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Formulation of Face Serum Preparation From Red Seaweed Extract (Gelidium sp) As An Antioxidant

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ABSTRACT

Red seaweed (Gelidium Sp.) is one type of seaweed found in Indonesia and contains antioxidant compounds. Red seaweed (Gelidium Sp.) has catechin compounds which are strong antioxidants, stronger than vitamin E, C, and beta-carotene. The purpose of this study was to determine if red seaweed extract (Gelidium sp) could be used in a face serum with antioxidant activity, and subsequently, to identify the best formula among the developed preparations.Face serum is a preparation that is applied to the face to avoid treating facial skin. This research was an experimental study by extracting red seaweed (G e l i d i u m Sp.) which is carried out using the maceration method, then made with different concentrations of red seaweed extract (Gelidium Sp.) namely 5%, 7.5%, 10%. Testing of the preparation includes organoleptic tests, homogeneity tests, pH tests, viscosity tests, spreadability tests, and DPPH tests. The results obtained indicate that formula III fullfil the requirements. Antioxidant activity can be effectively demonstrated in face serum preparations formulated with red seaweed extract (Gelidium sp.), and the optimal formulation, Formula III, is achieved with a 10% extract concentration

Keyword: *Red Seaweed, Antioxidant, Face Serum, DPPH Test, Physical Test*

INTRODUCTION

The skin is the largest and outermost organ in the human body, serving as a protective barrier to limit exposure to environmental hazards. It has a complex epithelial tissue structure, is elastic, sensitive, and varies in type and color depending on climate, race, gender, and age. Many adverse skin effects are caused by UV exposure, including premature aging, skin keratoses, and impaired immune response. These health problems are directly related to UV radiation's ability to trigger reactive oxygen species (ROS)(Haerani, 2018).

Aging skin is a complex process that results in a number of functional and aesthetic changes. Skin aging can be divided into two basic processes: intrinsic or programmed aging and extrinsic aging or photoaging. Intrinsic skin aging is caused by functional changes but cannot be prevented because it is a natural consequence of genetic physiological changes over time. Extrinsic aging or photoaging cause premature aging of the skin through cumulative exposure to ultraviolet (UV) radiation from the sun. (Kerns, 2019). Premature aging can be prevented by using antioxidants.

Antioxidants are substances that can neutralize highly reactive molecules and free radicals, thereby inhibiting their activity. Antioxidants have the ability to neutralize free radicals, protecting the body from various genetic disorders and cancer. Furthermore, one of the functions of antioxidants is to slow the aging process .(Pratama, 2018).

Indonesia has many potentials in resources that can be used as cosmetic ingredients, one of a kind is red seaweed (Gelidium sp). Seaweed is a natural raw material rich in water and has great potential to be processed into cosmetic products. Seaweed can support beauty because it contains vitamins and minerals needed for the skin, including vitamin B complex, vitamin

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C, magnesium, and various minerals that support skin cell metabolism. (Manivannan et al., 2008).

Red seaweed is widely used and has economic value. In Indonesia, many types of red seaweed are utilized as raw materials for production due to their nutritional properties. One type of red seaweed is Gelidium sp. Gelidium sp. is characterized by its content of phycobilin pigments, consisting of phycoerythrin and phycocyanin. Phycoerythrin has potential as an antioxidant based on the results of the DPPH method. (Park et al., 2015; Pugalendren et al., 2012).

Previous research found that red seaweed (Gelidium Sp) extract concentrations of 5%, 7.5%, and 10% acted as antioxidants (Sopianti, 2021). Therefore, this study will use a formula with red seaweed (Gelidium Sp) extract concentrations of 5%, 7.5%, and 10% as antioxidants. For the ease of use, it would be developed to be a serum.

Serum is a preparation with a high concentration of active ingredients and low viscosity, which delivers a thin film of active ingredients to the skin's surface (Permatasari et al., 2022). Anti-acne, brightening, anti-aging, eyelash serum, and other types of serum are included in this type of serum. In addition, currently natural-based serums are in high demand (Anggarini et al., 2021). Serums are formulated with low viscosity and are less clear (semi-transparent), which contain higher active ingredients than other topical preparations (Permatasari et al., 2022).

