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Optimisation of Non-Stick Insect Repellent Cream Formulation

Mariani Rajin, Awang Bono, Sariah Abang and Duduku Krishnaiah
Chemical Engineering Programme, School of Engineering and
Information Technology University Malaysia Sabah, 88999 Kota Kinabalu, Sabah, Malaysia

Abstract: Nowadays, insect repellent is widely used by consumer, especially insect repellent that is produced from natural-based. Since the component of insect repellent could not be applied directly to human skin, base cream with insect repellents need to be formulated. The quality of the base cream is directly linked to the basic material used in the formulation. In this work, various compositions of carbopol, triethylamide, glycerine, water and ethanol were used to prepare the base cream formulations. D-optimal mixture design was performed to obtain the optimum formulation. Twenty-five combination components were selected according to the D-optimal criterion. The consumer acceptance and physical properties of the base cream such as viscosity, drying time stickiness were studied. Three-dimensional surface plots were formed to assess the change in the response surface and to understand the effect of the mixture composition on lipstick characteristics. The result indicates that there are relationships between the processing variables of the lipstick formulation and the consumer acceptance.

Key words: Base cream formulation, D-Optimal mixture design, insect repellent

INTRODUCTION

An insect repellent work by vaporizing the active ingredients such as diethylotoluamide and dimethylphthalate in the insect repellent product, was reported (Page *et al*., 2002). The effectiveness of the insect repellent depends on the vaporization rate and washed-off properties. An insect repellent can be produced in the form of spray, lotion, or stick. There are two types of the insect repellents; synthetic chemicals and plant derived essential oil (Fradin and Day, 2004). Insect repellents such as the camphor, citronella, cedar, or DEET cannot be applied directly to human skin. Therefore, creams or lotions are used as the base of the insect repellents. The physical properties of the base cream may influence the consumer acceptance.

The challenge faced in formulating the base cream of the insect repellent is to achieve a base cream that has the optimum performance, with the addition of acceptable physical characteristics. In a formulation work, statistical experimental design such as D-optimal mixture design is commonly used to obtain a product with the required characteristics. The primary goal of designing an experiment statistically is to obtain valid results at minimum of effort, time and resources (Myers and Montgomery, 2002).

The objective of this work was to ascertain a base cream of insect repellent formulation, which was assisted by D-optimal mixture design. In this work, carbopol, triethylamide, glycerine, water and ethanol were selected as the raw materials to produce base cream insect repellent formulations. The formulations were based on the compositions that were suggested by D-optimal mixture design. The consumer acceptance and physical properties of the base cream such as viscosity, drying time and stickiness were studied. Three-dimensional surface plots were formed to assess the changes in the response surface where the relationships between the mixture compositions, physical properties and consumer acceptance of the base cream of the insect repellent were examined.

MATERIALS AND METHODS

Formulation process: The experimental design of the five-components system was conducted by using Design Expert (version 6.10, Stat-Easy Inc., Minneapolis, USA). A set of candidate points in the design space was selected by using the D-optimal criterion (Myers and Montgomery, 2002). The constraints of the components proportion are demonstrated in Table 1.

Twenty five base creams of insect repellent formulations were prepared in a laboratory scale in accordance with the composition percentage as suggested by the mixture design. The ingredients used in producing the base cream formulations were carbopol,

Corresponding Author: Mariani Rajin, Chemical Engineering Programme, School of Engineering and Information Technology, Universiti Malaysia Sabah, 88899 Kota Kinabalu, Sabah, Malaysia Tel: +6088-320000 Ext 3042

triethylamide, glycerine, water and ethanol. Firstly, water and ethanol were mixed in a 250 mL vessel. Next, carbopol was added gradually to the mixture. The mixture was stirred for two minutes before glycerin was added. Finally, fragrance and triethylamide (TEA) were added into the mixture. TEA acted as an emulsifier to concentrate the mixture. The mixture was then stirred homogeneously at a speed of 50 rpm by using a mechanical stirrer. The base cream produced was stored for twenty-four hours before the physical characteristic tests.

