market (Pradiningsih et al., 2022)

Virgin Coconut Oil (VCO) has long been used as a natural skin moisturizer because of its ability to prevent tissue damage and protect the skin (Rao et al., 2024). Compared with regular coconut oil, often referred to as cooking oil, pure coconut oil is of better quality. Regular cooking oil tends to have a yellowish to brownish color, an unpleasant odor, and is prone to becoming rancid; thus, its shelf life is short (less than two months) (Marlina et al., 2017). Farmers can use tape yeast as a starter to ferment coconut cream and obtain VCO. Another method involves adding an enzyme, such as papain, to break down proteins in the cream, thereby enhancing oil yield. Papain catalyzes protein breakdown by hydrolyzing peptide bonds into simpler compounds (Rusman et al., 2021).

VCO can also prevent the development of age spots and protect the skin from sunlight. Furthermore, VCO can repair damaged or diseased skin. VCO offers numerous health benefits, one of which is its high moisturizing content that effectively prevents skin dryness (Purnamasari, 2020). When formulating lotion preparations, it is essential to consider the ingredients that form the basis of the preparation, such as emulsifying agents, which can affect the physical properties of the product. Cetyl alcohol is chosen as an emulsifying agent due to its properties as an emulsifier, emollient, and water absorber. This enhances the stability of consistency and improves the texture of the lotion (Rowe et al., 2009).

In addition to its role as an emulsifying agent, cetyl alcohol functions similarly to stearic acid in lotion formulations as a thickening agent, maintaining stability by thickening the aqueous phase. TEA (Triethanolamine) is used in lotion preparations to stabilize the pH of stearic acid (Tumbelaka et al., 2019). Cetyl alcohol can be replaced by carrageen. The advantage of carrageen is that, in addition to being a natural emulsifying agent, it also functions as a humectant that can retain skin moisture (Irmayanti et al., 2021). Carrageen is a seaweed extract that serves as a natural emulsifying agent in lotion preparations (Frediansyah, 2021). It is widely utilized in the pharmaceutical, cosmetic, non-food, and food industries as an emulsifier, suspending agent, and stabilizer (Fardhyanti & Julianur, 2015). Carrageen also functions as a thickening agent; therefore, variations in its concentration will affect the appearance of the lotion (Tumbelaka et al., 2019).

This served as the basis for the optimization of the VCO lotion formulation by varying the concentrations of cetyl alcohol and carrageen using the simplex lattice design method to determine a lotion formulation that meets the parameters of physical properties. The cosmetic products available in the market are diverse and popular among various age groups, from teenagers to adults. Not all cosmetics contain halal ingredients, and some contain non-halal substances that can be detrimental to Muslim consumers. Therefore, there is a need for halal cosmetic products that use Virgin Coconut Oil (VCO) as a moisturizer in lotion formulations to ensure that they are safe for daily use. The lotion formulations used were based on previous studies. In previous research, each emulsifier was prepared individually, but in this study, the product was prepared by combining both emulsifiers to optimize lotion preparation.

RESEARCH METHODS

This study was conducted in an experimental laboratory. This research stage started with optimization using the Simplex Lattice Design method with variations of Cetyl Alcohol and Carrageenan, making lotion preparations, and physical testing of the preparations.

The independent variable in this study was the use of Virgin Coconut Oil (VCO) as a skin moisturizer. Lotion preparations are made into eight formulas with varying concentrations of cetyl alcohol and carrageen.The dependent variable in this research is the physical characteristics test of lotion preparations, which include organoleptic tests, homogeneity tests, spreadability tests, pH tests, stickiness tests, emulsion type tests, viscosity tests and stability tests.

Equipment and Materials

Equipment

The equipment used included a magnetic stirrer, measuring cylinder, beaker (Pyrex), analytical balance (Ohaus), pH meter (Ohaus), water bath (Memmert), viscometer (Brookfield Ametek DV-1), watch glass, parchment paper, dropper, stirring rod, spatula, porcelain dish, plastic horn spoon, microscope slide, petri dish, and a lotion container.

