SKIN BENEFITS OF A COCOA-BASED FACIAL SCRUB WITH ENCAPSULATED COCOA POD HUSK POWDER

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ABSTRACT – *Formulation of facial scrub based on cocoa butter liquid soap (CBLS) was conducted using response surface methodology (RSM). The factors were Sodium Methyl Cocoyl Taurate (SMCT), Sodium Cocoyl Glutamate (SCGL) and Cocoamidopropyl betaine (COBET), with level of 3g-10g, 3g-7g and 5g-10g, respectively. The amount of CBLS was kept constant. The dependent variables are pH and pH_{CA}, which were significantly affected by the factors as follows. The pH was affected by COBET amount, where increasing the level of COBET will reduce the pH of the facial scrub. Another dependent variable, pHCA, was significantly affected by all the factors. Low pH_{CA} was obtained with high levels of SCG, and low amounts of COBET and SMCT. However, at a high level of COBET, the SMCT and SCGL needed was less to obtain low pH_{CA}. The model for pH was represented by pH = 8.0055 - 0.0259*COBET, while the model for pH_{CA} was pH_{CA} = 6.6824 + 0.0384*SMCT - 0.1368*SCGL - 0.1079*COBET + 0.0228*SCGL*COBET. The optimum pH was obtained at pH 7.70 and pHCA 5.65 with SMCT 0.6137, SGCL 1.6364 and COBET 11.7045. The model was validated with pH 7.645$\pm$0.066 and pH_{CA} 5.665$\pm$0.028. The optimized facial scrub formula was tested for its stability using LUMIFuge, and the rheological properties were obtained from a rheometer. Cocoa pod husk powder encapsulated in a mixture of seaweed and carrageenan powder, was incorporated into the final facial scrub formula. The final product was monitored for 6 months to confirm the stability of the encapsulated cocoa pod husk powder in the formula. The efficacy of this product was tested by 13 volunteers aged 30-40 years old, 6 women and 7 men, for 4 weeks' duration. Measurement using Visioscan was carried out, on the initial and interval of one week of usage, for skin roughness, hydration and wrinkles reduction. The results showed positive improvement on the parameter measured.*

Keywords: Cocoa facial scrub, cocoa pod husk powder, efficacy, skin, Visioscan

INTRODUCTION

The growing consumer demand for natural and sustainable skincare products has sparked interest in using agricultural by-products as cosmetic ingredients. Cocoa, rich in bioactive compounds, is a promising source for these ingredients. This research aims to develop and assess a facial scrub using cocoa pod husk powder, a typically discarded byproduct of cocoa processing. Cocoa butter has been widely used as a base in soap making, including liquid soap bases for facial care (Abdul Karim, A. *et al*., 2022) and shampoo (Abdul Karim, A. *et al*., 2023).

Cocoa pod husk powder has shown potential as a physical exfoliant in body care, effectively removing dead skin cells and improving skin texture (Abdul Karim, A. & Abdullah, N.A., 2012). Additionally, cocoa pod extract has demonstrated dermatological benefits, including wrinkle reduction (Abdul Karim, A. *et al*., 2014; Abdul Karim, A. *et al.*, 2016), modulation of MMP-1 gene expression (Abdul Karim, A. *et al*., 2020), and wound healing after tooth extraction (Rahayu, C.Y. *et al.,* 2024). These benefits are attributed to the antioxidants and other beneficial compounds found in cocoa pod husk.

Direct integration of ground cocoa pod husk into cocoa butter liquid soap base leads to the expulsion of pectin and other compounds from the husk, consequently compromising the product's aesthetic quality (Abdul Karim, A. & Abdullah, N.A., 2012). Moreover, in cosmetic liquid cleanser formulations, such as cocoa butter liquid soap, the ground cocoa pod husk exhibits a tendency to settle at the bottom of the container because the density of the husk powder is greater than that of the liquid soap base. To mitigate these challenges, encapsulation of cocoa pod husk powder was implemented prior to its incorporation into a cocoa butter liquid soap base. Encapsulation achieves stable suspension in three ways. First, it creates microcapsules by coating the denser cocoa pod husk powder with a lighter material, bringing the overall effective density closer to the liquid soap base to slow gravitational settling and maintain suspension. Secondly, the compatible outer shell also prevents the cocoa pod husk powder from aggregating due to poor compatibility, ensuring individual particles are uniformly dispersed and mitigating accelerated settling caused by clumping. Thirdly, the resulting increased hydrodynamic size and reduced effective density enhance the viscous drag from the liquid soap, enabling the microcapsule to resist gravity and remain stably suspended (Wagner, N.J. *et al*., 2021). This study was designed with the objective of improving skin health through enhancements in texture, hydration, and wrinkle reduction.