Characterisation of base cream's physical properties: In this study, viscosity, drying time and stickiness of the base cream was characterised. The viscosity of the base cream of the insect repellents is a very important factor in determining its stability. The viscosity measurement was performed by using Cole-Palmer Rotational Viscometer with spindle no. R7. A volume of 100 mL of base cream was poured into a beaker. The viscometer speed was set to 20 rpm. After approximately twenty minutes, the final reading was taken.

Drying time was defined as the time taken for the cream to vaporise. One gram of the sample was spread on the skin and the vaporisation time was taken in second (Butler, 2000).

On the other hand, there is no specific equipment to measure stickiness property. Small amount of the sample was taken and spread on the skin. When the sample had dried, the sample was tested for its stickiness. The results of the stickiness test were interpreted as 1 for sticky and 0 for not sticky (Butler, 2000).

RESULTS AND DISCUSSION

Effect of the composition variation on the viscosity of the base cream of insect repellent: Since there are significant interaction effects between mixture composition and the viscosity of the cream, the response surface graph is shown in Fig. 1. The diagram describes the variation on viscosity response as a function of the mixture composition. In order to represent the response evaluation in a bidimensional system, two of the variables were to be kept constant. In this case, water and ethanol composition were kept constant since these components have the less effect on viscosity. Figure 1 shows that the viscosity of the base cream decreases with a decrease in the TEA composition. This is because TEA acts as an emulsifier to thicken the base cream. However, the viscosity of the base cream increases with the decrease in the glycerine and carbopol composition.

Effect of the composition variation on the drying time of the base cream of insect repellent: Figure 2 describes the variation on drying time response as a function of the mixture composition. In this case, water and ethanol composition were kept constant since these components have the less effect on drying time. Figure 2 shows that the moisture content of the base cream decreases with the increase in the glycerine composition. A high quantity of glycerine has resulted in an increase of the vaporisation time of the base cream. On the other hand, the moisture content of the base cream of insect repellent increases with the decrease in the TEA and carbopol composition.