Materials

Table I. Standard grade range of materials used

Standard materials used			
Material	**Benefit**	**Material standards**	**Reference**
Stearic acid	Thicking agen	1-20%	(Rowe et al., 2009)
VCO	Active Ingredient	1-25%	(Mu'awanah et al., 2019)
Cetyl alcohol	Emulsifying agent	2-5%	(Rowe et al., 2009)
Carrageenan	Emulsifying agent	1-3%	(Irmayanti et al., 2021)
Glycerin	Humectant	<30%	(Rowe et al., 2009)
TEA	Alkalinizing agent	2-4%	(Rowe et al., 2009)
Nipagin	Preservative	0,02-0,3%	(Rowe et al., 2009)
Rosae oil	Aroma	0,01-0,05%	(Romadhonni et al., 2022)
Aquadest	Solvent	Ad 100	(Rowe et al., 2009)

Std	Run	Component 1 A:Cetyl Alcohol %	Component 2 B:Karagenan %
4	1	2.75	2.25
2	2	2	3
7	3	2	3
6	4	5	0
3	5	4.25	0.75
8	6	5	0
1	7	5	0
5	8	3.5	1.5

Figure 1. Optimization of Cetyl alcohol and Carrageenan ingredients in SLD

Table II. Concentration of ingredients used in each formula

		Formula (%)							
Ingredient	**Function**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**
VCO	Active Ingredient	7	7	7	7	7	7	7	7
Cetyl Alcohol	Emulgator	2,75	2	2	5	4,25	5	5	3,5
Carrageen	Emulgator	2,25	3	3	0	0,75	0	0	1,5
Stearic Acid	Thickening Agent	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5
Glycerin	Humectant	5	5	5	5	5	5	5	5
TEA	Alkalinizing agent	2	2	2	2	2	2	2	2
Methylparaben	Preservative	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3
Oleum Rosae	Fragrance	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05
Aquadest	Solvent	100	100	100	100	100	100	100	100

Procedure

The first step in the production of a Virgin Coconut Oil lotion involves melting the oil phase components (stearic acid, VCO, and cetyl alcohol) in a beaker glass using a magnetic stirrer until it liquefies at a temperature of 70°C. Carrageen, used as an emulsifying agent, was first dissolved in water before incorporation into the aqueous phase. The aqueous phase components (carrageen, glycerin, TEA, nipagin, and distilled water) were then melted together in a beaker glass. Subsequently, once melted, the aqueous phase was gradually added to the beaker containing the oil phase at 70°C, and the mixture was vigorously and rapidly stirred for 10 minutes or until a lotion-like consistency was formed. Oleum Rosae is introduced into the mixture and stirred. Upon cooling, the resulting lotion was transferred to an appropriate container for storage.

Evaluation of the preparation of lotion

1. Organoleptic Test

   Organoleptic testing was performed to observe the physical appearance of the preparation by observing using the human senses the shape, texture, color, and odor of the preparation that has been made.

2. Homogeneity Test

   This test aimed to determine the presence of coarse grains in the preparation and homogeneous mixing of the active ingredients and excipients. A small sample of hand body lotion was taken, kept between two glass objects, and then observed for the presence of coarse particles. The preparation is homogeneous if there are no coarse particles or lumps and is mixed evenly if there is an even color similarity (Mardikasari et al., 2017).

3. Spreadability test

   The spreadability test aims to determine the ability of a lotion preparation to spread on the skin. The lotion preparation is expected to have a good spreading ability, making it easy to apply to the skin. Testing the spreadability of the lotion was carried out by weighing the lotion (0.5 g), which was placed in the middle of a round glass device. First, glass was placed on top of the lotion mass and left for 60 seconds. The diameter of the lotion spread was measured by taking the average length of the diameter on several sides. Then another 50 g additional load was added and left for 60 seconds and the diameter of the lotion spread was recorded until no significant change in diameter occurred. Replication was carried out 3 times for each formula (Ulfa et al., 2019).

