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FORMULATION OPTIMIZATION OF SKIN REPAIRING AND HYDRATING FACIAL CLEANSING STICK USING RESPONSE SURFACE METHODOLOGY

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ABSTRACT

The present study was carried out to optimize a skin-repairing and hydrating facial cleansing stick containing Centella asiatica leaves extract using Response Surface Methodology (RSM). Glycerin and sodium cocoyl isethionate (SCI) were selected as independent formulation variables due to their major influence on hydration and cleansing performance. A Design of Experiments (DOE) approach was employed to study the combined effect of glycerin (15–25) and SCI (20–40) on spreadability and foamability, which were selected as critical response parameters. Experimental data were analyzed using response surface and contour plots to understand the effect of formulation variables on the selected responses. The results showed that glycerin had a positive influence on spreadability, while increasing SCI improved foamability but reduced spreadability at higher levels. Numerical optimization based on the desirability function identified an optimized formulation containing 25 glycerin and 20 SCI, which provided a balanced response for both spreadability and foamability. The study

demonstrates that RSM is an effective tool for optimizing facial cleansing stick formulations containing Centella asiatica leaves extract.

KEYWORDS: Formulation optimization, skin repair and hydration, response surface methodology, centella asiatica extract, Design expert software.

INTRODUCTION

The facial cleansing stick is a solid face cleanser that cleanses the skin by dissolving dirt, oil and makeup, it also nourishes to leave skin softer. When applying the facial cleansing stick, it gently massages the skin because you need to roll the stick around your skin. The facial cleansing stick is the novel skincare product on the market.[1] Cleansing sticks are solid and dissolve into creamy suds that help rinse away dirt, oil, impurities and more once paired with water. Due to their compact size, cleansing sticks are extremely portable and can carry without fear of spillage. It offers a completely different way of cleansing the skin after a long day out. Facial cleansing sticks are solid and dissolve into creamy suds that help rinse away dirt, oil, impurities and more once paired with water. Due to their compact size, cleansing sticks are extremely portable and can carry without fear of spillage. It offers a completely different way of cleansing the skin after a long day out.

Skin cleanser remove dirt, sebum, oil and dead skin cells ideally without damaging or irritating the skin. Cleansing sticks are stored in a twist-up tube and applied directly to the face. Most sticks are meant to be massaged directly onto a damp face with gentle, circular motion.

MATERIALS AND METHODS

LIST OF INGREDIENTS USED FACIAL CLEANSING STICK

Table no 1.

SLNO	INGRIDENTS
1.	Centella asiatica leaves extract
2.	Distilled water
3.	Sodium cocoyl isethionate
4.	Cocamido propoyl betaine
5.	Lactic acid
6.	Sodium benzoate
7.	Lavender oil macerate
8.	ricewax
9.	glycerin
10.	Tocopherol

PREPARATION OF SKIN REPAIRING AND HYDRATING FACIAL CLEANSING STICK[1]

Phase A

Mix water and glycerine in a china dish add sodium cocoyl isethionate and cocamido propyl betaine slowly while stirring heat gently to 70-75^{0}C until surfactants are dissolved add latic acid and stir well.

Phase B

In another china dish melt rice wax at 70-75^{0}C add tocopherol and lavender oil macerate while still warm.

Phase C

Slowly add Phase B into Phase A with continuous stirring. When the temperature of the combined phase is under 70^{0}C add 5% Centella asiatica leaves extract and sodium benzoate. Pour the whole blend into stick containers. Leave the mixture to settle overnight.

DESIGN EXPERT SOFTWARE

Design expert software a statistical method produced by state ease. This was released in 1996 to help carry out experimental designs such as determining the optimum formula for a preparation.[3] In software it this is divided into three choices of research directions depending on experimental design to be carried out. They are screening, characterization and optimization options.

RESPONSE SURFACE METHODOLOGY

RESPONSE SURFACE METHODOLOGY is a method that is also known as the Box Wilson methodology. surface methodology responses are a collection of statistical and mathematical techniques that are useful for modeling and analyzing problems where the response is influenced by various variables. In RSM there are two designs, namely central composite design and Box Bhenken design.[3]

Central composite design (CCD)

Central composite design in the optimization process is carried out to determine the approximate optimal direction because the optimization and optimal location are unknown in RSM. . In CCD, there are several models, namely mean, linear, quadratic, 2FI, and cubic. The criteria for selecting the response model are the same as in the selection of models in mixture designs. Determination of the optimum point is seen from the value desaribility resulting. Desirability shows how fulfilled or close to the optimum point. The value desirability close to 1 is the expected value. The optimum point which either has a desirability higher is close to 1.

Design Expert Factorial method is used to find the optimum formula and to determine the interaction between factors, namely the independent variable. The interaction of each variable is used to predict the optimum formula using mathematical calculations in the Design-Expert software.

In the formulation of skin repairing and hydrating facial cleansing stick, screening and characterization studies were not performed, as the formulation variables directly influencing the performance of the facial cleansing stick were already well established. Based on prior knowledge and literature evidence glycerine and sodium cocoyl isethionate which influence spreadability and foamability. Therefore the study proceeded to formulation optimization using Design of experiments by central composite design.