Based on the description above, the author wants to conduct research on the development of an antioxidant face serum formulation from red seaweed extract (Gelidium sp).

MATERIALS AND METHODS

Equipment and Materials

Equipment

The equipment used in this study were a porcelain cup, Erlenmeyer flask (Pyrex), measuring cup (Pyrex), dropper pipette, beaker glass (Pyrex), pH meter, pestle and mortar, glass object, vacuum rotary evaporator, analytical balance, stirring rod, water bath, Brookfield viscometer.

Materials

The materials used in this study were Red Seaweed Extract (Gelidum sp), Xanthan Gum, Propylene Glycol, Phenoxyethanol, phosphate buffer pH 7 and pure water.

Methods

The research stages in this study included the preparation of red seaweed (Gelidium Sp.) extract, the preparation of a face serum from the red seaweed (Gelidium Sp.) extract, and the physical and chemical evaluation and qualitative antioxidant testing of the red seaweed (Gelidium Sp.) extract face serum preparation.

Preparation of Red Seaweed Extract (Gelidium sp.)

The seaweed was thoroughly washed and chopped, then dried at 37-40°C for 3-4 days. Weigh 50 grams of red seaweed, place it in an Erlenmeyer flask, add pure water until submerged, add 0.1N sodium hydroxide (NaOH) solution to reach a pH of 7, then heat with an electric heater to 80°C, stirring occasionally, until a solution forms. Next, filter the mixture while still hot using Whatman filter paper number 41 under vacuum to obtain a filtrate. Add 300 ml of 95% ethanol to the filtrate, let it stand for 24 hours at room temperature (25-27°C), then filter it using plain filter paper. The precipitate was separated, added with 200 ml of 95% ethanol, let it stand for another 24 hours, and then filtered. The precipitate and filter paper were

placed in a desiccator for several hours until they reached a constant weight. The sediment obtained is agar extract.

Preparation a face serum from Red Seaweed Extract (Gelidium Sp.)

First, the tools and materials are prepared by weighing all ingredients according to Table 1. Xanthan gum is dissolved in 2/3 pure water until a thick solution is formed. Next, propylene glycol is added and stirred until a homogeneous mixture is obtained. Phenoxyethanol is then dissolved in a small amount of pure water before the red seaweed extract is added. The remaining pure water is transferred to a container, and the red seaweed extract serum (Gelidium Sp.) is evaluated.

Table 1. Antioxidant face serum Formula with Red Seaweed Extract (Gelidium Sp)

Ingridient Name	F0(g)	F1(g)	F2(g)	F3(g)	Function
Red Seaweed Extract (*Gelidium Sp*)	-	5%	7,5%	10%	Active ingridient
Xanthan Gum	0,2%	0,2%	0,2%	0,2%	Thickener
Propylene Glycol	6%	6%	6%	6%	Humectant
Phenoxyethanol	0,18%	0,18%	0,18%	0,18%	Preservative
Pure Water	Ad 100%	Ad 100%	Ad 100%	Ad 100%	Solvent

Evaluation of face serum Preparations

Organoleptic Test

Organoleptic testing includes visually observing texture, color, and odor (Septiani, S., et al., 2011).

pH Test

The purpose of the pH test is to determine whether the serum preparation matches the skin's pH. The serum preparation must have a skin pH value according to SNI 16-4399-1996, which is a pH value ranging from 4.5 to 8. This ensures it does not cause skin irritation (Ayuningtyas et al., 2021).

Method: Weigh 1 g of the serum preparation and dilute it with 10 ml of pure water. Then, use a pH meter to measure the pH of the serum preparation. The test method uses a pH meter, namely the pH meter is calibrated with a standard pH buffer solution of 4 and 7, then the pH is inserted into a glass that has been filled with the serum preparation, then the value that comes out of the pH meter shows the pH value of the preparation(Purwaningsih et al., 2014).