MATERIALS AND METHODS

Materials

The materials used in this study namely distilled water, cocoamidopropyl betaine (COBET), cocoa butter liquid soap (CBLS), glycerin, cetyl alcohol, glyceryl monostearate, sodium cocoyl glutamate (SCGL), sodium methyl cocoyl taurate (SMCT), sodium chloride, phenoxyethanol (and) ethylhexylglycerin, citric acid, sodium chloride (NaCl) and fragrance. All the chemicals and reagents were purchased from authorized chemical suppliers in Malaysia. The ingredients function and lists of facial scrub based are listed in Table 1.

Table 1: The Ingredients of Cocoa Facial Scrub Based

Ingredients	*Function*	*Weight (wt%)*
Distilled water	Diluent	30 - 50
Glycerin	Humectant, moisturising agent	5 - 7
Glyceryl monosterate	Emulsifier, gives body to creams and leaves the skin feeling soft and smooth.	2 - 4
CBLS	Surfactant	8 - 10
SMCT	Copious rich and dense foaming with easy rinsibility, provide softening and moisturizing skin feel	3 - 10
SCGL	Mild and gentle surfactant, foaming boosters	3 -7
COBET	Coconut oil derived amphoteric surfactant, foam booster, viscosity enhancer	5-10
Cetyl alcohol	Co-emulsifier and non-gelling thickener in all emulsions	3 - 4
NaCl	Viscosity enhancer	0.3 - 0.5
PARABEN-FREE	Preservative	0.3 - 0.5
Citric acid solution	pH adjuster	q.s
Fragrance	Perfuming	q.s

CBLS is Cocoa Butter Liquid Soap, SMCT is Sodium Methyl Cocoyl Taurate, SCGL is Sodium Cocoyl Glutamate, PARABEN-FREE is preservative of phenoxyethanol (and) ethylhexylglycerin.

To prepare the mixture, all ingredients listed in Table 1, except for NaCl, preservative, and fragrance, were weighed and combined in a beaker. The mixture was then heated until all solid ingredients melted and blended homogeneously. Once the mixture cooled to 40°C, the remaining ingredients were added and thoroughly stirred. The mixture was poured into a container and left to set for at least 24 hours before further testing.

Table 2: The composition of SMCT, SCGL and COBET regarding the RSM Experimental Design and the pH of the mixture

Run Order	SMCT	SCG	COBET	pH	pH_{CA}
1	6.5	5	7.5	7.76	6.39
2	6.5	5	7.5	7.79	6.29
3	10	3	5	7.89	6.44
4	3	3	5	7.96	6.15
5	12.386	5	7.5	7.81	6.34
6	10	7	10	7.75	6.5
7	10	3	10	7.7	6.26
8	0.614	5	7.5	7.71	6.05
9	6.5	5	7.5	7.81	6.26
10	6.5	1.636	7.5	7.83	6.31
11	3	7	5	7.84	5.87
12	3	7	10	7.69	6.44
13	6.5	5	7.5	7.86	6.42
14	6.5	8.364	7.5	7.85	6.52
15	10	7	5	7.87	6.55
16	6.5	5	3.296	7.92	6.23
17	6.5	5	7.5	7.79	6.21
18	6.5	5	7.5	7.84	6.39
19	3	3	10	7.77	5.94
20	6.5	5	11.705	7.78	6.27

Methods

Making Cocoa Facial Scrub Based

The compositions of SMCT, SCGL and COBET (in weight percentage) are presented in Table 1, following the RSM experimental design outlined in Table 2, with significant parameters (pH and pH_{CA}). A central composite design was employed to uniformly evaluate the effects of varying SMCT, SCG, and COBET compositions on the alkalinity of the facial scrub-based mixture (Table 3).