Here, the formulation of skin repairing and hydrating facial cleansing stick was optimized using Design Expert software to study the effect of independent variables. Glycerin and Sodium cocoyl isethionate were selected as independent variables while spreadabillity and foamability were selected as dependent responses.

Glycerin was selected as an independent variable due to its well known humectant and spreading ability. sodium cocoyl isethionate were selected for mild surfactant action and foaming ability. Spreadability and foamability were chosen as response parameter because they influence ease of application and cleansing efficiency of the facial cleansing stick.

The range of each factors was determined based on reported literature. Glycerin concentration was selected in the range of 15 – 25% and sodium cocoyl isethionate was in the range of 20-40% for formulation optimization.

EVALUATION OF DEPENDENT FACTORS

Determination of spreadability

The spreadability of test samples was determined using 0.5g test formulation was placed within a circle of 1cm diameter premarked on a glass plate over which a second glass plate was placed. A weight of 500g was allowed to rest on the upper glass plate for 5 minutes.

Spreadability refers to the area covered by a fixed amount of sample after the uniform spread of sample on the glass slide. The increase in the diameter due to spreading of the test formulation was noted.[1]

Foamability test

The foaming ability of a formulation is tested to assess its foam production and stability. In this method, 1 ml of the formulation is taken in a 100 ml graduated cylinder, and distilled water is added to make up to 50 ml. The cylinder is closed and shaken vigorously for 10 seconds to produce foam. The foam volume is recorded after 1 minute to determine initial foaming. The cylinder is then left undisturbed, and the foam volume is noted again after 10 minutes and measure the height of the foam in centimeter.

RESULT AND DISCUSSION

FORMULATION OF FACIAL CLEANSING STICK USING DOE ACCORDING TO SPREADABILITY AND FOAMABILITY

Table no. 2.

		Factor 1	Factor 2	Response 1	Response 2
Std	**Run**	**A:glycerine**	**B:sodium cocyl isethionate**	**spreadability**	**foamability**
		%	%	cm	cm
13	1	20	30	70	2.7
5	2	12.9289	30	100	2.2
1	3	15	20	110	2.4
3	4	15	40	120	3.3
7	5	20	15.8579	170	4.1
2	6	25	20	200	4.8
9	7	20	30	70	2.7
11	8	20	30	70	2.7
12	9	20	30	70	2.7
4	10	25	40	100	4.5
6	11	27.0711	30	90	3.7
8	12	20	44.1421	80	4.4
10	13	20	30	70	2.7

RESPONSE 1: spredability

Spreadability is evaluated by using the equation Spreadability= m × l/t

m= Standard weight which is tied to or placed over the upper slide, l= length of a glass slide, t= time taken

Statistical analysis of effect of variables on spreadability.

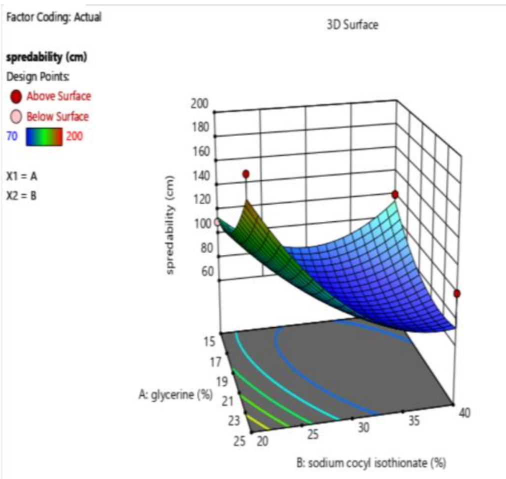
ANOVA for Quadratic model

Table no: 3.

Source	**Sum of Squares**	**df**	**Mean Square**	**F-value**	**p-value**	
Model	18298.03	5	3659.61	12.37	0.0023	significant
A-glycerine	390.01	1	390.01	1.32	0.2886	
B-sodium cocyl isethionate	5901.28	1	5901.28	19.94	0.0029	
AB	3025.00	1	3025.00	10.22	0.0151	
A^2	2285.33	1	2285.33	7.72	0.0273	
B^2	7633.15	1	7633.15	25.80	0.0014	
Residual	2071.20	7	295.89			
Lack of Fit	2071.20	3	690.40			
Pure Error	0.0000	4	0.0000			
Cor Total	20369.23	12				

The **Model F-value** of 12.37 implies the model is significant.

P-values less than 0.0500 indicate model terms are significant. In this case B, AB, A^2, B^2 are significant model terms. Values greater than 0.1000 indicate the model terms are not significant.



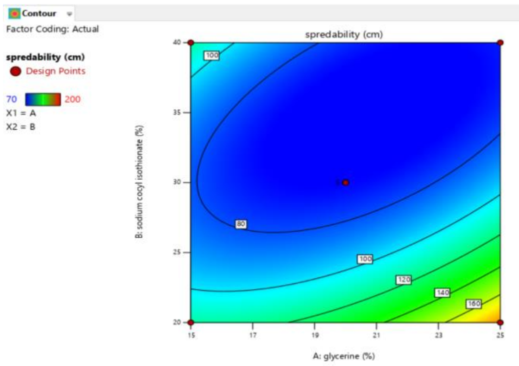


Fig No 1: 3D Response Surface Plot. **Fig No 2: Contour Plot.**

Spreadability is positively influenced by glycerin concentration.