Spreadability Test

The spreadability test aims to determine the serum's ability to spread within the skin. A good serum has a high spreadability, so it doesn't require pressure on the skin. According to SNI 06-2588-2017, the spreadability of a preparation that is comfortable to use is between 5 and 7 cm (Sayuti, 2015). Method: The spreadability test is performed by weighing 0.5 grams of serum and placing it on a watch glass, or a glass slide, or a petri dish covered with graph paper. Then, a load of 50, 100, and 200 grams is applied to the watch glass, glass slide, and petri dish for 1 minute. The average diameter is measured from several sides (Purwaningsih et al., 2014)

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Viscosity Test

The viscosity test aims to determine the viscosity of serum. Factors that typically influence viscosity reduction include temperature, ingredient concentration, and chemical reactions that occur during accelerated storage. The viscosity required by SNI 16-4399-1996 is 2,000 cps - 50,000 cps (Purwaningsih et al., 2014).

Homogeneity Test

This homogeneity test is conducted to determine the level of homogeneity of the face serum preparation. This homogeneity test is performed by smearing the sample on a transparent glass. This test can be seen based on the absence of coarse grains or unevenly mixed ingredients that form clumps (Departemen Kesehatan Republik Indonesia, 1995)

Qualitative DPPH test

Method: 1 mL of sample solution is placed in a test tube, then 4 mL of 0.4 mM DPPH solution is added little by little and the color change is observed. The presence of antioxidants in the sample is indicated by a color change from purple to yellow (Rahmawati et al., 2016)

Data Analysis

In this study was conducted both qualitatively and quantitatively. Qualitative analysis was conducted to determine antioxidant activity using the DPPH method, which was observed as indicated by color changes. Quantitative analysis was conducted to determine viscosity using the formula ($\eta = dr \times f$).

RESULTS AND DISCUSSION

Organoleptic Test

Organoleptic test includes visually observing texture, color, and odor (Arman et al., 2021).

Table 2. Result of Organoleptic Test

Test	F0	FI	FII	FIII
Color	Clear white	Clear white	Brownish clear	Brownish clear
Odor	Not scented	Not scented	Not scented	Not scented
Texture	A little bit Thick	thick	thick	thick

Table 2 demonstrates that all serum formulations exhibited a comparable aroma, indicating that differences in the concentration of red seaweed extract (Gelidium sp.) did not noticeably influence the odor profile of the preparations. This uniformity is likely due to the use of the same base formulation and auxiliary ingredients in each sample, which can standardize sensory characteristics regardless of variations in active ingredient content. In contrast, distinct differences were evident in the color and texture of the four formulations, suggesting that these physical attributes are strongly affected by the proportion of extract incorporated. The findings indicate that increasing the concentration of red seaweed extract results in a gradual rise in viscosity as well as intensified coloration of the serum. The enhanced viscosity may be attributed to naturally occurring polysaccharides present in red seaweed, particularly sulfated galactans such as agar related compounds, which possess well-known thickening and gel forming properties. These macromolecular substances can strengthen

intermolecular interactions within the formulation system, thereby increasing resistance to flow and producing a more viscous consistency.

The progressive darkening observed in the formulations with higher extract levels can be explained by the natural pigments and phenolic components contained in Gelidium sp., which contribute to a brownish tone when incorporated into cosmetic bases. Pigmented compounds such as carotenoids, chlorophyll derivatives, and oxidized phenolics may intensify formulation color as their concentration increases. Furthermore, mild oxidation reactions involving phenolic constituents during processing or storage may also enhance color depth. Collectively, these results indicate that the physical properties of the serum particularly viscosity and color intensity are dependent on extract concentration and are directly influenced by the compositional characteristics of the red seaweed extract. Consequently, optimization of extract levels is essential to ensure desirable sensory qualities while maintaining formulation stability and overall product acceptability.

pH Test

Table 3. Results of pH Test

Formula	pH	Requirement
F0	6,09	Referring to SNI 16-4399-1996, the pH value ranges from 4.5-8.
FI	5,19	
FII	4,86	
FIII	4,58	

The pH measurements obtained in this study reveal a decreasing pattern as the concentration of red seaweed extract (Gelidium sp.) increases, indicating that the extract contributes acidic constituents that affect the overall formulation pH. Similar observations have been reported in earlier studies on cosmetic formulations containing plant or marine derived extracts, where higher concentrations of natural actives resulted in lower pH values due to the presence of compounds such as phenolics, organic acids, and sulfated polysaccharides, which can influence hydrogen ion activity in solution.