Table 3: The Response Surface Methodology Experimental Design parameter

Central Composite Design
Factors: 3 Replicates: 1
Base runs: 20 Total runs: 20
Base blocks: 1 Total blocks: 1
Two-level factorial: Full factorial
Cube points: 8
Center points in cube: 6
Axial points: 6
Center points in axial: 0
Alpha: 1.68179

Potential Hydrogen (pH) Measurement

To measure the pH, 1 gram of the facial scrub base was dissolved in 9 mL of distilled water. The measurement was carried out using a pH meter (Accumet, Fisher Scientific, U.S.A). The pH of the mixture before the addition of citric acid was recorded in the column labelled "pH," while the pH after the addition of citric acid was recorded in the column labelled "pH_{CA}."

Accelerated Stability

The stability of the final facial scrub formula was measured using a LUMiFuge 1113-81 (LUM GmbH, Germany). Approximately 20 µL of the sample was placed into a cuvette. To predict an 18-month shelf life, the following parameters were used: 200/10/4000/1/25°C for the first cycle, and 200/20/4000/1/25°C for three subsequent cycles. The measurement took approximately 3.9 hours. Physical stability was evaluated using SepView 6.1 software by analyzing the transmission profile through integral transmission and front tracking.

Rheological Measurement

The rheology of the final formula of facial scrub based was measured using a TA HR10 Rheometer (TA Instruments, U.S.A.) equipped with a 40.0 mm Peltier cone stainless steel plate. Data collection and analysis were performed using TRIOS Software. The infinite-rate and zero-rate viscosity were determined using the best-fit model of viscosity (Pa·s) versus shear rate (1/s). Similarly, the yield stress and viscosity were obtained through the best-fit model of viscosity (Pa·s) versus shear stress (Pa).

Cocoa Pod Powder Scrub Beads

The cocoa pod powder scrub was encapsulated using sodium alginate combined with seaweed to create scrub beads. To prepare the encapsulation solution, 1 gram of sodium alginate powder was dissolved in 90 mL of distilled water. In a separate beaker, 2 grams of seaweed were heated in 100 mL of distilled water until fully dissolved. Both solutions were then filtered and combined in a 1:4 ratios (sodium alginate solution to seaweed solution). To preserve the mixture, 0.5 mL of a paraben-free preservative was added. One gram of cocoa pod powder (as described by Azila and Nur Azilah, 2012) was mixed with the prepared solution. The scrub beads were formed by dropping the mixture into a 2% calcium chloride solution using a syringe. The resulting encapsulated particles, designed to function as scrub beads, were kept under 0.5 cm in size; strict particle uniformity was not prioritized because the encapsulation is intended to break apart (rupture) upon being squeezed out of the tube or during application on the skin. The formed beads were then stored in a container for future use.

Efficacy of Cocoa Based Facial Scrub

Thirteen volunteers, aged 30 to 40 years, including seven males and six females, participated in this test. Prior to their involvement, each participant was provided with a consent form. To maintain participant welfare and uphold ethical standards, the panels were freely allowed to withdraw from the trial at any time if they experienced any irritation or discomfort. This protocol was established to confirm the product safety ensuring the study prioritized participant well-being. In addition, to ensure the safety and non-irritancy of the product, a Patch Test was conducted on each panel member before the execution of this experiment (data not shown). The Patch Test is the standard dermatological method used to assess whether a product causes skin irritation or allergic sensitization, strengthening the study's credibility and confirming product safety prior to the full four-week trial.

The panels were supplied with a tube of cocoa-based facial scrub to use at least three times per week as part of their facial cleansing routine. They were allowed to continue using their existing facial products, except for their usual facial scrub, which was replaced with the provided product. Approximately 0.5 grams of the scrub was applied during each use.

Measurements were conducted weekly over five sessions, starting with an initial baseline reading. The assessments were performed using the Visioscan device. The study focused on evaluating key parameters, including facial texture, smoothness, hydration, and wrinkle reduction. The improvement in facial texture is influenced by the reduction in surface roughness and SEr indexes, which are associated with the unevenness or bumpiness of the skin's surface. Smoothness is associated with the volume and SSc indexes, which are linked to the assessment of the absence of flaky skin. The increase in skin hydration is evaluated using the energy index, while wrinkle reduction is assessed through the SWr index. As a token of appreciation, the volunteers received a small gift upon completing the final measurement.