4. Adhesion test

   The purpose of this test was to determine the ability of the preparation to remain on the skin according to the requirements, namely, not < 4 seconds (Ulandari & Sugihartini, 2020). A number of preparations were placed on a glass object, another glass object was placed on top of the preparation, then a 50 gram weight was placed on it and left for 5 minutes. Subsequently, the time until the glass was released was calculated (Ulfa et al., 2019). The time at which the slide slid together was recorded.

5. Test pH

   PH measurements were carried out using a pH meter. First, the electrode was calibrated using a standard buffer between pH 4 and 7. The electrode was then dipped into the preparation. The pH values that appeared on the screen were then recorded. Measurements were performed at room temperature. This test was performed to measure the acidity of the preparation. According to SNI 16-3499-1996, the pH of the skin is 4.5-8 (Hidayati et al., 2021).

6. Emulsion Type Test

   Lotion type checks were carried out by adding a few drops of methylene blue to the lotion formula. If all lotions are uniform, then the lotion tested is of the O/W type because water is in the external phase (Rasyadi et al., 2022).

7. Viscosity Test

   This test was performed to determine the flow properties and viscosity levels of the preparation. The viscosity of semisolid dosage forms is influenced by the inherent physical properties of the product, product sampling techniques, and sample temperature. The viscosity range for lotion preparations is 2,000-50,000 cps (Ulfa et al., 2019). Viscosity tests were performed using a Brookfield viscometer. The preparation was placed into the cup, and the spindle was installed. The rotor was operated at a speed of 30 rpm (Rahayu, 2016).

Data Analysis

Several evaluations were conducted for data analysis, including organoleptic testing, homogeneity testing, spreading testing, pH testing, adhesion testing, emulsion type testing, and viscosity testing. Subsequently, the Design Expert software version 13 was used for formulation testing. The next examination involved stability testing of the preparations. The final tests were the Shapiro-Wilk test and One-Sample T-Test, which were performed using SPSS software version 23.

RESULTS AND DISCUSSION

In this study, eight oil-in-water (O/W) lotions were used. The lotion formulations were based on the study by Tumbelaka et al., (2019), with modifications to the concentrations of the emulsifiers cetyl alcohol and carrageen. The percentages of cetyl alcohol and carrageen concentrations were determined through optimization using Simplex Lattice Design (SLD) version 13. Based on the results of the physical evaluation tests, including organoleptic testing, homogeneity testing, spreading testing, pH testing, adhesion testing, emulsion type testing, viscosity testing, and stability testing, the optimal formulation values for the VCO lotion preparation were as follows:

1. Organoleptic Test

   Organoleptic tests were conducted to observe the appearance, odor, and color of the preparations. The results of organoleptic tests for the 8 formulations are presented in Table III.

Table III. Results of Organoleptic Test for VCO Lotion

Formula	Evaluasi		
	Form	Color	Odor
Standard Criteria	Viscous	White	Rose
F1	Viscous	A bit grayish	Rose

F2	Viscous	White	Rose
F3	Viscous	A bit grayish	Rose
F4	Viscous	White	Rose
F5	Viscous	White	Rose
F6	Viscous	White	Rose
F7	Viscous	White	Rose
F8	Viscous	White	Rose

Based on Table III, the organoleptic test results indicate that all formulations have a viscous texture and a rose aroma owing to the addition of rose oil in the preparation. All formulations were white, except for formulations 1 and 3, which had a slightly grayish color. This was attributed to the influence of other substances during the mixing of the preparation.

2. pH Test

The pH test aims to determine the acidity level of the preparation to ensure that it complies with the pH of the topical preparations. pH testing was conducted using litmus paper to assess whether the lotion did not irritate the skin upon application. According to SNI 16-3499-1996, the optimal pH range for skin is 4.5-8 (Hidayati et al., 2021). The results of the pH test can be seen in Table IV.