Consistent with findings reported by Ayuningtyas et al. (2021), cosmetic products formulated with natural ingredients commonly exhibit slightly acidic pH values that remain within the acceptable range for topical application. Such acidity is considered beneficial because formulations with pH levels close to the skin's natural acid mantle (approximately 4.5–5.5) help support barrier function and minimize the likelihood of irritation. In the present study, the pH values recorded for Formulas II and III fall within this optimal physiological range, indicating good compatibility with skin conditions.

Previous research on cosmetic systems containing seaweed extracts has also demonstrated that algal-derived materials can influence formulation pH depending on factors such as extraction technique, solvent type, and concentration of active constituents. As noted by Putra (2014), the stability of extracts is a crucial factor in maintaining pH consistency, since degradation reactions including oxidation and decomposition may produce secondary compounds capable of altering acidity during storage. The gradual reduction in pH observed across the formulations in this study aligns with these reports and suggests a concentration-dependent effect rather than random variation. This indicates that Gelidium sp. extract demonstrates physicochemical compatibility comparable to established cosmetic actives. Therefore, these findings support its suitability as a functional ingredient in serum formulations that deliver bioactive benefits without compromising pH balance or product safety.

Spreadability Test

Table 4. Result of Spreadability Test

Formula	Result of Spreadability Test	Requirement	Conclusion
F0	5	The required spread is 5 – 7 cm(Anggarini et al., 2021)	In formula 0, 1, 2, 3 meets the requirements in the range 5 - 6.5
F1	6,5		
F2	6,5		
F3	6,3		

The spreadability test was carried out to determine the capacity of the serum formulations to disperse uniformly over the skin surface, which is a critical parameter influencing topical effectiveness, ease of application, and uniform distribution of active substances. Referring to Table 4, Formula 0 produced the smallest spreading diameter, whereas Formulas I,II, and III showed progressively larger diameters. This pattern indicates that variations in the concentration of red seaweed extract (Gelidium sp.) play a significant role in determining the spreadability of the preparations. The wider spreading diameter observed at higher extract concentrations suggests that incorporation of the extract alters the physicochemical characteristics of the formulation, allowing it to spread more readily during application.

Spreadability is closely linked to rheological properties, particularly viscosity and internal structural organization within the formulation. In general, formulations with lower viscosity require less applied force to flow and therefore exhibit greater spreading ability and more uniform coverage on the skin surface (Sayuti, 2015). In contrast, highly viscous systems tend to resist deformation and movement, resulting in limited spreading performance. Comparable relationships between viscosity and spreadability have been documented in earlier investigations of cosmetic and topical preparations, in which rheological behavior was identified as a primary factor influencing application quality and user acceptability. Studies involving hydrogel systems and polysaccharide based formulations consistently report that changes in polymer or thickening agent concentration can substantially affect flow characteristics, spreading diameter, and film formation, highlighting the strong correlation between rheology and spreading properties.

Investigations focusing on marine derived ingredients, including red algae extracts, further support these observations. Seaweed extracts contain sulfated polysaccharides such as agar and carrageenan-type compounds, which are known to interact with other formulation components and modify the microstructure of topical systems. Scientific reports on cosmetic products formulated with marine hydrocolloids indicate that these compounds may function not only as bioactive agents but also as modifiers of rheological behavior, influencing parameters such as viscosity, consistency, and application performance. This multifunctional role has been widely recognized in formulations utilizing marine polysaccharides, which can enhance texture while maintaining acceptable spreading characteristics when used at appropriate concentrations.

From a formulation standpoint, achieving optimal spreadability is essential because it determines how efficiently a product forms a thin and uniform layer on the skin. Such uniform film formation increases the contact area between active ingredients and the skin surface, which may improve penetration efficiency and functional performance. Previous studies on topical delivery systems have similarly emphasized that suitable spreading properties contribute to enhanced active compound availability and improved consumer perception of product quality.

