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Research Articles

Effect of Stearic Acid and Cetyl Alcohol Concentration Variations on the Physical Characteristics of Face Scrub Formulations Containing Gelatik Clam Shell (*Anadara pilula*) Powder

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Abstract: The increasing consumption of seafood has led to the accumulation of waste by-products. In Indonesia, clam shell waste is estimated to reach about 70% of the total weight, indicating that shell waste represents a significant environmental concern. Gelatik clam (*Anadara pilula*) shells, rich in calcium carbonate, offer potential as natural exfoliating agents derived from fishery by-products. Face scrub exfoliation efficiently removes dead skin cells and enhances skin texture. This study aims to analyze the effects of stearic acid and cetyl alcohol concentration - as stiffening agents - on its physicochemical characteristics. There are 4 formulas with different levels of stearic acid and cetyl alcohol, they are 8% and 4% (F1), 8% and 6% (F2), 10% and 4% (F3), 10% and 6% (F4). The face scrub was prepared using an overhead stirring method. The evaluation of physicochemical characteristics included organoleptic, pH value, viscosity, spreadability, and adhesiveness. The formulated face scrub was semisolid, white, odorless, and had pH value range of 7.36 - 7.5. F1 demonstrated the optimal physical properties, including a viscosity of 66333.33 ± 3214.55 cP, a spreadability of 0.083 ± 0.006 cm^2, and an adhesiveness of 17.333 ± 0.577 s. These results suggest that Gelatik clam shell powder is a promising and sustainable ingredient for face scrub formulations.

Keywords: Cetyl Alcohol; Face Scrub; Gelatik Clam Shells; Stearic Acid; Physicochemical Characteristics

1. Introduction

The Indonesian cosmetic industry has experienced rapid growth, particularly in the facial care segment, in line with increasing public awareness of skin health and aesthetic appearance. The tropical climate of Indonesia is characterized by high temperatures, elevated humidity levels, and intense ultraviolet radiation directly influences the physiological condition of the skin [1]. These environmental factors contribute to increased sebum secretion, reduced skin hydration, and a slower rate of cellular regeneration, which collectively lead to various skin problems such as excessive oiliness, dullness, dryness, and acne [2]. In this context, innovative skincare formulations are required, not only to function as cleanser but also providing exfoliating effects to support optimal skin cell regeneration.

Exfoliation is an essential step in skincare, aimed at removing dead skin cells from the stratum corneum to help improve skin texture, enhance complexion brightness, and stimulate the formation of new skin cells [3]. Based on its mechanism of action, exfoliation is divided into chemical exfoliation and physical exfoliation. Physical exfoliation, such as in face scrub formulations, utilizes abrasive particles that produce a gentle peeling effect through mechanical friction on the skin surface [4]. Natural materials such as coffee ground, oatmeal, and apricot seed powder have been widely used as physical exfoliators. However, the potential of other local materials with similar characteristics, such as clam shell, has not been fully optimized. Analytical results indicate that clam shell contain a high level of calcium carbonate ($CaCO_3$), approximately 98%, which possesses both abrasive and adsorptive properties, making it effective for removing excess oil and dead skin cells [5].

Indonesia has an abundant supply of clam shell, resources, one of them called Gelatik clam (*Anandara pilula*), commonly found in coastal areas such as Madura. To date, clam shell waste has mainly been utilized for livestock feed or handicrafts. Its application in the cosmetic field remains limited [6]. Supporting the effectiveness of face scrub formulation, there are several ingredients that enhance the sensory effect on the skin when the product is applied. Stiffening agents, such as stearic acid and cetyl alcohol, play a crucial role in regulating viscosity, adhesion, and spreadability, which directly affect user comfort and the effectiveness of the exfoliation process [7]. Based on these considerations, this study was conducted to develop a face scrub formulation using natural ingredients derived from gelatik clam shell waste, with variations in stearic acid and cetyl alcohol concentrations aimed at achieving optimal physical and functional characteristics as well as potential application as an innovative cosmetics product.

2. Materials and Methods

2.1 Materials

Clam shell was collected from local fishermen in Bangkalan, Indonesia; Moringa leaf extract (*Moringa oleifera*) (Herbal Materia Medica Laboratory Unit); mango butter (PT Indonesia Organic Butter); rice bran oil (Making Cosmetics); stearic acid, cetyl alcohol, kaolin, tween 80, glycerin, phenoxyethanol, distilled water (CV Duta Jaya).

