Carbopol-940 Improves the Physical Properties of Cocoa Peel Extract Emulgel

Nisa'ul Khoiriyah, Dwi Bagus Pambudi (✉), Nuniek Nizmah Fajriyah, Eko Mugiyanto, and Nur Izzah

University of Muhammadiyah Pekajangan Pekalongan, Pekalongan 51173, Indonesia
dwibagus589@gmail.com

Abstract. Recently, the utilization of the herbal skincare industry has drawn much attention. One component utilized in formulations to provide a gel-like consistency and maintain the stability of a medical preparation is carbopol-940, a cosmetic gelling agent. It is frequently combined with an emulgator, triethanolamine. This study aims to assess the effect of blending Carbopol-940 and triethanolamine in the formulation of a cocoa peel extract gel using the Simplex Lattice Design (SLD) approach. In principle, using a magnetic stirrer, the water and oil phases are mixed to produce the gel at 70^0C. The procedure begins with dissolving Carbopol-940 in water, which is then combined with triethanolamine to form the base. After combining the gel base and emulsion, cocoa fruit peel extract is added. The SLD method was employed to evaluate the physical characteristics of emulgel (adhesion, viscosity, and dispersibility) to determine how Carbopol-940 and triethanolamine affected those characteristics. The result showed that using carbopol 940 and triethanolamine simultaneously significantly affected the adhesion and viscosity of cocoa peel extract emulgel. The ratio carbopol-940 to triethanolamine 1:8 gave the best physical properties; it shows a spreading power of 5.50-5.60 cm, an adhesive power of 1.16-1.25 seconds, and a viscosity of 20,456-21,472 mPa.s. Furthermore, compared to triethanolamine, carbopol 940 has a more substantial impact on the emulgel of cocoa peel extract. In conclusion, carbopol 940 and triethanolamine contributed to the adhesion and viscosity of cocoa peel extract emulgel. Meanwhile, carbopol 940 has a more significant effect on the emulgel of cocoa peel extract than triethanolamine.

Keywords: Carbopol 940, Triethanolamine, Physical parameters, Emulgel.

1 Introduction

The skin is one of the largest and most easily accessible organs of the body, being an ideal part and multiple sites for distributing therapeutic agents both locally and systemically. The skin will be a barrier layer created to keep what is inside and outside. Most pharmaceutical preparations on the skin aim to provide local effects, so they are formulated to have prolonged local contact with minimal drug absorption in the systemic tract [1]. One pharmaceutical dosage form that can be used topically is an emulgel. The combination of gel and emulsion will form a preparation known as an emulgel. Gels

M. Setiyo et al. (eds.), *Proceedings of the 4th Borobudur International Symposium on Science and Technology 2022 (BIS-STE 2022)*, Advances in Engineering Research 225,
https://doi.org/10.2991/978-94-6463-284-2_33

form when large amounts of water are trapped in colloidal solid particles [2]. Gels are unable to distribute hydrophobic substances in the body. Meanwhile, the combination of water, oil, and gel phases can be a carrier for hydrophobic substances.

This dosage form will combine the advantages of both the emulsion and gel phases. Kshirsagar (2000) in Pamwar et al. (2011) suggest that in its use dermatologically, emulgel has several advantages such as thixotropic, easy to spread, non-greasy, easy to remove, soft, non-staining, transparent, environmentally friendly, long shelf life, and good appearance. Most topical preparations in the form of creams, lotions, and ointments have a sticky texture, making it difficult for patients to use them. They have less spreadability and need to be rubbed when applied [1]. According to Gibson (2004) in Talat et al. (2021), emulgel is an O/W or W/O emulsion in which the drug particles trapped in the internal phase will pass through the external phase to gradually be absorbed into the skin, which will provide a regulated effect [2]. Emulgel has better stability when compared to other dosage forms. Creams may exhibit phase separation, ointments may become rancid, and powders may be hygroscopic. To maintain the physical stability of the emulgel, gelling and emulsifying agents are used.