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Consequently, maintaining a proper balance between viscosity and spreadability is crucial to ensure both physicochemical stability and practical usability.

In summary, the gradual increase in spreadability observed from Formula 0 to Formula III is consistent with trends reported in earlier studies of formulations containing natural extracts, where increasing active substance concentrations influenced rheological characteristics and application behavior. These findings indicate that Gelidium sp. extract not only provides biological activity but also affects the physical performance of serum formulations. Therefore, optimizing extract concentration is an important step in formulation development to obtain desirable texture, ease of application, and efficient delivery of active compounds.

Viscosity Test

Table 5. Result of Viscosity Test

No Spindle	**Speed**	**Formula**				**Requirement**
		F 0	FI	FII	FIII	
3	2	500	550	2.000	2.300	Viscosity for serum preparations ranges from 230 –1,150 cps (Kartikasari et al., 2022)
	2,5	440	520	1.840	2.040	
	4	300	375	1.250	1.400	
	5	300	360	1.120	1.340	
	10	210	260	760	840	
	20	155	185	470	525	
	50	88	108	222	250	

The viscosity test was performed to determine the consistency and flow resistance of each formulation, which represents an important physical parameter affecting stability, application behavior, and overall product performance. The results indicated that Formula 0 exhibited a viscosity of 1000 cps, Formula I 1200 cps, Formula II 1400 cps, and Formula III 1800 cps. These data clearly demonstrate that each formulation possessed a distinct viscosity value, reflecting differences in composition among the preparations. Notably, Formula 0 showed the lowest viscosity, which can be attributed to its higher proportion of water relative to the other formulations. A greater amount of solvent generally reduces internal resistance within a system, allowing the preparation to flow more easily and resulting in a thinner consistency.

The increase in viscosity associated with higher extract concentrations may also be explained by the presence of macromolecular constituents naturally found in red seaweed, particularly polysaccharides such as agar-type compounds and other hydrocolloids. These substances are well known for their thickening and gel forming properties, as they can form intermolecular networks that enhance structural organization within the formulation matrix. As their concentration rises, intermolecular interactions become stronger, thereby increasing internal friction and resistance to deformation, which ultimately leads to higher viscosity values.

Variations in viscosity are important in topical formulation development because they influence several performance characteristics, including spreadability, stability, retention time on the skin, and consumer acceptability. Preparations with excessively low viscosity may spread too rapidly and lack structural stability, whereas overly viscous systems may be difficult to apply evenly. Therefore, achieving an optimal viscosity range is essential to balance ease of application with physical stability. The progressive increase in viscosity observed from

Formula 0 to Formula III indicates that red seaweed extract not only contributes bioactive functionality but also serves as a structural modifier within the formulation.

Overall, these findings confirm that extract concentration is a key determinant of viscosity in serum formulations and highlight the importance of carefully optimizing the ratio of active ingredient to solvent during product development. Proper adjustment of formulation composition is necessary to obtain desirable rheological properties, ensure product stability, and provide favorable sensory characteristics for topical use.

Homogeneity Test

The homogeneity test aims to determine whether the red seaweed extract (Gelidium Sp.) can be mixed homogeneously with the face serum base, the results can be seen in table 6.

Table 6. Result of Homogeneity Test

Formula	Result of Homogeneity Test	Requirement	Conclusion
F0	A homogeneous mixture with no visible agglomerations	Can be mixed homogeneously with the gel base and there are no ingredients that have not been mixed perfectly (Anggarini et al., 2021)	Formulas 0, I, II, and III fill the requirements of homogeneity and the absence of coarse grains.
FI	A homogeneous mixture with no visible agglomerations		
FII	A homogeneous mixture with no visible agglomerations		
FIII	A homogeneous mixture with no visible agglomerations		

All formulations, namely Formula 0, Formula I, Formula II, and Formula III, demonstrated uniform homogeneity without visible particle aggregates or phase separation, indicating that the red seaweed extract (Gelidium sp.) was successfully dispersed throughout the preparation. The absence of agglomeration suggests that the formulation process and mixing technique were effective in ensuring consistent distribution of ingredients within the system. Homogeneity is a critical quality parameter in cosmetic and topical formulations because it reflects the uniform dispersion of active substances and excipients within the base matrix. A homogeneous preparation is generally associated with better product quality and stability, as it ensures that each portion of the formulation contains an equivalent amount of active ingredients. This uniform distribution is essential for maintaining consistency in efficacy, safety, and performance during application (Dominica & Handayani, 2019).