2.2 Preparation of Gelatik Clam Shell Powder

The collected gelatik clam shells (*Anandara pilula*) were thoroughly washed using hot water mixed with salt and sodium carbonate to remove organic residues. The shells were then sure dried until completely dry. The dried shells were ground using a hammer mill to obtain fine particles, followed by sieving with a mesh size of 20 to ensure uniform particle size. The resulting shell powder was stored in airtight containers and used as the exfoliating agent in the face scrub formulation at a concentration of 10%.

2.3 Preparation of Moringa Leaf Extract

The moringa leaf extract was prepared using a sonication extraction method. A total of 25 g of moringa leaf powder was extracted with 250 mL of 70% ethanol using an ultrasonic bath for 20 minutes, followed by filtration. The remaining residue was re-extracted twice using 50 mL of 70% ethanol with the same procedure. All filtrates were then concentrated using a rotary evaporator to obtain a thick extract. The resulting extract was weighed, and its yield was calculated [8].

$$\text{Yield} = \frac{extract\ weight}{sample\ weight} \times 100\% \quad (1)$$

2.4 Preparation of Gelatik Clam Shell Face Scrub Formulation

The face scrub formulation was developed using four different concentrations of stiffening agents (stearic acid and cetyl alcohol) were applied to examine their relationship with viscosity, spreadability, and adhesion values. Formulation ingredients and their respective percentages (%) were shown in the following Table 1.

Table 1. Formulation ingredients for face scrub

Material	Function	Amount (%)			
		F1	F2	F3	F4
Gelatik clam shell powder	Exfoliator	10	10	10	10
Stearic acid	Stiffening agent	8	8	10	10
Cetyl alcohol	Stiffening agent	4	6	4	6
Mango butter	Emolien, lipid phase	8	8	8	8
Rice bran oil	Anti-aging	5	5	5	5
Kaolin	Detoxifying agent	2	2	2	2
Tween 80	Emulsifier	3	3	3	3
Glycerin	Humectant	5	5	5	5
Moringa leaf extract	Antioxidant	0.0075	0.0075	0.0075	0.0075
Phenoxyethanol	Preservative	0.5	0.5	0.5	0.5
Aquadest	Solvent	Ad 100	Ad 100	Ad 100	Ad 100

The oil phase (stearic acid, cetyl alcohol, mango butter, rice bran oil) and the aqueous phase (glycerin, tween 80, aquadest) were heated separately at 70°C.. The oil phase was slowly added to the aqueous phase while being stirred at 200 rpm until a homogeneous mixture was obtained. The mixture was allowed to cool down to 40°C, after which kaolin was added gradually while stirring. Subsequently, the clam shell powder and moringa leaf extract were incorporated and the mixture was stirred until a homogen semi solid formulation was achieved. The formula was left to stand until it reached room temperature for 24 hours before testing was carried out.

2.4 Evaluation of Clam Shell Face Scrub

The physical characteristics of the face scrub were evaluated based on organoleptic, pH, viscosity, adhesion, spreadability, and physical stability. These parameters were compared to acceptance criteria stated in SNI 16-4380-1996 and to existing products on the market.

2.4.1 Organoleptic Test

Organoleptic evaluation included observation of the color, odor, and consistency of the face scrub through visual and sensory assessment. The evaluation aimed to ensure that the formula exhibited acceptable sensory characteristics, such as states of matter, appearance, and odor [9].

2.4.2 pH Test

The pH test was conducted to ensure that the formulation met the acceptability pH range for facial skincare products. If necessary, adjustments were made using 0.05N HCl. The pH was measured using a semi solid formulation pH meter (Horiba LAQUA) [9].

2.4.3 Viscosity Test

Viscosity was measured using a Brookfield viscometer equipped with spindle number 7 and the results were expressed in centipoise (cP) [10].

2.4.4 Spreadability Test

Spreadability was determined by placing 0.5 grams of the sample between two glass plates, followed by applying a 100 gram load for 1-2 minutes. The diameter of the spread sample was measured and the spreadability area (cm^2) was calculated using the formula [10] :

$$S = A = \pi \left(\frac{r}{8}\right)^2 \quad (2)$$

Where S is the spreadability (cm^2), π is constant with a value of 3.14, and r is the radius (cm).