The presence of a gelling agent in a formula can affect the physical properties and stability of the resulting emulgel. Some physical properties in question are organoleptic, spreadability, adhesion, viscosity, and pH. One example of a gelling agent is carbopol 940, which belongs to the carbomer group. Hydrogen bonds are formed between the carbomer and water. The gel mass will be formed when the dissolved carbomer is neutralized using an alkalizing agent [3]. One of the alkalizing agents commonly used in pharmaceutical formulations is triethanolamine (TEA). Apart from an alkalizing agent, TEA is also an emulsifying agent that combines the oil and water phases in an emulsion.

The presence of carbopol 940 and TEA is essential in formulating emulgels. Therefore, this study aims to determine the effect of carbopol 940 and TEA on the emulgel physical properties of cocoa peel extract (Theobroma cacao L.). Accepted physical properties will result in preparations that are easy to spread, safe for the skin, and comfortable to use.

2 Method

2.1 Tools and materials

The tools used in this study included: design expert software, sieve number 100, grinder, glass jar, rotary evaporator, glass beaker (Pyrex), magnetic stirrer (Thermo), mortar and pestle, stirring rod, pH meter, digital viscometer, oven (UN 55), spreadability and adhesion test kit, a glass slide. The ingredients include mature cocoa peel skin, 96% ethanol, olive oil, span 80, tween 80, carbopol 940, TEA, methylparaben, propylparaben, water, and propylene glycol. The cocoa peel skin comes from Siwatu Village, Batang Regency, Indonesia.

2.2 Sample preparation and extraction

Mature cocoa peel skin is sorted wet and washed with running water. Subsequently, it is cut into smaller sizes, dried in the sun, followed by grinding using a grinder, and sifted with sieve number 100.

The extraction followed a study conducted by Waznah et al. with slight modifications. The extract process was carried out by maceration method using 96% ethanol solvent with a sample and solvent ratio of 1:5 for 120 hours. The macerate was filtered to become filtrate 1. Then it was re-macerated with 2.5 L 96% ethanol to produce filtrate 2. Filtrate 1 and 2 are evaporated to form a thick extract.

2.3 Optimization of carbopol 940 and TEA in emulgel formulas

Table 1 shows the base of emulgel formula used. Carbopol 940 and TEA were optimized using design expert software version 13.0.5.0 to produce formulas with different carbopol 940 and TEA concentrations. Variations in the concentrations of carbopol 940 and TEA are shown in Table 2. The use of carbopol 940 as a gelling agent is 0.5-2.0%, while TEA as an emulsifying agent is 2.5-4.0% [4].

Table 1. The basic formula of cocoa peel extract emulgel

Components	Concentration (% w/w)
Cocoa peel extract	0.5
Olive oil	5.0
Tweens 80	5.0
Span 80	5.0
Methylparaben	0.02
Propylparaben	0.18
Propylene glycol	15.0
Aquadest	Ad 100

Table 2. The Results of optimization using SLD

	Concentration (% w/w)							
	F1	F2	F3	F4	F5	F6	F7	F8
Carbopol 940	0.5	1.625	0.50	1.25	2,00	2,00	0.875	1.25
TEA	4.0	2,875	4,00	3,25	2,50	2,50	3,625	3,25

The results of the optimization of the formula above were made into emulgel dosage forms, which were then tested for their physical properties (including spreadability, adhesion, viscosity, pH, and organoleptic). The spreadability, adhesion, and viscosity tests were analyzed into the Simplex Lattice Design (SLD) method expert software design to determine the effect of different concentrations of carbopol 940 and TEA on the physical properties of emulgels.