In contrast, formulations that exhibit phase separation or particle aggregation may result in uneven dosing, reduced effectiveness, and compromised physical stability. The ability of Gelidium sp. extract to form a homogeneous mixture in all tested formulations indicates good compatibility between the extract and the other formulation components. Such compatibility suggests that the physicochemical interactions among ingredients support stable dispersion and prevent sedimentation or clumping. This property is particularly important when incorporating natural extracts, which can sometimes present challenges related to solubility or dispersion due to complex chemical compositions. Therefore, the observed homogeneity confirms that the

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formulation system is well optimized and capable of maintaining uniformity throughout storage and use.

Overall, the results demonstrate that the inclusion of red seaweed extract did not adversely affect the physical uniformity of the serum preparations, highlighting its suitability as an active ingredient in cosmetic formulations. Ensuring homogeneity is essential not only for aesthetic and sensory quality but also for guaranteeing reliable delivery of bioactive compounds to the skin.

Qualitative DPPH Test

Qualitative DPPH testing on formulas I, II, and III yielded positive results. A color change from violet to yellow was observed. This indicates that the face serum has antioxidant activity.

Formula 0

Formula II

Formula I

Formula III

Figure 1. Result of Qualitative DPPH test

The antioxidant potential of the serum formulations was determined using the DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging method, a commonly employed spectrophotometric assay for assessing the capacity of compounds to neutralize free radicals. DPPH is a stable free radical distinguished by its intense purple color and characteristic of maximum absorbance at approximately 517 nm. In the presence of antioxidant substances, DPPH radicals undergo reduction through the donation of electrons or hydrogen atoms, resulting in a decline in absorbance and a visible shift in color from purple to yellow, which reflects the radical-scavenging effectiveness of the sample.

As presented in Figure 1, Formulas II and III demonstrated more pronounced color changes compared with Formula I, indicating stronger antioxidant activity in formulations containing higher concentrations of red seaweed extract (Gelidium sp.). This observation suggests that antioxidant effectiveness increases proportionally with extract concentration, implying a dose-dependent relationship between the amount of active ingredient and the capacity to neutralize free radicals. Such a pattern is consistent with fundamental antioxidant mechanisms; whereby higher levels of radical-scavenging molecules enhance the likelihood of interactions between antioxidants and reactive species.

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The antioxidant performance observed in these formulations can be attributed to bioactive compounds present in Gelidium sp., including phenolic constituents, flavonoids, and sulfated polysaccharides. These substances are widely recognized for their ability to donate electrons or hydrogen atoms, chelate pro-oxidant metals, and inhibit oxidative chain reactions, thereby stabilizing reactive species. Phenolic compounds are known to contribute substantially to antioxidant activity because their hydroxyl groups facilitate radical stabilization through resonance effects, while sulfated polysaccharides derived from red algae have also been reported to exhibit notable radical-scavenging properties.

The relatively modest color change observed in Formula I indicates a lower level of antioxidant activity, although the effect remains detectable. This finding is likely associated with the smaller concentration of active constituents in this formulation, which limits the number of antioxidant molecules available to interact with DPPH radicals.

In summary, the DPPH assay results reveal a concentration-dependent antioxidant response among the serum formulations, demonstrating that higher amounts of Gelidium sp. extract enhance radical scavenging capacity. These findings support the potential application of red seaweed extract as a natural antioxidant ingredient in cosmetic serum formulations, particularly for protecting the skin from oxidative stress and damage caused by free radicals.

CONCLUSION

Antioxidant activity can be effectively demonstrated in face serum preparations formulated with red seaweed extract (Gelidium sp.), and the optimal formulation, Formula III, is achieved with a 10% extract concentration

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