Response 2: foamability

Statistical analysis of effect of variables on foamability.

ANOVA for Quadratic model

Table no: 4.

Source	**Sum of Squares**	**df**	**Mean Square**	**F-value**	**p-value**	
Model	9.20	5	1.84	39.97	< 0.0001	significant
A-glycerine	4.09	1	4.09	88.90	< 0.0001	
B-sodium cocyl isethionate	0.1311	1	0.1311	2.85	0.1353	
AB	0.3600	1	0.3600	7.82	0.0266	
A^2	0.1837	1	0.1837	3.99	0.0859	
B^2	4.59	1	4.59	99.78	< 0.0001	
Residual	0.3222	7	0.0460			
Lack of Fit	0.3222	3	0.1074			
Pure Error	0.0000	4	0.0000			
Cor Total	9.52	12				

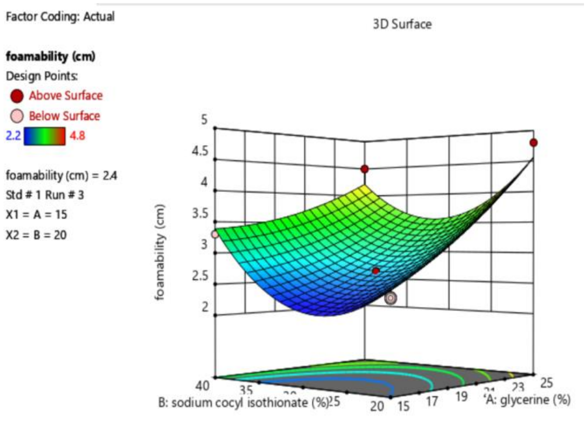


Fig No 3: 3D Response Surface Plot.

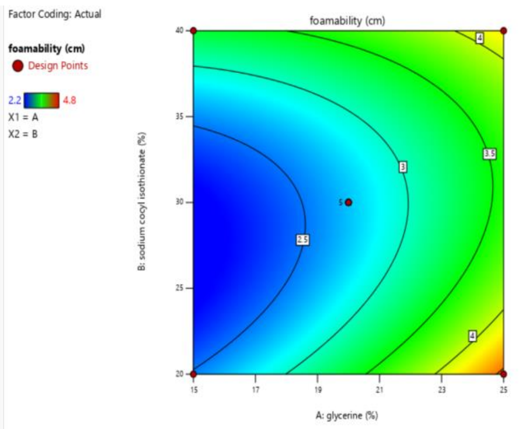


Fig No.4: Contour Plots Foamability.

Sodium cocoyl isethionate has a significant effect on foamability as compared to glycerin.

Table no 5.

Factor	**Name**	**Level**	**Low Level**	**High Level**	**Std. Dev.**	**Coding**
A	glycerine	25.00	15.00	25.00	0.0000	Actual
B	sodium cocyl isethionate	20.00	20.00	40.00	0.0000	Actual

7 Solutions found

Table no 6.

Number	**glycerine**	**sodium cocyl isethionate**	**spredability**	**foamability**	**Desirability**	
1	**25.000**	**20.000**	**182.892**	**4.562**	**0.848**	**Selected**
2	25.000	20.094	181.753	4.545	0.838	
3	24.719	20.000	178.981	4.487	0.808	
4	24.464	20.000	175.514	4.420	0.772	
5	25.000	20.863	172.709	4.413	0.756	

6	24.250	20.000	172.690	4.365	0.742	
7	15.000	40.000	114.608	3.388	0.177	

Numerical optimization was performed using the desirability to obtain the optimal levels of glycerine and sodium cocoyl isethionate.

Multiple solutions were generated among these the formulation contain glycerine 25 and sodium cocoyl isethionate 20 showed the highest overall desirability value (0.848) and was selected as the optimized formulation.

CONCLUSION

The present study successfully applied Response Surface Methodology (RSM) to optimize a skin-repairing and hydrating facial cleansing stick containing Centella asiatica leaves extract. Glycerin and sodium cocoyl isethionate (SCI) were identified as critical formulation variables influencing product performance. The Design of Experiments approach helped in understanding the individual and combined effects of these variables on spreadability and foamability. Results indicated that glycerin positively affected spreadability, while higher concentrations of SCI increased foamability but adversely affected spreadability. Numerical optimization using the desirability function enabled the selection of an optimized formulation with 25 glycerin and 20 SCI, providing a balanced combination of both responses. The study confirms that RSM is an efficient and systematic tool for formulation optimization, reducing trial-and-error and ensuring product quality. This optimized formulation may serve as a suitable base for further evaluation of skin-repairing and hydrating properties of facial cleansing sticks containing Centella asiatica leaves extract.

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