2.4 Emulgel of cocoa peel extract

The two processes of creating the emugel are emulsification and basis gelification. Using a magnetic stirrer, the gel base was prepared by dissolving carbopol 940 in a portion of distilled water, followed by adding TEA modestly until a transparent gel base was formed. Meanwhile, the emulsion was made by mixing the water phase (tween 80 and distilled water, propylene glycol, and methylparaben) with the oil phase (olive oil, propylparaben, and span 80) at 70oC using a magnetic stirrer to form an emulsion corpus. The extract is added to the emulsion until it is homogeneous. Then the cocoa peel extract emulsion is put into the mortir. Add the gel base into the mortir and stir until homogeneous.

2.5 Evaluation of physical properties of cocoa peel extract emulgel

Organoleptic. Organoleptic tests were carried out by observing the color, shape, aroma, and texture produced by the emulgel.

pH. The acidity level was measured using a digital pH meter.

Spread power. The spreadability test was performed by placing 0.5 g of emulgel on top of the test equipment and then giving it another glass plate and a load weighing 250 g for 5 minutes. Furthermore, the spreading power of the resulting emulgel was measured.

Viscosity. A viscosity test was carried out using a digital viscometer with a speed of 12 rpm.

Stickiness. 0.5 grams of emulgel is placed on a glass object on the test equipment and then covered with another glass object. Place a 1 kg weight on the emulgel for 5 minutes, followed measured the time needed for the glass plates to detach from each other.

3 Result and Discussion

3.1 Organoleptic

A type of polymer that is widely used in cosmetic products due to its ability to improve the appearance of the product is Carbopol 940. It is can enhance the texture and consistency of a product, making it more appealing to consumers. It can also improve the stability of the product by preventing separation and settling of the ingredients, which helps to maintain the product's appearance over time. Additionally, Corbopol 940 can help to create a smooth and even surface on the skin, which can enhance the overall appearance of the skin.

The organoleptic test aims to determine the visual appearance of the resulting emulgel. The results of observations on the brightness of emulgel of cocoa peel extract are shown in Fig. 1. It demonstrates that the color intensity increases with increasing carbopol 940 concentrations (the resulting color is brighter). In general, the appearance of the emulgel was semisolid, light ivory, and oily.

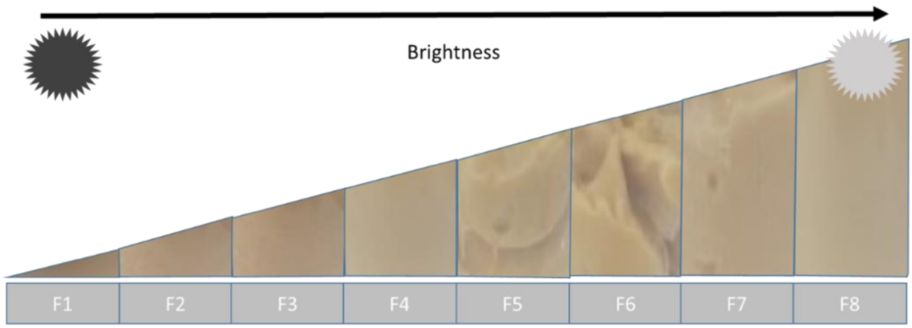

Fig. 1. The effect of Carbopol940 in the cocoa peel extract emulgel base.

3.2 Emulgel pH

The pH test aims to determine the acidity of the resulting emulgel to ensure its safety on the skin. Emulgel pH value should be in the range of normal skin pH to be convenient and not irritate [5]. For topical preparations suitable for the skin's pH balance, the standard pH must be 4.5-6.5[6]. The results of observations on the pH value of the resulting emulgel are listed in Fig. 2.