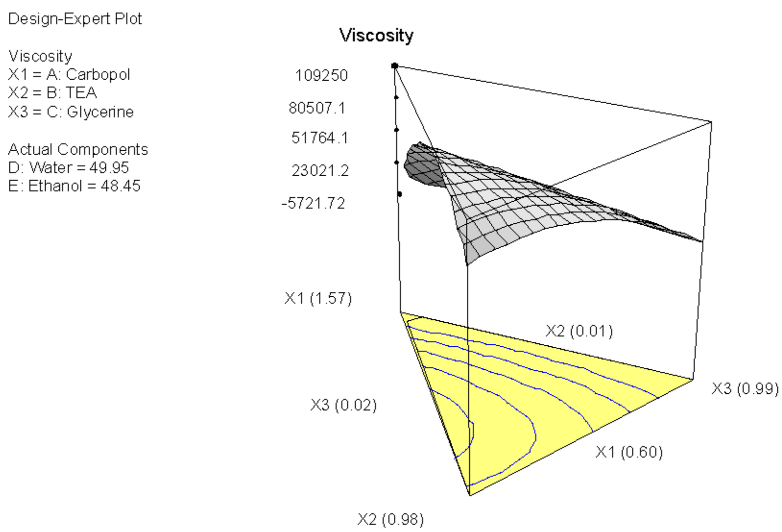

Fig. 1: Three-dimensional surface of viscosity response

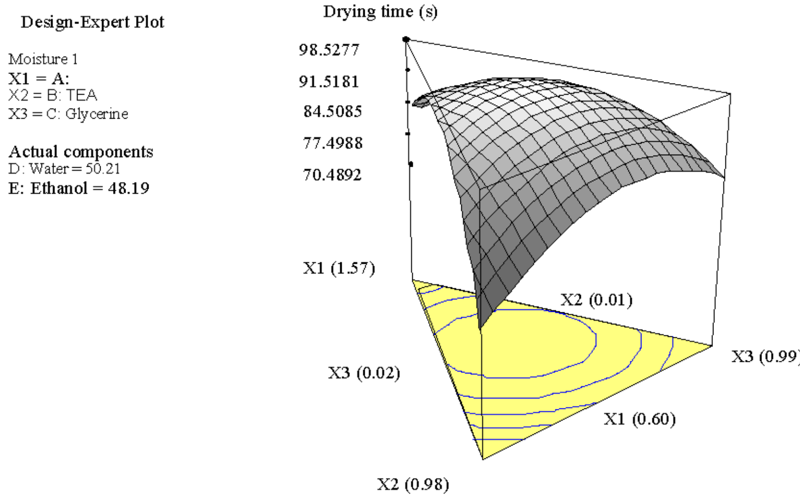

Fig. 2: Three-dimensional surface of drying time response

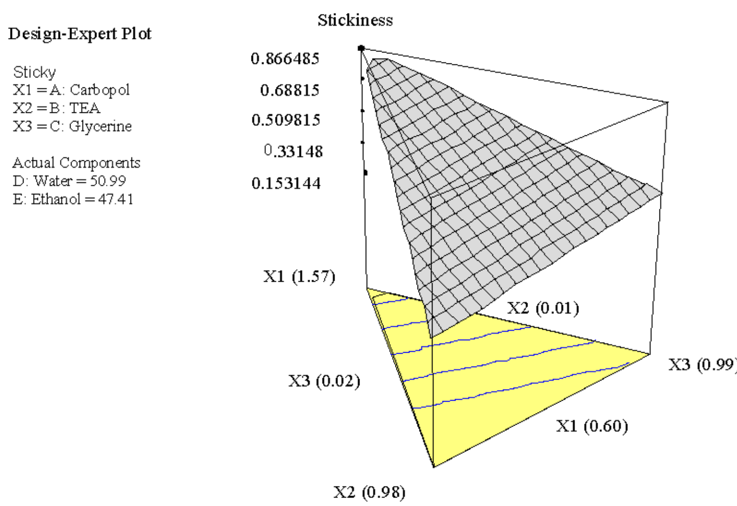

Fig. 3: Three-dimensional surface of stickiness response

Effect of the composition variation on the stickiness of the base cream of insect repellent: Figure 3 describes the variation on stickiness response as a function of the mixture composition. In this case, water and ethanol composition were kept constant since these components have the less effect on stickiness. Figure 3 shows that the stickiness of the base cream of insect repellent increases with the decrease in the glycerine composition. In contrast, the stickiness decreases with the decrease in the carbopol and TEA composition.

Optimisation of base cream insect repellent formulation: Numerical optimisation was performed in order to obtain the formulation with desired characteristics. The optimisation goal was based on the instrumental measurement and consumer evaluation data. The goal for each response is shown in Table 2.

The result of the optimisation method suggests that the optimum formulation consists of 0.6% carbopol, 0.98%TEA, 0.07%glycerine, 44.07% water and 52.28% ethanol, with the highest desirability of 0.95.

Table 1: Constraints of the components proportion

Component, X_i	Lower limit, L_i (%)	Upper limit, U_i (%)
Carbopol, X_1	0.60	1.50
Triethylamide, X_2	0.01	0.10
Glycerine, X_3	0.02	1.00
Water, X_4	40.00	59.37
Ethanol, X_5	40.00	59.37

Table 2: Optimization target for the response

Response	Goal
Viscosity	Minimum
Drying time	Minimum
Stickiness	In the target = 0

CONCLUSION

Twenty-five non-stick base creams of insect repellent formulations have been prepared. The effects of the carbopol, TEA, glycerine, water and ethanol compositions on the physical properties and consumer acceptance of the base cream formulation have been studied. The results indicate that the physical properties and consumer acceptance can be manipulated by changing the mixture compositions. The statistical study shows that the fitted model is adequate to describe the viscosity, drying time and stickiness response. Numerical optimisation has been conducted based on the physical properties and consumer acceptability

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