2.4.5 Adhesion Test

The adhesion test was conducted by placing 0.5 grams of the sample between two glass slides and applying a 500 grams load for 5 minutes. After the load was removed, the time required for the slides to separate was recorded as the adhesion time [12].

2.4.6 Physical Stability Test

Physical stability was assessed using a short-term real-time method by storing the samples at room temperature (30°C ± 2°C) for 7 days. The formulations were examined for changes in organoleptic properties throughout the storage period [13].

2.5 Data analysis

Data analysis in this study was conducted using two complementary approaches: theoretical analysis and statistical analysis. Theoretical analysis was employed to compare the physical characteristics of the face scrub including viscosity, spreadability, and adhesion, against acceptance criteria established by SNI 16-4380-1996 and existing products on the market as comparative reference.

Statistical analysis was performed using IBM SPSS 25 and included normality and homogeneity testing as prerequisites for parametric analysis. Normality was assessed using the Shapiro–Wilk test, while homogeneity of variance was examined using Levene's test with a significance criterion of $p > 0.05$. When both assumptions were met, the data were analyzed using One-Way ANOVA to determine differences in mean values among the formulations, followed by Tukey's HSD post hoc test if statistical significance was observed ($p < 0.05$). However, if the assumptions for parametric testing were not satisfied, the data were analyzed using the non-parametric Kruskal–Wallis test [14, 15].

These analytical procedures were carried out to ensure that any observed differences in the physical characteristics of the formulations were attributable to the treatment effects rather than random variations within the dataset.

3. Results

3.1 Moringa Leaf Extract

The extraction of moringa leaves using the sonication method produced a thick, dark green extract with a characteristic moringa aroma. From 25 grams of moringa leaf powder extracted with 70% ethanol, a total of 2.4 grams of concentrated extract was obtained after sonication, filtration, and evaporation using a rotary evaporator.

$$\text{Yield} = \frac{extract\ weight}{sample\ weight} \times 100\%$$

$$\text{Yield} = \frac{2.4}{25} \times 100\% = 9.6\% \qquad (3)$$

The resulting extract yield was 9.6%, which meets the minimum yield requirement for moringa leaf extract according to the Indonesian Depkes RI (2017), set at no less than 9.2% [16].

3.2 Gelatik Clam Shell Powder Face Scrub

In this study, the face scrub was formulated using clam shell powder as the primary exfoliating agent. The resulting powder, produced through drying and milling, appeared grayish-white with a slightly coarse texture and demonstrated good stability during storage. Its high calcium carbonate content provided mild abrasive properties, making it effective in helping remove dead skin cells and impurities. Four formulations were developed by varying the concentrations of stearic acid and cetyl alcohol, consisting of F1 (8% and 4%), F2 (8% and 6%), F3 (10% and 4%), F4 (10% and 6%). These formulations were subsequently evaluated for their physical characteristics.

3.3 Organoleptical of Face Scrub

The organoleptic parameters assessed included the appearance, odor, and states of matter of the face scrub. The result indicated that all formulations had a white color, a neutral odor, and a semisolid texture (**Figure 1**). Although the texture of the four formulations was slightly coarse, such texture is generally desirable in face scrubs, as it contributes to their ability to exfoliate effectively by removing dead skin cells. In addition, the resulting face scrub exhibited a smooth texture with evenly distributed *Anadara pilula* shell exfoliating particles, without clumping or forming excessively coarse granules. The surface of the formulation appeared soft and easy to spread, indicating that the mixing process was optimal and produced a homogeneous exfoliant dispersion [17].

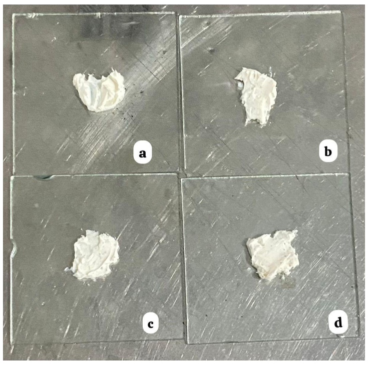

Figure 1. Results of face scrub formulation : (a) F1; (b) F2; (c) F3; (d) F4

3.4 pH Value

The pH test was conducted to ensure that each formulation fell within the acceptable range for facial skin products. According to SNI 16-4380-1996, the ideal pH range for facial cleanser is 4.5 - 7.8. Triplicate measurements were performed for each formulation. **(Table 2)**. This pH range is still considered acceptable for topical facial application, as it is neither too acidic nor too alkaline, thereby maintaining the skin's natural balance and minimizing the risk of irritation [9]. All formulations were within reference range.