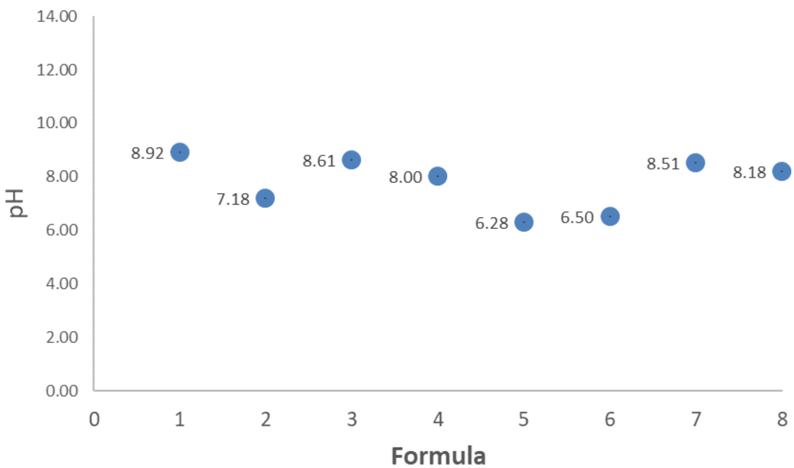

Fig. 2. The pH value of the resulting emulgel

Based on Fig. 2, compared to other formulations, pH values for F2, F5, and F6 are lower, averaging 7.18, 6.28, and 6.49, respectively. These three formulas can be considered safe for use on the skin because they have a pH that matches the skin's pH. While F1, F3, F4, F7, and F8 did not meet the pH standards for topical preparations that were safe for the skin. The higher the concentration, the lower the pH value. Meanwhile, the higher the concentration of TEA, the more alkaline the pH of the emulgel will be. It is due to TEA being alkaline.

3.3 Spreadability

Corbopol 940 improves the spreadability of products such as creams, lotions, and gels, allowing for better coverage and application. Its ability to improve spreadability is particularly useful in topical products where it helps to ensure that the active ingredients are evenly distributed across the skin. Furthermore, Corbopol 940 can also enhance the sensory properties of the products, such as providing a silky or smooth feel, thus improving the user experience.

Spreadability indicates the ability of the emulsifier to spread quickly and out of the container when it is shifted [7]. Spreadability will cause more comprehensive contact between the drug and the skin; therefore, the process of absorption of the drug into the skin will occur quickly [8]. Based on the results of this study, the spreadability of the emulgel from F1 to F8 is shown in Fig. 3. The greater the value of the spreading power, the easier it is for the emulgel to spread on the skin surface [9].

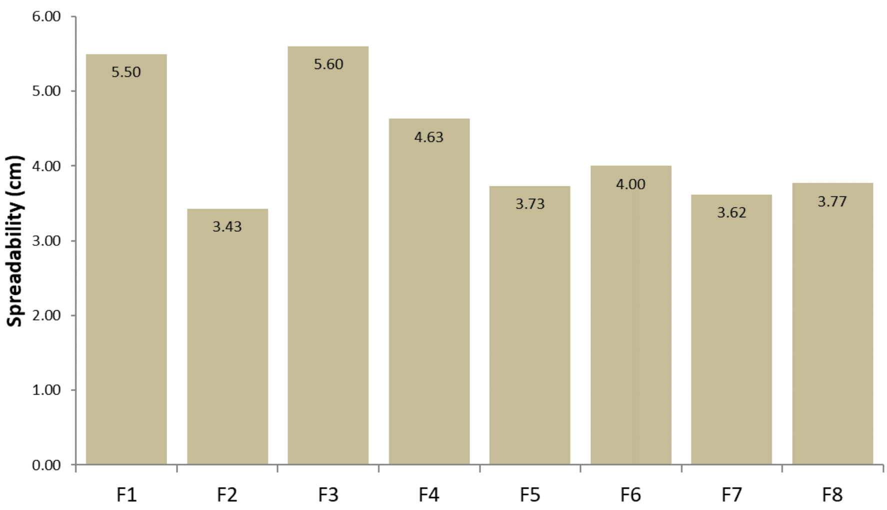

Fig. 3. Emulgel spreadability value of cocoa peel extract

Based on the results of the analysis using the SLD (Simplex Lattice Design) method, the equation obtained for the spreadability response is as follows:

$$Y = 3.57391 (A) + 1.64205 (B) – 1.46126 (A)(B) \quad (1)$$

Which is Y = Response, A = Carbopol 940, and B = TEA.