Table IV. Results of pH Test for VCO Lotion

Formula	pH	Standard	Information
F1	6.5	4.5-8 (Hidayati et al., 2021).	Qualify
F2	6		Qualify
F3	6		Qualify
F4	7.5		Qualify
F5	7		Qualify
F6	7.5		Qualify
F7	7		Qualify
F8	6.5		Qualify

Based on the table above, the pH test for VCO body lotion shows an average pH of 6.75 with a range of 6-7.5, which falls within the pH standard for the skin, indicating that all eight lotion formulations are safe to use on the body. The ingredient that influences the pH of the preparation is TEA, which has a strong alkaline property with a pH of 10.5 (Rowe et al., 2009).

3. Spreadability Test

The spreading test aims to determine the ability of the lotion to be easily applied or used. The results of the spreading test can be seen in Table V.

Table V. Results of Spreadability Test for VCO Lotion

Formula	Spreadability Diameter (cm)	Standard	Information
F1	5.3	5-7 cm (Ulfa et al., 2019)	Qualify
F2	5.2		
F3	5		
F4	5.9		
F5	5.5		
F6	5.8		
F7	5.8		
F8	5.5		

Based on Table V, the spreadability test of VCO lotion meets the requirements. Variations in the concentrations of cetyl alcohol and carrageenan affected the spreadability of the resulting lotion. The higher the concentration of carrageen, the higher is the viscosity of the lotion, resulting in decreased spreadability. Replication was performed three times for each formula.

4. Adhesion Test

The adhesion test aims to determine the ability of the preparation to adhere to the skin, according to the criteria. The results of the adhesion tests are listed in Table VI.

Table VI. Results of Adhesion Test for VCO Lotion

Formula	Adhesion Test (Second)	Standard	Information
F1	4.57	Not less than 4 seconds (Ulandari & Sugihartini, 2020).	Qualify
F2	4.8		Qualify
F3	5		Qualify
F4	4		Qualify
F5	4.3		Qualify
F6	4		Qualify
F7	4.1		Qualify
F8	4.5		Qualify

Based on Table VI, the adhesion test for all preparations (8 formulations) of the VCO lotion met the criteria, where the requirement for good adhesion was not less than 4 seconds (Ulandari & Sugihartini, 2020). The variation in concentrations of cetyl alcohol and carrageen affects the adhesion of the resulting lotion. The higher the concentration of carrageen, the higher is the viscosity of the lotion, resulting in greater adhesion.

5. Emulsion Type Test

The emulsion type was determined to ascertain whether it was O/W or W/O in the preparation. The results of the emulsion type test are listed in Table VII.

Table VII. Results of Emulsion Type Test for VCO Lotion

Formula	Emulsion Type	Standard	Information
F1	Oil in Water (O/W)	O/W emulsions are the most commonly used type of lotion for topical use (Mardikasari et al., 2017).	Qualify
F2			
F3			
F4			
F5			
F6			
F7			
F8			

The results of the emulsion type test for all preparations (8 formulations) indicated an O/W emulsion type, as determined by adding a few drops of methylene blue to the lotion formula. If all lotions are uniform, then the lotion tested is of the O/W type because water is the external phase. This is because the dispersed phase volume (oil phase) used in the lotion preparation is smaller than that of the dispersing phase (aqueous phase), causing oil globules to disperse into the aqueous phase, forming an O/W emulsion. O/W type lotions are easier to clean or rinse off with water. O/W emulsions are the most commonly used type of lotion for topical use owing to their excellent absorption quality (Mardikasari et al., 2017).

6. Viscosity Test

The viscosity test aimed to determine the thickness of the lotion preparation. The higher the viscosity, the thicker is the preparation. The results of the viscosity tests are listed in Table VIII.