Table 2. pH Value of Gelatik Clam Shell Face Scrub

Formula (stearic acid : cetyl alcohol)	**pH ± SD**	**Reference**
F1 (8 : 4)	7.36 ± 0.035	4.5 - 7.8
F2 (8 : 6)	7.6 ± 0.053	
F3 (10 : 4)	7.4 ± 0.090	
F4 (10 : 6)	7.5 ± 0.086	

3.5 Viscosity Test

The viscosity test aimed to determine the thickness of the formulation, which influences ease of application. The target viscosity range for commercial face scrub is 64000 - 84000 cP. As results (**Table 3**), formulation F3 and F4 exceeded this range. These results indicate that higher concentrations of stearic acid and cetyl alcohol increase viscosity, confirming their role as stiffening agents [18].

Table 3. Viscosity of Gelatik Clam Shell Face Scrub

Formula (stearic acid : cetyl alcohol)	Viscosity (cP) ± SD	Reference (unit???)
F1 (8 : 4)	66333.33 ± 3214.55	64000 - 84000
F2 (8 : 6)	83333.33 ± 7023.77	
F3 (10 : 4)	100666.66 ± 2516.61	
F4 (10 : 6)	131333.33 ± 2516.61	

3.6 Spreadability Test

Spreadability test is aimed for the easiness of product spread on the skin, an important parameter influencing user comfort and active ingredient absorption. The acceptable spreadability range for comparable commercial products is 0.110 - 2.405 cm^2. According to the results in **Table 4**, none of the formulations met the range specification based on the existing products sampel on the market reference. However, F1 exhibited the closest value to the reference range. The data showed that decrease in spreadability in line with increased viscosity.

Table 4. Spreadability of Gelatik Clam Shell Face Scrub

Formula (stearic acid : cetyl alcohol)	Spreadability (cm^2) ± SD	Reference (cm^2)
F1 (8 : 4)	0.083 ± 0.006	0.110 – 2.405
F2 (8 : 6)	0.063 ± 0.003	
F3 (10 : 4)	0.063 ± 0.003	
F4 (10 : 6)	0.045 ± 0.005	

3.7 Adhesiveness

The adhesion test was conducted to determine the adherence of to the skin, which associated with duration of contact between the product and the skin surface. A good adhesive property for topical formulations is indicated by longer time of adhesion. The required time for adhesion is more than 4 seconds [19] The result of adhesiveness is presented in **Table 5.** Based on the findings, adhesion time of all face scrub formulations have met the required standard. The higher stiffening agent concentrations yielded longer adhesion time.

Table 5. Adhesiveness of Gelatik Clam Shell Face Scrub

Formula (stearic acid : cetyl alcohol)	**Adhesiveness (s) ± SD**	**Reference (s)**
F1 (8 : 4)	17.33 ± 0.58	> 4
F2 (8 : 6)	18.66 ± 0.58	
F3 (10 : 4)	23.66 ± 1.53	
F4 (10 : 6)	33.33 ± 3.06	

3.8 Face Scrub Physical Stability Test

Stability testing was performed using a short-term real time method in which the samples were stored at room temperature (30°C ± 2°C) for 7 days. According to **Table 6,** none of the formulations exhibited changes in color, odor, and states of matter throughout the testing period, indicating good physical stability for 7 days, in terms of organoleptic.

Table 6. Stability Test of Gelatik Clam Shell Face Scrub

Formula (stearic acid : cetyl alcohol)	**Organoleptic Characteristic**	**Day**	
		0	**7**
F1 (8 : 4)	States of matter	Semi solid	Semi solid
	Color	White	White
	Odor	None	None
F2 (8 : 6)	States of matter	Semi solid	Semi solid
	Color	White	White
	Odor	None	None
F3 (10 : 4)	States of matter	Semi solid	Semi solid
	Color	White	White
	Odor	None	None
F4 (10 : 6)	States of matter	Semi solid	Semi solid

	Color	White	White
	Odor	None	None

4. Discussion

The results of the physicochemical evaluation demonstrate that variations in stearic acid and cetyl alcohol concentrations significantly influenced the viscosity, spreadability, and adhesiveness of the formulated face scrubs. Overall, increasing the proportion of stiffening agents led to higher viscosity and adhesiveness, while inversely reducing spreadability.