Based on equation 1, carbopol 940 gives a positive and contributes to the spreadability as indicated by coefficient A, which is positive, and the coefficient value is greater than the others. Contrarily, the emulgel spreadability responded negatively to mixing the carbopol940 fraction and TEA fraction components, with a coefficient of 1.46126. The power response profile obtained from the SLD method is shown in Fig. 4.

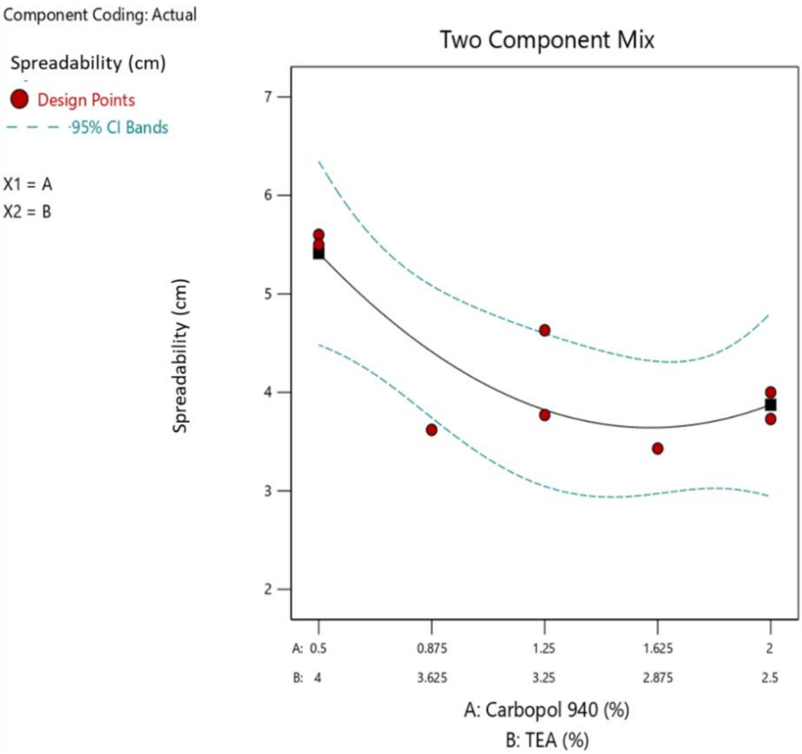

Fig. 4. Effect curve of TEA and Carbopol 940 on spreading power

3.4 Viscosity

As a thickening agent, Corbopol 940 helps to improve the texture and consistency of a product, making it more pleasant to use. In addition, it can also increase the stability and shelf life of a product by preventing separation and settling of the ingredients. Due to these properties, Corbopol 940 is widely used in various formulations such as creams, lotions, gels, and suspensions.

The consistency of a preparation and drug release depends on viscosity; therefore, the viscosity test is an important parameter that needs to be evaluated [10]. Viscosity and spreadability have inverse comparisons. The higher the viscosity of an emulgel, the lower the spreadability value [11]. The results of the viscosity test for the cocoa peel extract emulgel formula are shown in Table 3.

Table 3. Emulgel viscosity value of cocoa peel extract

	F1	F2	F3	F4	F5	F6	F7	F8
Viscosity (mPa.s)	20.456	49.136	21.472	49.177	49.163	49.149	33.210	46.093

Based on the SLD method analysis results, the viscosity response equation is shown in equation (2). This value indicates that the combination of carbopol 940 and TEA has a positive value. It means that the combination of carbopol 940 and TEA has a more significant effect on viscosity. Furthermore, it is confirmed by the viscosity profile of carbopol 940 and TEA in Fig. 5, which demonstrates that the curve steepens with increasing carbopol and TEA concentration. According to Martin et al. (1993), the increase in viscosity in the presence of carbopol is due to the carbopol mechanism which binds solvents through cross-links to form a rigid and resistant structure to specific forces and pressures [6].