Table VIII. Results of Viscosity Test for VCO Lotion

Formula	Viscosity (Cp)
F1	5680
F2	6780
F3	7320
F4	4260
F5	5580
F6	4480
F7	4570
F8	5670

The viscosities of formulas 1–8 ranged from 4260 to 7320. The difference in viscosity between each lotion was caused by the variation in the concentrations of cetyl alcohol and carrageen. The quality requirement for skin moisturizers for viscosity parameters is between 2,000 - 50,000 cP, based on SNI 16-4399-1996. In this formula, spindle no. 04 is used at a speed of 20 rpm. Viscosity with the highest carrageen concentration (3%) resulted in the highest viscosity of 7320 cP. The higher the concentration of carrageen used, the higher the viscosity of the resulting lotion, where carrageen concentrations exceeding 3% can cause the lotion to become difficulty in pouring and tend to form a paste-like to solid (cream) consistency (Irmayanti et al., 2021). The viscosity of carrageen is greater than that of cetyl alcohol because, in the production of lotion, carrageen only acts as a thickening agent, which increases the viscosity of the lotion. Meanwhile, cetyl alcohol only serves as a surfactant in lotion synthesis (Tumbelaka et al., 2019). The difference in viscosity can also be attributed to variations in treatment during the mixing or stirring process.

7. Optimization of VCO Lotion Formulation

The physical properties of the lotion preparation were analyzed using Design Expert version 13. The results of the SLD analysis are shown in Figure 1.

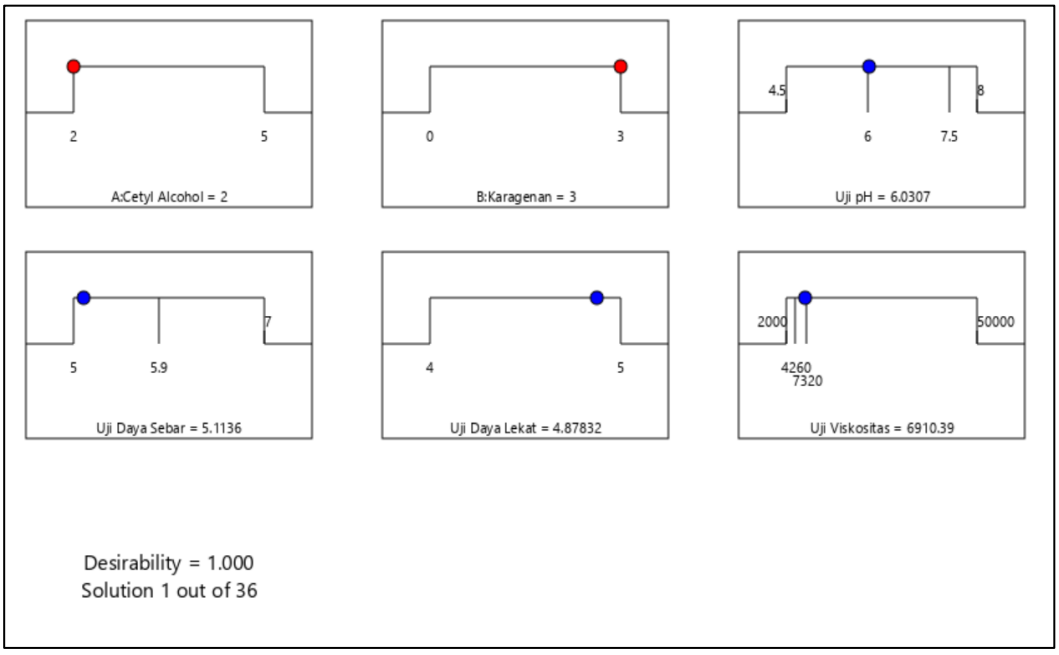

Figure 2. The analysis results from Design Expert

The analysis results from Design Expert yielded a good desirability value of 1.000, with 36 solutions generated. The selected solution was the ratio of cetyl alcohol to carrageen at 2:3. Replication was performed thrice for each formula (Ulfa et al., 2019). The physical evaluation results of the selected optimum formula are as follows:

1. Organoleptic Test

Table IX. Results of the Organoleptic Test for the Optimum Formulas

Replication	Organoleptic Evaluation			Emulsion Type
	Form	Color	Odor	
Replication 1	Viscous	White	Rose	O/W
Replication 2	Viscous	White	Rose	O/W
Replication 3	Viscous	White	Rose	O/W

2. Homogeneity Test

Table X. Results of the Homogeneity Test for the Optimum Formulas

Formula	Homogeneity
R1	Homogeneity
R2	Homogeneity
R3	Homogeneity
Formula	Homogeneity

3. pH Test

Table XI. Results of pH Test for the Optimum Formulas

Formula	pH
R1	7
R2	6
R3	6.5
Average	**6.5**

4. Spreadability Test

Table XII. Results of Spreadability Test for the Optimum Formulas

Formula	Spreadability Diameter (cm)
R1	5
R2	5.5
R3	5.3
Average	**5.26**

5. Adhesion Test

Table XIII. Results of Adhesion Test for the Optimum Formulas

Formula	Adhesion Test (Second)
R1	5
R2	4.7
R3	4.8
Average	**4.83**

6. Viscosity Test

Table XIV. Results of Viscosity Test for the Optimum Formulas

Formula	Viscosity Test
R1	6780
R2	5580
R3	5670
Average	**6010**

Based on the evaluation of the optimum formula, the results were found to closely align with the SLD values, as shown in Table XV.

Table XV. Comparison of SLD Values with Test Values

Test Result	SLD Values	Test Value
pH Test	6.0307	6.5
Spreadability Test	5.1136	5.26667
Adhesion Test	4.87832	4.83333
Viscosity Test	6910.39	6010

7. Stability Test

The accelerated stability test aimed to determine whether the prepared formulation remained stable within a specified storage period. The stability test was conducted by placing one cycle of the VCO lotion preparation at 4°C for 24 hours, then removing it and placing it at 40°C for 24 hours, making one complete cycle for 48 hours. The physical conditions of VCO lotion preparation were compared before and after the experiment.

Table XVI. Results of Stability Test for Optimum Formula

Replication	Organoleptic Evaluation	
	4^0C	40^0C
Replication 1	Stable	Stable
Replication 2	Stable	Stable
Replication 3	Stable	Stable

8. Optimum Verification

The comparison between the physical test results and the predicted SLD values showed no significant differences in the outcomes ($p>0.05$). The sample size of the study was less than 50; thus, the normality test was conducted using Shapiro-Wilk analysis. If the normality test yields normal results, the parametric one-sample T-test can proceed. The following are the results of the Shapiro-Wilk test from the research data:

Table XVII. Result of Normality Test Analysis

Shapiro Wilk Test	P-Value	Result
pH	1,000	Data is Normally Distributed
Spreadability Test	0,780	Data is Normally Distributed
Adhesion Test	0,637	Data is Normally Distributed
Viscosity Test	0,129	Data is Normally Distributed

Based on the results of the Shapiro-Wilk test analysis, all data were normally distributed ($p>0.05$); thus, the analysis can proceed with the One-sample T-Test, as indicated in the following table:

Table XVIII. Result of One Sample T-Test

Uji One Sample T-Test	P-Value	Result
pH	0,695	No Difference
Spreadability	0,512	No Difference
Adhesion	0,298	No Difference
Viscosity	0,679	No Difference

The results of the One-Sample T-Test analysis obtained a p-value > 0.05, indicating that the physical property test results of the VCO lotion preparation do not differ significantly from the predicted SLD values.

CONCLUSION

The optimum formula for the VCO body lotion has a concentration ratio of 2% cetyl alcohol and 3% carrageen. The pH, spreadability, adhesion, and viscosity tests yielded results that met the range of parameter values for good lotion quality, and were close to the values in the Simplex Lattice Design.

Suggestions that can be given after carrying out this research include modifying the formula by adding different active substances that can provide other benefits from using the lotion preparation.

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