Data Analysis

Minitab Software version 16 (Minitab Pty Ltd, Australia) was used for statistical analysis. Model factors were considered significant when the p-value was less than $\alpha = 0.05$. A Student's t-test was performed to validate the pH values predicted by the

Minitab-generated model against the laboratory-measured values. The model was deemed valid if the p-value from the Student's t-test exceeded α = 0.05.

The same software was used to analyze data related to facial texture, smoothness, hydration, and wrinkle reduction. A paired t-test was conducted to compare weekly measurements with the baseline (initial condition). Results were considered significant when the p-value was less than 0.05.

RESULTS AND DISCUSSIONS

This facial scrub formulation is designed with a balanced blend of functional ingredients to ensure efficacy, stability, and user satisfaction. Distilled water acts as the primary diluent, forming the base of the product and allowing even dispersion of other components. Glycerin and glyceryl monostearate provide deep hydration and a soft, smooth feel to the skin, while cocoa butter liquid soap (CBLS) offers gentle cleansing with the nourishing benefits of cocoa butter. Surfactants like Sodium Methyl Cocoyl Taurate (SMCT), Sodium Cocoyl Glutamate (SCGL), and Cocoamidopropyl Betaine (COBET) work together to create a rich, dense foam that cleans effectively while being mild and moisturizing, with COBET also enhancing viscosity for a consistent texture. Cetyl alcohol and sodium chloride stabilize the emulsion and adjust viscosity, ensuring a thick, creamy consistency that is easy to apply. The inclusion of a paraben-free preservative protects the product from microbial growth, while citric acid ensures the pH remains balanced for safe and comfortable use. Finally, a fragrance enhances the sensory experience, making the scrub enjoyable to use. This formulation combines effective cleansing, moisturizing, and stability, delivering a luxurious skincare product with long-term shelf life.

The facial scrub base was made of CBLS which was formulated using cocoa butter, in combination with three other surfactants; e.g. SMCT, SCGL and COBET. The SMCT and SCGL are the mild anionic surfactants while the COBET is the amphoteric surfactant. These combinations of surfactants are formulated to provide gentle cleansing and foaming for removal of dirt from facial skin surface. The surfactant also works as an emulsifier and solubilizer with other ingredients in the formula.

The model equation of pH was presented by the following equation (1);

$$pH = 8.00551 - 0.0259343COBET \qquad (1)$$

Based on the equation (1), the pH of the facial scrub base can be reduced by increasing COBET levels. However, while effective, this approach is not very economical. As a common practice in formulation, citric acid was added as pH adjuster (Carli, B., 2020 and Vandenberghe, L.P.S., et. al, 2017) and enhance stability (Fiume, M.M., et. al, 2014 and Carli, B. 2020). The pH of the facial scrub based after the addition of citric acid is described by the following equation (2);

$$pH_{CA} = 6.68239 + 0.0384468SMCT - 0.136826SGCL - 0.107972COBET + 0.02275SGCL * COBET \qquad (2)$$

Equation (2) demonstrates that the pH is influenced by SMCT, SGCL, and COBET, as illustrated in Figure 1. The optimum pH values were achieved at pH 7.70 and pHCA 5.65, with corresponding levels of SMCT at 0.6137, SGCL at 1.6364, and COBET at 11.7045. Both equations were validated in the laboratory, yielding results of pH 7.61 ± 0.025 and pHCA 5.67 ± 0.029.

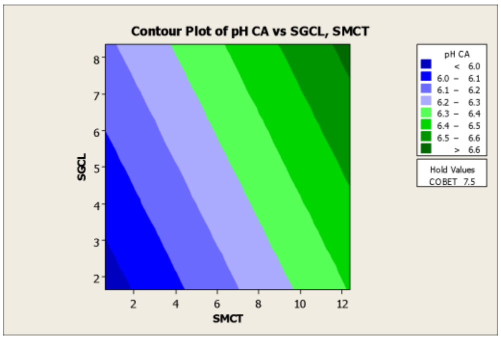

Figure 1: Contour Plot of pH_{CA} vs SMCT and SGCL

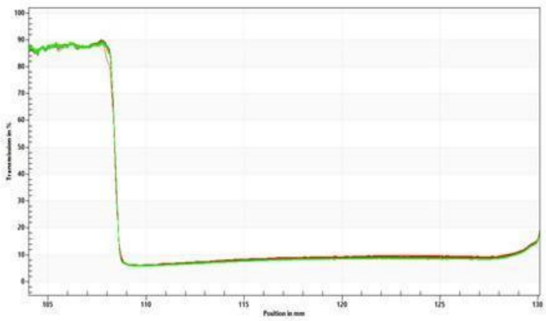

Figure 2 Transmission Profile of Facial Scrub Based

Figure 2 presents the transmission profiles for the facial scrub formulation, which reflect its stability over a period of months. The overlapping nature of the transmission lines indicates that the formulation exhibits good stability.