$$Y = -11934.88235 (A) - 859.99782 (B) + 15070.25708 (A)(B) \quad (2)$$

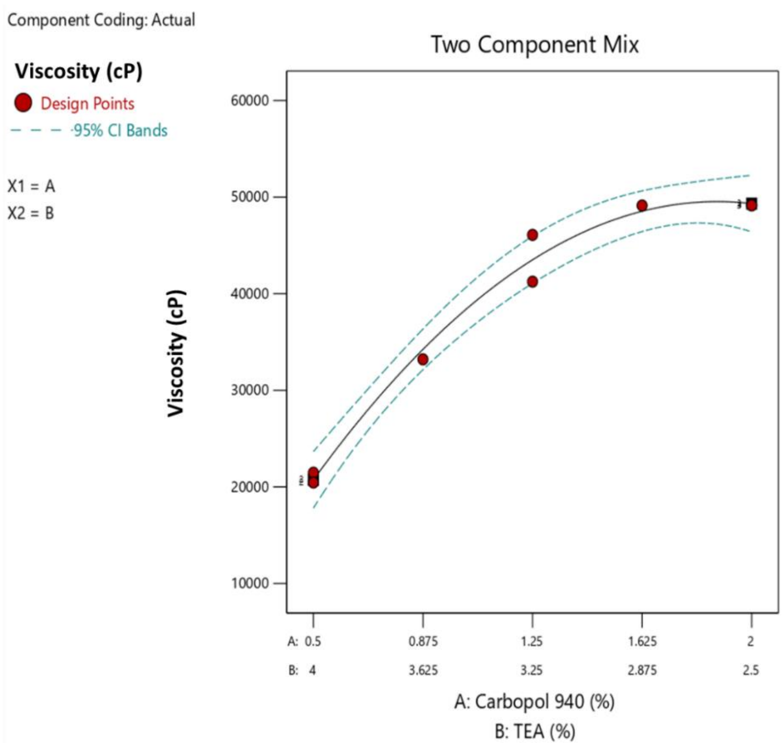

Fig. 5. Effect curve of carbopol 940 and TEA on viscosity

3.5 Adhesiveness

Adhesiveness refers to the ability of a material to adhere to another surface, whether it be the same or different surface. Corbopol 940 is a type of polymer commonly used in the manufacturing of cosmetic and pharmaceutical products because of its good adhesive properties. In cosmetic formulations, Corbopol 940 is used as a binding agent that helps maintain the consistency and stability of the product. The adhesive properties of Corbopol 940 also make it ideal for use in topical products, such as ointments and creams, as it can help the active ingredients in the product adhere to the skin and penetrate effectively. Therefore, adhesiveness and Corbopol 940 are closely related in the cosmetic and pharmaceutical industries.

The adhesion test was carried out to determine the ability of the emulgel to stick to the skin surface. A preparation will stick longer to the skin if the adhesion value is higher so that the effectiveness of the therapy will be more optimal [12]. Fig. 6 shows the adhesiveness values of all the resulting emulgel formulas.