A clear upward trend of viscosity was observed as the combined concentration of stearic acid and cetyl alcohol increased from F1 to F4. Formula F1, containing the lowest total stiffening agent (8% stearic acid and 4% cetyl alcohol), exhibited the lowest viscosity range. Viscosity increased progressively in F2, F3, and reached its highest values in F4. This trend aligns with the structural reinforcement properties of both stearic acid and cetyl alcohol, which thicken the lipid phase by increasing crystalline packing density. Notably, all formulas exceeded the specification limit of 3,000–50,000 cP, indicating the need for further optimization to reduce excessive stiffness [17].

Spreadability values demonstrated the opposite pattern. F1 showed the highest spreadability, while F4 showed the lowest. This inverse relationship is expected; higher concentrations of stiffening agents reduce deformability, resulting in a product that is harder to spread on the skin. All formulas fell below the reference specification (1.227–2.405 cm^2), confirming that the current formulations are too dense and require adjustment by reducing wax content or increasing emollients [16].

Adhesiveness, representing retention time on the skin, increased with viscosity. F1 showed the lowest adhesiveness, while F4 demonstrated the highest. Although higher adhesiveness may enhance exfoliation performance due to longer contact time, extremely high adhesion can reduce user comfort. All formulas met the specification (>4 seconds) [20], but F4's excessive adhesiveness suggests reduced spreadability and overly stiff texture. All formulas exhibited acceptable pH values (pH 7), remaining within the safe skin tolerance range (4.5–7.8) [9]. Organoleptically, all scrubs were semisolid, white, and odorless, suggesting that variations in stiffening agent concentrations did not affect appearance or scent.

The commercial face scrub showed viscosity values around 82,000–84,000 cP and spreadability of 0.110–0.118 cm^2. Compared to this benchmark, F1 presented performance closest to the commercial profile, particularly in terms of viscosity and spreadability balance. In contrast, F3 and F4 exhibited excessive viscosity and insufficient spreadability, indicating over-thickening of the base.

Statistical analysis indicates that variation in stearic acid and cetyl alcohol concentrations had a significant effect on the viscosity of the formulations, as confirmed by the One-Way ANOVA and Tukey's post hoc test ($p < 0.05$). For spreadability, both the Kruskal-Wallis test and subsequent Mann-Withney comparisons also revealed significant differences among the formulas ($p < 0.05$), except between F2 and F3, which showed no significant difference due to having identical spreadability values. In contrast, the adhesion test demonstrated no significant differences among the formulations, indicating that the variations in stiffening agent concentrations used in this study did not influence the adhesive properties of the face scrub.

Among all formulas, F1 demonstrated the most favorable physicochemical characteristics, with moderate viscosity, adequate adhesiveness, and the highest spreadability. Increasing stiffening agent concentrations (F2–F4) produced excessively dense and less spreadable textures that deviate from optimal sensory properties expected in face scrub products. These findings indicate that the combination of 8% stearic acid and

4% cetyl alcohol is the most suitable among the tested formulations. Further refinement—such as adjusting the ratio of butter, oils, or reducing the total wax concentration—may help achieve viscosity and spreadability values aligned with standard specifications and user expectations.

5. Conclusions

This study has successfully developed a face scrub formulation based on gelatik clam shell (*Anandara pilula*) powder by utilizing variations in stearic acid and cetyl alcohol concentrations as stiffening agents. Higher concentrations of stearic acid and cetyl alcohol lead to increase viscosity and adhesiveness but conversely reduce spreadability. Among the formulations, F1 (8% stearic acid and 4% cetyl alcohol) exhibited the most optimal physical properties, with viscosity and spreadability value closest to comparative existing products on the market. Therefore, F1 is recommended as the best formulation and has strong potential to be further developed into an innovative and environmentally friendly face scrub product derived from clam shell waste.

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