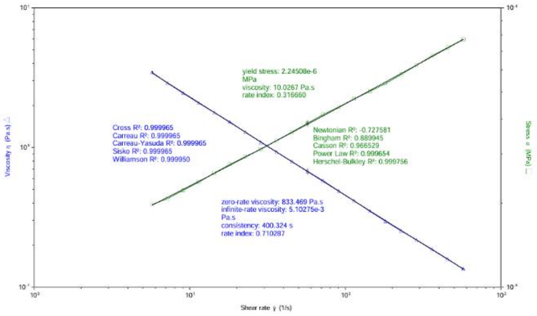

Figure 3: Rheological Profile of Facial Scrub Based at Initial

Figure 3 demonstrates the facial scrub's consistent and predictable shear-thinning behavior, ensuring easy spread ability upon application. This consistent rheological profile, illustrating the product's ability to smoothly transition to a lower viscosity under shear, suggests good formulation stability and implies that the facial scrub will maintain its desired consistency during storage even after six months.

Among the 13 panelists, over 50% reported positive results. The facial texture of the panelists improved, marked by a significant reduction in surface roughness (7.19%) and the SEr index (18.31%) after the second week of application. Smoothness was enhanced through reductions in volume (11.25%) and SSc (8.77) indexes. Skin hydration improved, as indicated by an increase in the energy index at 11.37%. The product also reduced wrinkles by 6.06%, as evidenced by the decrease in the SWr index. These positive effects persisted throughout the study period.

Table 4: Results of Skin Parameter with the Application of Cocoa Facial Scrub

PARAMETER / INDEX	TARGET	PANEL (%)	PERCENT (%)
Facial Texture			
Surface	Reduced	69	-7.19
SEr	Reduced	58	-18.31
Smoothness			
Volume	Reduced	69	-11.25
SSc	Reduced	54	-8.77
Hydration			
Energy	Increased	58	11.37
Wrinkles			
SWr	Reduced	50	-6.06

Figure 4 presents images of the facial skin condition of a male and a female panelist before and after four weeks of product application. In Figure 4(a), the removal of black spots is clearly visible, while in Figure 4(b), flaky and dry skin appears significantly smoother.

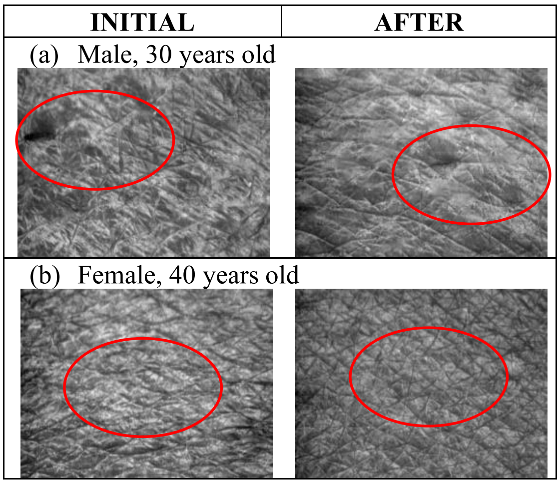

Figure 4: Picture of Skin Before and After Application of the Cocoa Facial Scrub (a) Removal of Black Spot; (b) Reduction of Flaky & Dry Skin

CONCLUSIONS

The facial scrub formulation, based on cocoa and developed using response surface methodology, exhibited optimal pH and pH_{CA} values. Stability and rheological measurements demonstrated good stability and consistent shear-thinning behavior, respectively. The facial scrub, incorporated with encapsulated cocoa pod husk powder, was tested on 13 volunteers and showed positive improvements in facial texture, smoothness, hydration, and wrinkle reduction. These improvements were measured by Visioscan, with over 50% of panelists reporting positive results and significant improvement in facial texture including smoothness and the hydration index.

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