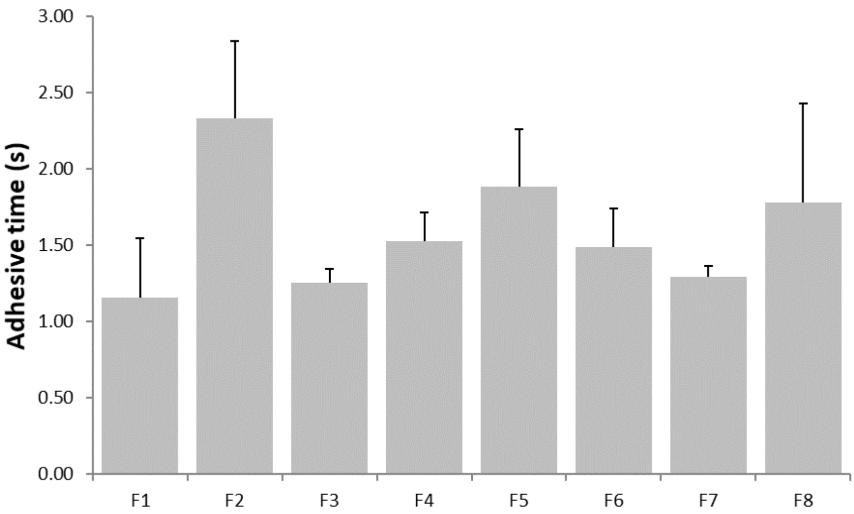

Fig. 6. Emulgel adhesiveness value of cocoa peel extract

The research conducted with the SLD method obtained the simplex lattice design equation below:

$$Y= -0.759644 (A) + 0.188678 (B) + 0.484532 (A)(B) \quad (3)$$

Based on equation (3), the combination of the two components, carbopol 940 and TEA, shows a positive coefficient value, which means that the combination of the two components is more influential in increasing adhesion. While coefficient a show a negative value, carbopol 940 can reduce the adhesive response. This model shows a p-value> 0.05 (not significant) with a model p-value of 0.2598, which means that carbopol 940 and TEA have no significant effect on the adhesive response (Fig. 7). Meanwhile, the lack of fit parameter shows insignificant with a p-value of 0.322, meaning there is no significant difference between the predicted data from the model and the observed data.

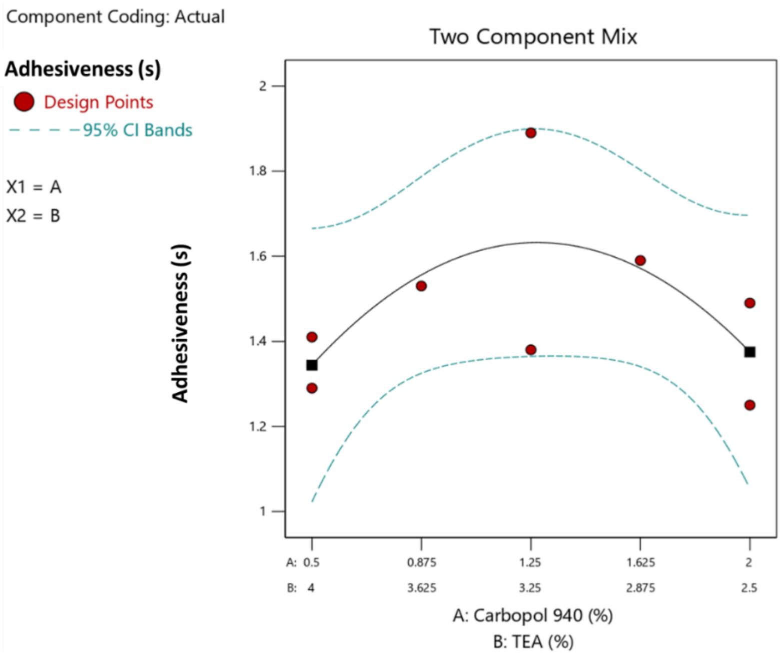

Fig. 7. Effect curve of the emulgel adhesion of cocoa peel extract

4 Conclusion

Based on the results of this study, carbopol 940 and TEA were proven to affect the physical properties of the emulgel of cocoa peel extract. The use of carbopol 940 and triethanolamine together significantly affected the adhesion and viscosity of the cocoa peel extract emulgel. Meanwhile, carbopol 940 contributed more to the spreadability of cocoa peel extract than triethanolamine. 0.5% carbopol 940 and 4% triethanolamine composition showed the best emulgel physical evaluation results.

Acknowledgment. The author is grateful to the Laboratory Staff of the Pharmacy Department of the Muhammadiyah University of Pekajangan Pekalongan, who have assisted in providing research materials.

References

1. A. S. Panwar *dkk.*, "Emulgel : A Review," vol. 1, no. 3, hal. 333–343, 2011.

2. M. Talat, M. Zaman, R. Khan, M. Jamshaid, M. Akhtar, dan A. Z. Mirza, "Emulgel : An effective drug delivery system Emulgel : an effective drug delivery system," *Drug Dev. Ind. Pharm.*, vol. 0, no. 0, hal. 1–7, 2021, doi: 10.1080/03639045.2021.1993889.
3. A. F. Tsabitah, A. K. Zulkarnain, M. S. H. Wahyuningsih, dan D. A. A. Nugrahaningsih, "Optimasi Carbomer, Propilen Glikol, dan Trietanolamin Dalam Formulasi Sediaan Gel Ekstrak Etanol Daun Kembang Bulan (Tithonia diversifolia)," *Maj. Farm.*, vol. 16, no. 2, hal. 111, 2020, doi: 10.22146/farmaseutik.v16i2.45666.
4. R. C. Rowe, P. J. Sheskey, dan S. C. Owen, *Handbook of Pharmaceutical Excipients*, 5 ed. Pharmaceutical Press, 2006.
5. O. Yandri dan W. Setyani, "Optimization Of Carbopol 940 And Propylene Glycol Concentration On The Characteristic And Inhibitory Effect Of Ethanol Extract Gel Of Papaya (*Carica papaya L.*) Seeds Against *Staphylococcus aureus*," *J. Pharm. Sci. Community*, vol. 18, no. 1, hal. 15–25, 2021, doi: 10.24071/jpsc.002562.
6. F. I. Safitri, D. Nawangsari, dan D. Febriana, "Overview : Application of Carbopol 940 in Gel," *Int. Conf. Heal. Med. Sci. (AHMS 2020) Proc.*, vol. 34, hal. 80–84, 2021.
7. D. A. Helal, D. Abd El-Rhman, S. A. Abdel-Halim, dan M. A. El-Nabarawi, "Formulation and evaluation of fluconazole topical gel," *Int. J. Pharm. Pharm. Sci.*, vol. 4, no. SUPPL. 5, hal. 176–183, 2012.
8. A. S. Wibowo, A. Budiman, dan D. Hartanti, "Formulasi Dan Aktivitas Anti Jamur Sediaan Krim M/A Ekstrak Etanol Buah Takokak (Solanum torvum Swartz) Terhadap Candida albicans," *J. Ris. Sains Dan Teknol.*, vol. 1, no. 1, hal. 15–21, 2017.
9. B. Ali Khan, S. Ullah, M. K. Khan, S. M. Alshahrani, dan V. A. Braga, "Formulation and evaluation of Ocimum basilicum-based emulgel for wound healing using animal model," *Saudi Pharm. J.*, vol. 28, no. 12, hal. 1842–1850, 2020, doi: 10.1016/j.jsps.2020.11.011.
10. G. Yassin, "Formulation and Evaluation of Optimized Clotrimazole Emulgel Formulations," *Br. J. Pharm. Res.*, vol. 4, no. 9, hal. 1014–1030, 2014, doi: 10.9734/bjpr/2014/8495.
11. A. Garg, D. Aggarwal, S. Garg, dan A. K. Singla, "Spreading of semisolid formulations: An update," *Pharm. Technol. North Am.*, vol. 26, no. 9, hal. 84–105, 2002.
12. I. Siswi Saputri, D. Bagus Pambudi, P. Studi Sarjana Farmasi, F. Ilmu Kesehatan, dan M. Pekajangan Pekalongan, "Optimasi Kombinasi Karbopol dan HPMC Sebagai Basis Dalam Formulasi Gel," Uuniversitas Muhammadiyah Pekajangan Pekalongan, 2021.